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PERCEPTION

Perception
2021, Vol. 50(1S) 1–244
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43rd European Conference on Visual Perception (ECVP) 2021 Online

Welcome Address

Welcome to the 43rd European Conference on Visual Perception (ECVP2021)! The tradition of holding an annual European Conference on Visual Perception has its origins in the "Workshop on Sensory and Perceptual Processes" that was held in Marburg, Germany in 1978 and organised by Dick Cavonius, John Mollon, Ingo Rentschler and Lothar Spillmann. The following year, a second meeting was held in Noordwijkerhout in the Netherlands and that established the practice of holding an ECVP meeting in a different European town or city and organised by academics and researchers in the local University. Uniquely, ECVP has no permanent organisation and, as a consequence, each meeting has been different and reflective of the ideas and interests of the local organisers. But the underlying goal has remained the same: i.e. to provide a forum for the presentation and discussion of new developments in our understanding of human, animal and machine vision, and an occasion where empirical, theoretical and applied perspectives of visual processing are presented and open for lively discussion.

At those early meetings, most of the presentations were from researchers in the UK, Germany, Belgium, France, Italy and the Netherlands but very soon ECVP became a truly international meeting with participants from all over the world. As a result of Richard Gregory's friendship with Adam Gelbtuch and his publishing company Pion, ECVP established a close link with the journal Perception, and the journal has published the ECVP Abstracts from nearly every meeting since the 1980's. There have also been many changes to ECVP in the 43 years since that first meeting - changes in the topics of greatest interest as well as changes in the technologies that have allowed us to study perception in different ways.

However, the Covid-19 epidemic created possibly the most significant challenge that ECVP has ever faced - the decision of whether to hold the 2021 meeting ONLINE. At the end of March 2021 (just five months before the start of the meeting), a group of ~40 individuals (including many who shared their experiences as past organisers of ECVP) met on Zoom to discuss the pro and cons of holding an online ECVP. There were many different opinions but one thing became obvious - no single individual could possibly organise such a meeting in such a short amount of time. The result - a group of 11 of us (the "Team") offered to plan and organise an online ECVP2021.

As none of us had previously organised an online meeting, there were many challenges. One of our first decisions was to restrict the timing of the talk sessions to just three hours in the afternoon (CEST) so that these could be heard live by attendees from the west coast of the USA to Australia and New Zealand. Second, we wanted the talk presentations to be given live (rather than recorded) in order to make the meeting more like the friendly and positive atmosphere of previous ECVP meetings. Third, the decision not to charge conference fees meant that the website (www.ecvp2021.org), registration and abstract submission systems, Zoom channels, online poster platforms etc., had to be created and maintained directly by members of the organising team and their respective institutions.

We initially thought that the conference might attract ~500 Abstract submissions and we thought that there would be some 800-1000 registrations. As it turned out, there were nearly 650 Abstract submissions and over 1900 registrations. After an extensive review process conducted by the session chairs and scientific

committee, the meeting hosted 150 talks, 3 Keynote speaker lectures, 2 symposia, a "Showtime!", a "Gathertown" meeting place and a total of 490 posters.

You will see below the abstracts of the scientific presentations. All of the abstracts were carefully evaluated according to pre-defined criteria by experts in the respective fields of research. We are extremely grateful to our session chairs and co-chairs and to all our colleagues who donated their time and energy to make ECVP2021 possible. We would also like to thank our exhibitors and sponsors for their financial contributions and in particular Sage Publications (publishers of Perception and i-Perception) for their on-going and generous support of ECVP.

The organising Team of the 43rd ECVP invites you to engage in the open-science interaction that is available to all, either by viewing the Abstracts in the electronic booklet below, or by interacting with the online materials that remain available via www.ecvp2021.org, www.ecvp.eu and our OSF video platform: https://osf.io/8tb9x/

Brian Rogers, on behalf of the ECVP 2021 Organising Team:

Tiziano Agostini, Marco Bertamini, Claus-Christian Carbon, Cristina de la Malla, Dražen Domijan, Mark Greenlee, Michael Herzog, Brian Rogers, Katherine Storrs, Ian Thornton & Sunčica Zdravković.

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Keynotes

Perception Lecture: Sunday August 22nd 2021

How do we search? When do we fail? Why do we care?

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Visual search is necessary because the visual field contains more information that the visual system can process at any one time. Search is far from random. It is 'guided' by multiple factors including bottom-up stimulus salience, top-down observer goals, prior history, and the structure of the scene to be searched. Working out the details of this process has been the 30+ year project of the Guided Search model (now in version 6.0). The empirical evidence shows that we have been given an excellent search engine, but not a perfect one. Search ends in failure more often than we would like. The most striking of these errors are those where the target is clearly visible once attended. These are sometimes called "Looked but failed to see" LBFTS errors. LBFTS errors arise from several different causes, suggesting that there might be several different paths to reducing them. We don't really need to reduce them in Where's Waldo games or in experiments in the lab. However, when the errors are pedestrians in crosswalks or tumors in mammograms, LBFTS errors are important, worth understanding, and worth trying to prevent.

Rank Prize Fund Lecture: Monday August 23rd 2021

The brain mechanisms for perceptual organization and Gestalt perception

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Our visual system groups image elements of objects and segregates them from other objects and the background. I will discuss how grouping operations unfold in the brain. There are two processes for perceptual grouping. The first is 'base grouping'. It relies on neurons tuned to feature conjunctions and occurs in parallel across the visual scene. If there are no neurons tuned to the required feature conjunctions, a second process, called 'incremental grouping', comes into play. Incremental grouping is a time-consuming and capacity-limited process that relies on the gradual spread of enhanced neuronal activity across the representation of an object in the visual cortex. At a perceptual level, the spread of enhanced neuronal activity corresponds to the gradual labelling of image elements with object-based attention. Inhibition of this labelling process in primary visual cortex completely blocks figure-ground perception, demonstrating a causal link between enhanced neuronal activity and perceptual organization. I will illustrate how these neuronal mechanisms account for many of the perceptual demonstrations by the Gestalt psychologists and how they unfold when we look at natural images.

ECVP Vision Lecture: Wednesday August 25th 2021

Putting binocular depth perception in context

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Early investigations of binocular depth perception often used physical stimuli such as needles and points of light under restricted viewing conditions to assess performance. In modern times, the widespread availability of computer-driven electronic display systems has facilitated the ease and precision with which stimuli can be presented. In most cases, the focus has continued to be on isolating stereopsis, to understand its limits and properties. This approach has provided important insights into the fundamental properties of binocular depth perception and its neural underpinnings. However, the restriction and manipulation of context can substantially alter how binocular depth information is processed by the visual system. For example, in stimuli viewed in a mirror stereoscope most often there are multiple conflicting sources of monocular depth information that can reduce the perceived magnitude of depth from binocular disparity (particularly for inexperienced observers). Here I will describe experiments (using both virtual and physical stimuli) where stimulus complexity, the presence and consistency with other depth cues, and observer experience, fundamentally impact binocular depth perception. I will argue that generalizing our understanding of binocular depth perception to the real world must take into account the rich visual context of real-world scenes.

Special Sessions

Symposium in memory of Michael F. Land FRS (1942-2020): Tuesday August 24th 2021

Inspiration from the Land of invertebrate vision

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Mike Land has spearheaded research in vision over a vast variety of animals and themes. His work has provided important insights that range from the optics of scallop eyes and jumping spiders, through visually mediated behaviour in crustaceans, flies, and jumping spiders, to the ways in which eye movements influence perception and behaviour in humans. Mike's publications carry three consistent hallmarks: (i) the questions are intriguing; (ii) the approaches to answering them are wonderfully imaginative; and (iii) the style of writing is very lucid and clear. I shall illustrate how my work has been hugely inspired and influenced by Mike Land.

From Tea to Tents: human visual behaviour through the eyes of a biologist

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Mike Land brought a unique perspective to the study of human visual behaviour which has a lasting influence on how we understand eye-movement control and continues to challenge the methods and results from more conventional laboratory-based studies. In this talk I will discuss work we carried out with Mike as part of his wider project to understand visual behaviour during the simple every-day task of making a cup of tea (Land, Furneaux, & Gilchrist; 2002). I will then move on to more recent work in which we explored eye movements and actions while participants are pitching a tent (Sullivan, Ludwig, Damen, Mayol-Cuevas & Gilchrist; 2021). I will argue that Mike's work is a testament to the value of exploratory science. The goal of this approach is to derive from observation, a rich, detailed description of behaviour while participants are doing everyday tasks in real environments. It is from these detailed descriptions that we can identify fundamental principles of how vision and action are coordinated.

Cognitive factors in gaze control: insights from natural settings

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Mike Land's work on natural behaviour not only demonstrated the intricate links between visual sampling and our current actions, but also that current retinal input is not sufficient for guiding gaze deployment. Simple yet profound observations made by Mike implicate memory for previously fixated objects and the ability to predict the consequences of our actions on the world around us as underlying mechanisms that support natural behaviour and are used to plan gaze shifts. Mike proposed that our behaviour is underpinned by a model of the surroundings that combines current retinal input and long-term allocentric models of our surroundings, but is crucially anchored in egocentric co-ordinates in order to serve the moment-to-moment requirements for interacting with objects around us. This egocentric model is not highly detailed or precise but is sufficient to get us close enough to our intended targets that visual sampling can provide the rest. Given the intimate links between gaze sampling and memory encoding, and between gaze sampling and behavioural goals, this model is shaped by our schemas and provides a mental substrate from which we can derive predictions about the consequences of our actions and use these to both plan gaze deployment and maintain a stable percept of our surroundings. In a typically Mike way, evidence for the rotating egocentric model comes from Mike's simple yet elegant observations of the consequences of spinning his colleagues around in an office chair.

What smooth eye movements tell us about vision and cognition

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Michael Land's work focused on eye movements during dynamic tasks, where critical objects were in constant motion, and eye movement planning took into account both where to look (saccades) and whether or when use smooth pursuit. Smooth pursuit provides a compelling, yet often under-appreciated, indication of the strategies used to distribute attention throughout a display of moving objects, as well as the predictions we make about the future motion of objects. This talk will illustrate the role of both attention and prediction in smooth pursuit during dynamic tasks by considering three different phenomena: (1) low-velocity smooth eye movements (micropursuit)

that are found while judging (and attending to) the relative motion of objects headed toward a common meeting point; (2) predictive smooth eye movements prior to impending collisions that do or do not conform to the principles of Newtonian physics; (3) smooth eye movements while pursuing clear or noisy displays of motion with varying levels of predictability. In each case smooth pursuit depended not only on sensory cues to immediate motion, but also on the cognitive aspects of task performance, in particular, the distribution of attention across the display, and the confidence in the beliefs held about the most likely future path of target motion. The findings show that smooth pursuit, like many other motor behaviors, is able to respond to the immediate needs of the dynamic visual tasks by means of inherent connections to the high-level processes involved in selecting and interpreting key portions of the visual display.

Visual Decisions in Natural Action

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Mike Land's ground-breaking work on control of gaze in humans in the context of natural behavior shed light on the way that gaze serves the needs of the current task, and the complex cognitive control mechanisms that are involved. It has become increasingly clear that even the simplest actions involve complex decision processes that depend on an interaction of visual information, knowledge of the current environment, and the intrinsic costs and benefits of actions choices. I will explore these ideas in the context of walking in natural terrain, where we are able to recover the 3D structure of the visual environment. We show that subjects choose flexible paths that depend on the flatness of the terrain over the next few steps. Subjects trade off flatness with straightness of their paths towards the goal, indicating a nuanced trade-off between stability and energetic costs on both the time scale of the next step and longer-range constraints. [Supported by NIH Grant EY05729.]

Open problems in modeling naturalistic sequential behavior

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Mike Land chose a radical approach to studying human behavior directly where it occurs in the context of every-day tasks. By abandoning paradigm-driven experiments and factorial designs his research cannot be reduced to studying feature attention or object attention, perception or motor control, cognitive control or perceptual decision making, intuitive physical reasoning or online control of movements. Instead, his investigations involving planning of action sequences, the visuomotor control of continuous actions, their temporal coordination with gaze shifts as in tea-making acknowledges the intertwined nature of perception, cognition, action, and motor control in goal directed behavior. The challenge this poses to explaining behavior computationally is not only still open but has recently been appreciated anew. First, sequential goal directed behavior under sensory uncertainty, action variability, internal model uncertainty, external and internal costs and benefits is still computationally hard. Secondly, it is still a challenge to provide computational models for questions such as: what is the uncertainty of spilling tea, what is the cost of a gaze shift in driving, and what is the catcher's uncertainty of a bowler's ball throw? These questions extend beyond the "what and where" in vision and are out of reach of current "big data for small tasks" approaches. I will present research addressing some of these questions by computationally integrating ideas and methods from psychophysics, statistical decision theory, intuitive physics, optimal control under uncertainty, and inverse reinforcement learning and by embracing Mike Land's approach of considering perception, cognition, and action jointly.

Online Experimental Methods: Thursday August 26th 2021

Running studies online, before, during and after COVID-19 lockdowns

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For a number of years there has been a migration towards collecting behavioural data in online (web-based) environments. Conducting studies via web browsers presents a number of advantages, such as allowing participant recruitment from harder-to-reach populations and allowing much more rapid data collection than is possible in-person. This migration to online studies has obviously been very much accelerated by the need to socially distance but its advantages mean that it is probably here to stay. Nonetheless, it also presents some new challenges, especially for experiments in visual perception, such as question marks about timing and about screen calibrations. This talk, as an introduction to the rest of the session, will consider some of the changes in technology that make online studies possible, some of the challenges to

running such studies, and some of the solutions that are available or currently under development. [Financial declaration: Open Science Tools Ltd derives revenue from scientists' use of its online hosting service, Pavlovia.org, although this revenue is used entirely to fund further tool development for the community.]

EasyEyes aids online testing by emulating a wireless keyboard and tracking viewing distance

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Online testing is taking off. For vision experiments, web apps achieve good timing by running on the participant's browser, but some pieces are missing. Most experiments need to know viewing distance, yet an initial measurement may become inaccurate as observers lean forward or back. And foveal testing of acuity or crowding demands a long viewing distance, too far to reach a built-in keyboard. EasyEyes can solve these problems for most experimenters and participants. EasyEyes Tracker is an open-source lightweight JavaScript module that tracks viewing distance using the computer's built-in webcam. It uses Google FaceMesh to estimate the interpupillary distance in pixels, and uses the reciprocal relation to provide the experimenter with a real-time estimate of viewing distance in cm. The initial measurement of the interpupillary distance in mm relies on the webcam view of an object of known size (e.g., a USB-A or C connector) held against the face. Tested against a tape measure, the EasyEyes viewing distance is 1% RMS accurate from 15 to 300 cm. The EasyEyes Virtual Keypad turns any smartphone into a peer-to-peer keypad, displaying, in the desired font, just the characters needed for the participant's response. The EasyEyes open-source package of online-testing utilities is available at www.easyeyes.app. [Supported by USA NIH grant 1R01EY027964 to DGP.]

Drawings and crowd-sourced scoring as a readout for visual and mental representations

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When we draw, we depict a rich representation of a percept, memory, or schema. In spite of the abundance of data created by drawings, drawings are rarely used as an output measure, due to concerns about their large variance and their difficult quantification. However, recent work leveraging pen-tracking, computer vision, and online crowd-sourcing has revealed new ways to capture and objectively quantify drawings, to answer a wide range of questions across fields of psychology. For example, drawings and online scoring have revealed impressive detail in visual memory (Bainbridge et al., 2019), have pushed back on classic theories about boundary extension (Bainbridge et al., 2020), and have shown surprising interactions in the visual, spatial and semantic detail in memory (Bainbridge et al., 2021a; 2021b). These studies generally rely on a bipartite experiment structure: 1) having online participants generate drawings of real-world images during both memory and perception, and 2) crowd-sourced scoring of these drawings on features such as object details, spatial information, and false memories. The combination of these methods allows for a rapid, large-scale quantification of the details in a drawing, and more broadly, a mental representation of an image. Here, I make these methods broadly available with a new open code base to support other researchers' investigations with drawings. I discuss how these new methods can be used to design fully closed-loop online drawing experiments to test vision and memory. I also discuss key methodological points of consideration, and provide a series of potential jumping points for new studies.

Home visual acuity assessment using the FrACT10

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The Covid-19 pandemic has quickened the digitalization processes of services and products, changing the behavior of people, who are now more likely to use the online tools available today. Also in the field of optometry and ocular health, there is an increased interest of people and vision professionals for online services. Among these, there may also be the possibility of providing some visual examinations, which must nevertheless take place in standardized and well-controlled circumstances. In the present study, the results of a visual acuity measurement obtained in the laboratory were compared with those collected with the FrACT10 (Bach, 1996), an online test that has proven to be usable in the literature, as well as precise and accurate. On a sample consisting of 23 optometry students, the validity of the self-administered test at home was assessed through this comparison. Subjects were provided with a questionnaire containing all the instructions necessary to measure visual acuity with the best possible precision. The same sample repeated the test during the day to estimate the repeatability of the results. The outcomes of the study reveal sufficient concordance between the

measurements in the laboratory and those carried out at home by the subjects of our sample and a good repeatability of the measurements. Our results indicate that FrACT10 may be a valid screening tool, but it is necessary to assess whether this precision and accuracy of the measurements can also be obtained by people without training in optometry and of various ages. [The authors have no conflicts of interest to declare.]

Is it necessary to gamma-correct screens for online colour vision experiments?

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The current pandemic has refocused the interest of many vision researchers towards conducting online experiments, where the viewing conditions are much less controlled than in traditional lab-based experiments. In the case of colour vision or colour perception research there is the extra burden of calibrating the screen to recover the approximate colours that the online subject actually saw. This screen calibration is usually done by the subject itself, using an array of protocols that include matching half-tone patterns to obtain the gamma characterization of the screen. This halt-tone matching protocol is sometimes fiddly and difficult to perform for untrained subjects that often make mistakes, which in most cases, remain undetected. We addressed this problem by asking our subjects to perform a simple colour matching experiment, preceded by a gamma-correction procedure based on half-tone pattern matching. Using these results and with the help of a colorimeter, we estimated whether it was worthy to burden the subjects with this extra work as opposed to just assuming a standard gamma value of 2.2 for all the measures. We evaluated the results' variability obtained with both, the half-tone calibration and the standard value and found that asking subjects to gamma-correct their screen by themselves did not improve on the results (and sometimes quite the opposite). The reason might be that small mistakes made by untrained/naïve observers during the gamma-correction protocol are likely to introduce an error larger than that introduced by just avoiding the process altogether. [D.J. and C.M were funded respectively by a Doc.CH fellowship grant P0LAP1_175055 and grant 100014_182138 from the Swiss National Science Foundation; C.A.P was funded by grant DPI2017-89867-C2-1-R from the Spanish Ministry of Science and Innovation.]

Talk Sessions

Monday August 23rd

Talk Session 1: Perception & Action

The role of readiness potential in motor-induced suppression of vision

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Motor-induced suppression is a consequence of voluntary actions (e.g., saccades, speech, etc.) that inhibit the subsequent processing of visual stimuli. Here, we explore the possibility that this suppression effect involves sensorimotor prediction mechanisms present in the readiness potential, a slow negative fronto-central EEG potential starting about 1 s before executing a voluntary action. We recorded EEG activity on 18 human volunteers and estimated motor-induced visual suppression in a spatial frequency discrimination task. Participants made a voluntary keypress, followed by a grating, presented randomly at 18 different delays, from 16 to 800 ms. As expected, visual accuracy around the time of keypress (<150 ms) is reduced by about 5% compared to accuracy for stimuli presented long after the button-press (>600 ms), suggesting motor-induced visual suppression. The magnitude of the readiness potential is correlated with perceptual accuracy of the stimuli presented near keypress over trials, and correlates across individuals with the magnitude of visual suppression between participants. The amplitude of the readiness potential, estimated in a separate experiment without visual stimulation, is also correlated with the motor-induced suppression effect. Together, these correlations suggest that the predictive signal from the (pre-)motor to the sensory brain areas is mediated by the readiness potential. [This project was supported by the European Research Council (ERC) under the European Union's Horizon 2020 program (Grant Agreement No 832813-GENPERCEPT) and by MIUR - PRIN 2017 - grant 2017SBCPZY_02.]

Predictions of visual fixations in a visual noise perception task

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Producing a very high-quality computer-generated image (CGI), termed photorealistic, involves lighting simulations that require significant computing power. The CGI algorithms induce some visual noise, which varies inversely with the number of iterations. A major issue is to automatically decide when to stop the image computation without a detectable loss of visual quality to optimize computing time. We conducted a 2-task experiment using 8 scenes at various stages of computation (i.e. with various noise levels). We first quantified the perceptual threshold in a 2AFC task by asking observers whether they detect some visual noise. Eye movements were then recorded while observers performed the same 2AFC task with stimuli at 50% threshold. A first group (n=11) participated in 5 sessions with 5 scenes from indoor and outdoor space. The second group (n=11) participated in the same study but with 4 variations of the same indoor scene. We manipulated some of the textures of the image without changing the global image structure. We constructed fixation maps to quantify the visual exploration of the scenes. These maps were then compared to noise maps and Graph-Based Visual Saliency maps computed over the visual noise to assess whether the fixation of visible noisy parts of a scene might be predicted. Results indicated that the noise saliency maps provide the closest prediction to the actual fixation maps. They also revealed regions where some visual noise is present but has not been fixated as participants explored mostly diagnostic regions where the visual noise is more easily detectable. [Funding from ANR grant ANR-17-CE38-0009.]

The critical temporal delay between gaze shift and visual feedback for maintaining a sense of agency – Gaze-contingent multiresolutional display study

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Gaze-based human-computer interaction has recently begun utilizing gaze-contingent multiresolutional displays, which render high-resolution images in the human viewer's central vision area and low resolution in their peripheral area. However, temporal delays between gaze shifts and multiresolutional display updates are unavoidable. The critical temporal delay that allows for practical applications while maintaining a good user experience remains unknown. While the sense of agency (SOA) toward own hand movements have been thoroughly investigated, to the best of our knowledge this study is the first to show SOA's temporal property at own eye movements. To determine the critical temporal delay for maintaining gaze agency, we performed a simple visual search for Chinese characters with gaze-contingent foveated window. The relative temporal delay between the single-letter-sized window and eye movement varied from 0 to 4000 ms. A recorded gaze behaviour condition was also conducted as a control. Self-reported SOA scores and calculated controllability scores of the window decreased as the temporal delay increased. SOA was lowest above 200 ms of temporal delay. Distribution of the fixation duration differed between that of more and less than 200 ms. These results indicate the potential Influences of attenuating SOA on fixation duration as well as some relevant processes. The results of this study are consistent with previously reported SOA time courses using hand movements, suggesting that the underlying mechanism can be similar. Furthermore, the results suggest that temporal delay should be kept within 200 ms to maintain the user's SOA and controllability when eye-gaze input devices are designed.

Age-related changes to online control of reaching may be due to longer saccade latencies

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Effective goal directed hand movements rely on integration of visual and proprioceptive feedback during online control, and coordination of eye and hand movements. There are notable changes to both visual processing and motor control with healthy ageing, including longer saccade latencies (Munoz, Broughton, Goldring and Armstrong, 1998), and longer reach durations (Seidler et al., 2010). Since age-related changes to visual and motor performance are typically studied independently it is not well understood how these changes affect eye-hand coordination for goal directed movements, especially during online control. We used a target perturbation paradigm, where changes in the target location could occur at different times during the reach, to investigate how healthy ageing impacts eye-hand coordination during online control. We quantified eye and hand movements across all stages of the movement and analysed how quickly and how frequently younger and older participants responded to the change in target location. Our results show that older participants were slower to initiate a correction and did so less frequently compared to younger participants. Older participants' saccade latencies were also slower. For both groups, touch responses were more accurate when there was more time between the saccade landing and the touch. We argue that increased saccade latencies may delay the availability of visual feedback during movement and therefore lead to age-related

changes in online control. [This work was supported by an Australian Goverment and Research Training Program Scholarship to JLO.]

Grasping objects held by the hand or by a tool: do haptics and tools supplement vision in equivalent ways?

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Haptic inputs from the hand holding an object complement visual inputs by providing object's positional and size information and improve grasping movements. However, distal objects can be successfully localized also via handheld tools. Here we investigated whether object features sensed with a tool (a grabber) can enhance contralateral hand grasping to the same extent as in multisensory grasping in which the hand is in direct contact with the object. We replicated our previous findings that multisensory guided actions show smaller grip apertures and are faster than visually guided actions. Importantly, we found that tool-guided actions exhibited the same grip aperture reduction as actions toward objects we hold with the hand, but no boost in velocity. We excluded that the grip aperture reduction effect was due to the force exerted on the tool's handle by contrasting tool-guided grasping with or without enclosing the object with the grabber. Furthermore, we also manipulated which object features were available via the tool (position and size versus position only) and observed that action performance was not hindered by the absence of size information. In sum, tools can be effectively used as sensing devices to improve object localization and guide contralateral hand movements. However, the lack of haptic on-line control might explain why contacting the object with a tool only partially mimics the multisensory grasping performance achieved with direct hand-to-object contact.

Computer cursor orientation affects both pointing behaviour and the sense of agency in a target pointing task

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The sense of agency is the feeling of authorship over our own actions. This can extend to tool use, including the feeling that we are in control of a virtual tool, such as a computer mouse cursor, when we move the physical mouse. This study investigates how familiarity with the shape and orientation of the tool affects behaviour and these feelings of agency. Participants performed a target-pointing task where they moved the cursor to click targets at 8 different locations as quickly as possible. The cursor was either an arrow or hand shape of varying rotations (45°, 135°, 225°, and 315°). After a set of 8 trials, during which the shape and orientation of the cursor stayed constant, participants answered questions on the level of agency they felt over the movement and how natural the cursor felt. This was repeated for all cursor types and rotations in blocks, with each block repeated a total of 5 times. Results show that both the agency and naturalness ratings were highest when the cursor orientation was the most familiar 45° (pointing top left). This was particularly the case for the more common arrow cursor. Movement completion times were also significantly faster for this familiar cursor orientation for both cursor shapes. Across cursor orientations movement paths to the target were longer, with greater curvature, for targets orthogonal to cursor orientation. These results show that even in a simple pointing task, cursor appearance and familiarity affects both pointing behaviour and the feeling of agency.

Talk Session 2: Computational & Neural Mechanisms

How endogenous and exogenous attention differ: A model of visual perception

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[Goal] Endogenous and exogenous attention differentially alter visual perception. However, current models of attention do not distinguish between their effects. Here, we use their distinct effects on texture segmentation as a model system to characterize their underlying computations. [Approach] We developed an image-computable model that simulates responses from a collection of receptive fields, each tuned to orientation and spatial frequency (SF) at each position in an image. SF and eccentricity-dependent gain account for variations in spatial resolution. Divisive normalization and spatial summation facilitate texture segmentation. Attentional gain factors scale sensory responses before normalization, following the Reynolds-Heeger normalization model of attention (Reynolds & Heeger, 2009). To dissociate endogenous and exogenous attention, we tested attention gain models that

differed in their SF selectivity. The broad SF model uniformly enhances a wide SF range whereas the narrow SF model preferentially boosts a smaller range. [Results] The model captured signatures of segmentation and attention across ten experiments. 1) The parafoveal advantage in segmentation. 2) The narrow SF model predicted the peripheral improvements and foveal impairments induced by exogenous attention. 3) The broad SF model predicted the uniform benefits by endogenous attention. Model predictions generalized to attentional effects on tasks mediated by acuity and contrast sensitivity. [Conclusion] We present a model of attention that flexibly reproduces behavior across texture segmentation, acuity and contrast sensitivity tasks. At the model's core, endogenous and exogenous attention differentially alter SF sensitivity. Overall, we unveil a computational dissociation between each attention type that underlies their effects on visual perception. [Funded by NIH National Eye Institute R01 EY019693 to MC.]

Bayesian modelling of suppression favours contrast gain over response gain control

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Suppression is a ubiquitous neural process, which in the visual system occurs between neurons representing different stimulus features, such as orientation, spatial location and eye of origin. Single-unit studies have provided mixed evidence for the mechanism by which suppression impacts, with some pathways being more consistent with a contrast gain change (a horizontal shift in the input-response function), and others with a response gain change (a vertical scaling of the function). This is consistent with suppression involving different neural circuits for different mask types. Here we asked whether steady-state electroencephalography can distinguish these mechanisms by using a Bayesian modelling framework to estimate posterior probabilities for contrast and response gain parameters. We first re-analysed data from 16 published studies in a computational meta-analysis that divided studies by stimulus type. When target and mask stimuli were superimposed (overlay masking), data were consistent with a contrast gain effect, whereas the results for dichoptic and surround stimuli were inconclusive. We then conducted two new experiments to directly compare the effects of four types of mask (overlay, dichoptic, aligned surround and orthogonal surround) in suppressing a target stimulus flickering at 5Hz. At the occipital pole, there was strong evidence for contrast gain effects from all four mask types at the flicker frequency (5Hz). Suppression generally became stronger at more lateral electrode sites, but there was little evidence of response gain effects. Suppression was generally stronger at the second harmonic frequency (10Hz), and involved both contrast and response gain effects. [Supported by the Royal Society, grant number RG130121.]

Neural Encoding Variation as an explanation for Weber's Law

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The just-noticeable difference between two stimuli with contrasts C and C+dC often follows Weber's Law, where dC is proportional to C. Weber's Law is commonly explained by a logarithmic neural response plus internal noise. Here we suggest that Weber's Law arises because a stimulus of fixed intensity can be encoded in many ways by a population of neurons. A stimulus of intensity C generates a set of neural activations, which can be imagined as a point in multidimensional "brain space". Repeated stimulus presentations yield different points in brain space, even without noise, because the stimulus position is not precisely repeatable. A stimulus with intensity C is thus represented by a "cloud" of points in brain space; similarly, a stimulus with intensity C+dC is represented by a different cloud of points. The extent these clouds overlap (defined as the fraction of points that could belong to either cloud) determines our ability to distinguish them. At threshold dC, the clouds overlap so much that we can only successfully discriminate them say, 75% of the time. Under weak assumptions, if we scale the intensities to kC and kC+kdC, the overlap between the two scaled clouds is unchanged, and so our ability to discriminate them is also unchanged. Thus the threshold difference dC is proportional to C. This model for Weber's Law is illustrated using a sparse-coding model for V1, with a variety of discrimination algorithms used to quantify point-cloud overlap.

Evidence for transducer nonlinearity in the perception of global form

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Weber's law states that an observer's threshold for detecting changes in a stimulus is a fixed proportion of the underlying stimulus intensity. Decades of psychophysical experiments have shown that the perception of luminance contrast violates Weber's law at very low intensities: contrast discrimination thresholds are lowest at small (but non-zero) pedestals. This so-called 'dipper function' is thought to be due to an accelerating nonlinearity in the transducer function of neurons that represent contrast. Here, we asked whether the sensitivity to global pattern

stimuli (Glass patterns) detected by mid-level visual processing areas exhibits a similar input-output relationship, and whether the shape of this relationship depends on the axis along which a pattern is aligned. We parameterised 'coherence' - the global alignment of centrally presented Glass pattern dipoles in a circular field subtending 10° of visual angle. Over a range of coherence levels, and 3 alignment axes (translational, radial, & concentric), we measured psychophysical discrimination/detection thresholds to static Glass patterns and steady-state EEG responses to dynamic Glass patterns. Our psychophysical detection and discrimination thresholds violate Weber's law, showing a pattern of sensitivity resembling the dipper-function found in lower-level visual perception. Likewise, our EEG results show a pattern of responses consistent with the presence of a nonlinear transducer. Our findings indicate that mid-level visual processing is mediated by a set of global pattern detectors with a sigmoidal input-output function suggesting that neuronal transducer functions are similar across the visual system.

Perceptual Grouping and Selection Strategies in a Letter Discrimination Task

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Although perceptual grouping and selection have been widely studied, their mechanisms remain poorly understood. Building on previous work (Francis et al., 2017; Grossberg & Raizada, 2000) we propose neural circuits for visual perception that have these properties. The circuits connect neural representations of visual elements and enable their selection in a way that promotes performance. Through top-down control of these circuits, the model implements a grouping strategy, i.e., a connection strategy (which elements to connect) and a selection strategy (spatiotemporal properties of selection signals). Here, we apply the model to a letter discrimination task (Han et al., 1999) that investigated relationships among uniform connectedness and grouping by proximity and shape similarity. The task was to determine whether a set of spatially separated circles formed the global shape of a letter E or H. Across different stimulus conditions, the circles were sometimes connected by a line and were sometimes embedded within a matrix of squares. According to the model, a good grouping strategy for this task consists of a connection strategy that connects circles but not squares for all conditions and a selection strategy that uses a selection signal of varying size, depending on whether squares were present. Consistent with the response times found by Han et al. (and verified in a replication study), the model is slower with distractor squares, and line connectors improve performance only in the condition with squares. In general, the data in Han et al. are consistent with the proposed neural mechanisms for grouping and selection.

What just happend? Using a volatile Kalman filter to predict perceptual history biases

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It is well-established that perceptual choices can be biased by preceding responses --- a phenomenon known as serial dependency. Previous work has described serial dependencies in terms of low-level perceptual adaptation effects, as well as prior expectations. It has been argued that prior expectations reflect an adaptive inference mechanism to natural environments with an autocorrelated temporal structure and only appear maladaptive in artificial experimental settings. Here, we investigate potential mechanisms underlying the emergence of local transient priors in entirely unpredictable environments. Specifically, we hypothesize that trial-wise fluctuations in expected volatility increase the precision of prior beliefs and thereby cause periods of increased influence of past choices on current decisions. Fitting a volatile Kalman filter to behavioral responses enables us to track these trial-wise statistics and link them to individual history biases. Based on the data of a visual perceptual discrimination experiment, we show that model estimates of prior strength, volatility and uncertainty indeed predict trial-wise accuracy and choice repetition. Moreover, we find that estimated uncertainty correlates with subjects' reaction times and pupil dilation at response time --- both of which have previously been associated with the strength of history dependence. We conclude that a hierarchical volatile Kalman filter model provides a good fit to serial dependency biases in perceptual decision making. In particular, we argue that serial dependencies are partially explained by interactions between prior predictions and volatility.

Talk Session 3: Ageing & Development

Age-Related Inter- and Intra-Hemispheric Neural Changes in Visuo-Spatial Working Memory

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According to the Hemispheric Asymmetry Reduction in Older Adults (HAROLD) and the Posterior-Anterior Shift

in Aging (PASA), two influential models of neurocognitive aging, elderly tend to recruit supplementary brain areas (bilateral as proposed by HAROLD, anterior as proposed by PASA) while performing different cognitive tasks. We tested whether these two models could explain the age-related differences observed in the EEG responses to a task commonly used to assess visuo-spatial working memory (vWM), whose capacity significantly decreases with increasing age. Young and older adults performed a lateralized delayed match-to-sample task with different memory loads. At the behavioral level, overall older adults exhibited a reduction in vWM capacity. In line with both HAROLD and PASA hypotheses, data-driven whole scalp EEG analysis revealed how the elderly engaged additional bilateral posterior and frontal sites when processing the different memory loads. However, the supplementary recruitment of these areas did not act as a compensatory mechanism, since it did not support the behavioral performance of the elderly. Indeed, the pattern of behavioral and EEG data better calls for a dedifferentiation view: the supplementary recruitment of cortical areas exhibited by the elderly might result in a loss of selectivity of brain responses. This reduced neural differentiation can lead to a decrease in older adults' performance. [Funded by Fondazione Cassa Di Risparmio Di Trento E Rovereto (CARITRO).]

The role of context in facial expression perception in healthy ageing

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Context is important in facial expression perception. For instance, it is well established that perceiving a facial expression in the context of an affective body posture biases face perception toward the emotion conveyed by the body. This effect is stronger in older compared to younger adults, a finding that has been explained by an increase in integrative processing with age: older people make more use of contextual cues due to increased social expertise. However, given that facial expression recognition is known to deteriorate with age, an alternative interpretation might be that older adults rely more on body posture in order to compensate for their decreasing abilities in facial expression perception. In order to adjudicate between these two hypotheses, we characterised the reliability of isolated facial expression and body posture representations, and the influence of body on facial expression perception, across the adult lifespan (18- 80 years old) in a large online sample. As expected, we found that facial expression recognition decreases with age. Critically, we also find that this change closely relates to an increased influence of body posture on facial expression perception. These findings conflict with previous suggestions that increased social expertise underpins greater reliance on contextual cues in older adults. Rather we suggest that the reliance on body context might be a compensatory mechanism. These findings have important implications for our understanding of the influence of contextual cues during healthy ageing.

Sense of positive and negative numbers in visually impaired children

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Several pieces of evidence have shown that the absence of visual feedback (blindness) or visual impoverishment (low vision) from an early age can compromise the development of spatial abilities, such as the ability to perceive different auditory stimuli in depth. Since it has been hypothesized that the numerical and the spatial domains are strictly related, in the present work, we investigated whether complete or partial vision loss from birth can alter numerical estimation other than specific spatial abilities. We enrolled 21 visually impaired children (13 low vision, 8 blind, age range 6-15 years) and age-matched sighted controls and asked them to perform a haptic number line task, requiring them to indicate the spatial position of positive and negative numbers on a tactile bar positioned in the horizontal or vertical plane. Results suggest that both low vision and blind children performed worse than sighted controls only when asked to represent negative numbers, suggesting that visual experience might be necessary for this specific numerical estimation task. Moreover, results indicate that the spatial dimension (horizontal vs. vertical) does not affect overall performance in all vision groups, suggesting that the mental number line is not strictly related to a specific spatial dimension. Overall, such findings are not in contrast with studies showing preserved numerical abilities in the blind population because such studies assessed numerosity in adult individuals and mainly for positive numbers. The outcomes of this study stress the need to implement early rehabilitation strategies to overcome possible perceptual impairments in visually impaired children. [The research is the results of MYSpace project, which has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement No 948349) and received support from the Joint-Lab funded by Unit for Visually Impaired People, Istituto Italiano di Tecnologia (Genoa, Italy) in partnership with Center of Child Neuro-Ophthalmology IRCCS Mondino Foundation (Pavia, Italy).]

Visual object categorization in infancy reflects the organization of the adult visual cortex

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What are the first object categories that emerge in infancy? We investigated whether visual object categorization in infancy matches the organization of the adults' visual cortex, representing categorical distinctions such as animate/inanimate, human/nonhuman, face-body, big-small real-world size, and natural-artificial. Using eye-tracking, we measured the differential looking time (DLT) of 4-, 10- and 19-month-olds (N=97), as they looked at pairs of pictures belonging to eight animate and inanimate categories (human/nonhuman faces/bodies and big/small natural/artificial objects). Taking DLT as a measure of perceptual (dis) similarity, we defined representational dissimilarity matrices (RDMs), where each object was defined in relation to others of the same or different categories. RDMs for the same categories were created based on the dis(similarity) between neural activity patterns recorded for the same images, from various sectors of the adults' visual cortex (N=15), using fMRI. DLT-RDMs and fMRI-RDMs were compared through representational similarity analysis. Four-month-olds' could categorize objects by animacy; their behavior correlated with the representational structure in the most anterior aspects of the adults' visual cortex, but only when image size was controlled for. Otherwise, they looked at the larger of two images, a behavior that did not match any representational space along the visual cortex. Other categories emerged from the infants' looking behavior between 10 and 19 months. As visual categories multiply, infants' looking behavior matched neural representation in ever-larger portions of the adult visual cortex, suggesting progressive recruitment and integration of more and more feature spaces distributed over the visual cortex.

The Critical Role of GABA in Stabilizing Visual Perceptual Learning in Children

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Visual perceptual learning (VPL) can be defined as a long-term performance enhancement as a result of visual experience or training. Although mechanisms involved in VPL have been intensely studied in adults, it has remained unclear whether these mechanisms remain stable across the life span. In this study, we investigated whether mechanisms that stabilize VPL after training ends differ between children (7 – 11 years old) and adults (18 – 30 years old) using psychophysics and magnetic resonance spectroscopy (MRS). Participants (n = 14 for each age group) trained on a two-interval forced choice orientation detection task using two different orientations in separate training blocks. There was a 1h-interval between training blocks during which time participants rested. We found that children exhibited VPL for both trained orientations, whereas adults exhibited VPL only for the second trained orientation. This indicates that VPL of the second trained orientation retrogradely interfered with the stabilization of VPL of the first trained orientation in adults whereas no retrograde interference occurred in children. In a second experiment we measured neurochemical changes in visual cortex involved in stabilizing VPL in new groups of participants (n = 13 children, n = 14 adults) using MRS. We found that children exhibited increased inhibitory processing involving the chief inhibitory neurotransmitter GABA after training ended, whereas no such dynamics occurred in adults. These results indicate that GABA contributes to stabilizing VPL in children by inhibiting interfering processing in visual cortex immediately after training ends, whereas VPL in adults initially is more fragile. [Fred M. Seed Foundation, United States – Israel Binational Science Foundation BSF2016058.]

How the lack of vision affects the development of alpha activity in the earliest stages of life

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The visual input is fundamental to develop neural activity underlying our space representation. Vision is associated with the maturation of alpha EEG activity. Indeed, no alpha activity is present in blind adults. However, it is still unclear when, during the development, alpha activity diverges between sighted and blind individuals. To explore that, here we measure alpha activity during earliest stages of life in blind and sighted subjects. We hypothesize that the difference in neural activity of blind compared to control group is: absent at birth, progressive with age, specifically occipital and linked to a gradual motor dysfunction. We consider spectral power of resting-state EEG and its association with motor dysfunction indices, in blind subjects and in sighted controls between 0 and 11 years of age. Blind subjects show posterior alpha activity during the first three years of life, although weaker and slower maturation compared to sighted subjects. Although a

difference is already evident in the earliest period of life, the first great differentiation between groups occurs between 3 - 6 years of age. Starting from this period, reduced alpha activity increases the probability of motor dysfunctions in blind subjects, likely because of impaired perception and interaction with the environment. These results show that visual experience mediates the neural mechanisms underlying alpha activity during the earliest phase of life, suggesting that this is a sensitive period for the plasticity of this process. We discuss the results in association with new multisensory integration data and MRI structural changes measured in blind and sighted infants. [The research is the results of MYSpace project, which has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement No 948349).]

Talk Session 4: Attention I (Cueing)

Using attentional modulation of the pupillary light response to examine different accounts of object-based attention

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Observers react faster when a precue appears on the same object as the target than when the precue appears at the same distance on a different object. 'Attentional shifting' is one account of such object-based effects, which underscores the higher cost of shifting attention between objects than within an object. 'Attentional spreading' is another account, which proposes that object-based effects arise due to spreading of attention along the object. We used attentional modulations of the pupillary light response (PLR) to test these accounts in two series of experiments. To test the spreading account, we employed objects composed of white-to-gray and black-to-gray luminance gradients. If attention indeed spreads along the objects, a difference in pupil size should arise when the gray ends of the different types of objects are cued. To test the shifting account, we displayed a single object that could be black or white. A precue appeared at one end of the object or in a location outside the object, and a target followed at the same location or in a different location – inside or outside the object. If disengaging attention from a location inside the object is indeed slower, then changes in pupil size should start later when the precue appears inside the object and the target appears outside the object. We found evidence for the attentional shifting account; changes in the PLR were observed later when the attentional shift involved disengaging from an object. In contrast, no evidence for involuntary spreading of attention was observed. [This study was supported by the German-Israeli Foundation for Scientific Research and Development (GIF) Grant I-1418-105.4/2017.]

Many studies of object-based attention seem "too good to be true"

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Many cognitive and neurophysiological theories of perception suppose that people can focus attention on objects. Indeed, a small object-based attention effect has been demonstrated in many studies over the past thirty years. In a new large sample (n=264) study, we find that there is a small (14 ms) object-based attention effect, but that commonly used sample sizes are much too small to reliably detect it. A power analysis based on our empirical findings indicates that future studies of object-based attention that desire 90% power need sample sizes of at least n=324. Surprisingly, the object-based attention effect has been consistently found with studies having much smaller sample sizes (around n=20). Such studies have a power of around 15%, so simply due to random sampling, they should often fail to show the effect. The absence of experimental failures in a set of studies suggests publication bias or the use of questionable research practices, and implies that the reported findings may not represent reality. We formally investigated this issue with a Test for Excess Success (TES) analysis for 37 articles related to object-based attention that have four or more experiments. The TES analysis estimates the probability that a direct replication of the studies reported in a given article with the same sample sizes would have the same success (or better) as the original report. Our analysis suggests that 19 (51%) of these multi-study investigations seem "too good to be true", thereby casting doubt on the validity of those investigations' conclusions.

A Feed-Forward Convolutional Neural Network Learns to Covertly Attend like Humans to Cues and Context

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Introduction: Attentional effects on perceptual performance, once thought to be exclusive to primates, have been more recently measured in simpler organisms such

as dragonflies and honeybees (Nityananda 2016). What are biologically plausible computations that allow these simpler organisms to learn the statistical relationships between cues and target from visual input? We assess whether a simple Convolutional Neural Network (CNN) trained to detect a target among distractors implicitly learns to utilize a predictive cue and gives rise to three classic human results in the attention literature: Posner cueing paradigm, set-size effects in visual search, and contextual cueing. We benchmark the CNN against a Bayesian Ideal Observer (BIO) and compare the results to six human observers. Methods: We trained a CNN on 6000 noisy images with two convolution layers, each followed by max-pooling, followed by two dense layers and an output layer. We evaluated human, BIO, and CNN performance for a Posner cueing task with varying contrast of a peripheral box cue, visual search with varying cued locations (set size =1,2,4,8), and contextual cueing. Results: The CNN trained to optimally detect the target learns the predictive cues and context, resulting in cueing effects for all three tasks. With one fitting parameter that adjusted the external noise, the CNN and BIO could fit human performance. Conclusion: Our results suggest how a simple neural network can learn to utilize cues and context in a similar manner as humans and Bayesian Optimal Models. The findings might help explain how simple organisms learn to attend.

Spatial spread of visual attention on a uniform random-dot field with and without border

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Visual attention plays a key role in selecting important information from the large amount of visual inputs. Spatial location and/or objects may serve as the units of attentional selection. Here, we studied the spatial spread of visual attention on a uniform random-dot field while manipulating object segmentation via changes in borders. The stimulus was a random-dot pattern divided into eight sectors flickering with different temporal frequencies, thereby eliciting distinct steady-state visual evoked potentials (SSVEPs), which, together with recordings of target elicited event-related potentials (ERPs), allowed us to quantify the spread of attention. The sectors were directly adjacent and appeared to be uniform to observers, providing no salient cues for object segmentation. In some conditions, red borders were attached to the edges of adjacent sectors to group those sectors together. Participants' task was to detect infrequent target shapes ('H') embedded in rapid serial visual presentations (RSVP) of letter-like shapes constructed by 3*3 squares to form H, 90-degree-turned-H, U, N, C, and mirror-C shapes, respectively. Results showed that attentional selection as measured by SSVEPs was wider in the 'border' condition than in the 'no border' condition while the opposite pattern was observed for ERPs. These results suggest that the spread of visual attention is more broad and less constrained by object boundaries at early stages of visual processing than at later stages.

Dissociable neural mechanisms of selective visual information processing underlie the effects of attention on visual appearance and response bias

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There has been a long debate about whether attention can alter visual appearance or whether it just induces response bias. Recently, research studies have provided psychophysical evidence for both theoretical accounts, yet it is unclear how the effects of attention on stimulus appearance and response bias are implemented in the brain. Here, we found that these two effects of attention are associated with different patterns of attentional modulations on different EEG markers of visual information processing. While attention enhanced the multiplicative response gain of the early visually evoked potential (i.e., the P1 component), it induced the baseline shift in alpha amplitude. Quantitative linking models revealed that the response gain amplification of the P1 component could account for attention-induced changes in the psychometric parameter indexing contrast appearance. In contrast, models that included the baseline shift in the alpha amplitude performed better at predicting attention-induced changes in response bias indexed by the baseline offset of the psychometric data and the lateralized readiness potential. Together, our findings suggest that attention can bias both early sensory information and later stages of motor-related processes. Importantly, the effects of attention on contrast appearance and response bias are supported by modulations of different electrophysiological markers

that track different stages of visual information processing in the human cortex [No conflicts of interest. Funding was provided by NEI R01 and a James S. McDonnell Foundation award to John T Serences. This project was also funded by the National Research Council of Thailand grant (fiscal year 2021), the Thailand Science Research and Innovation Basic Research grant (fiscal year 2021 under project numbers 64A306000016 and fiscal year 2020 under project number 62W1501), the Asahi Glass Foundation grant, the research grant from the Research & Innovation for Sustainability Center, Magnolia Quality Development Corporation Limited, Thailand, the KMUTT Partnering initiative grant (fiscal year 2021), and the startup fund for junior researchers at King Mongkut's University of Technology Thonburi (KMUTT), and the KMUTT's Frontier Research Unit Grant for Neuroscience Center for Research and Innovation to Sirawaj Itthipuripat.]

Context-based prediction and neural variability

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Contextual cueing describes the phenomenon that an implicitly remembered, invariant (vs. random) layout of distractors facilitates visual search by cueing attention to, or predicting, the target location. Once a specific distractor-target configuration has been learned, relocating the target within the same distractor layout abolishes any contextual-cueing effects. Relearning this novel target position is much more difficult than during the initial learning phase – likely due to consistent attentional misguidance towards the previous (learned) target position. While previous research has explored the effects of memory-guided attention on lateralized evoked potentials (Zinchenko et al., 2020), here we studied how the different processes involved in contextual cueing and relearning affect the variability of neural responses, as measured with EEG (N = 30). Spatial attention has previously been shown to reduce trial-by-trial variability in a lateralized manner (Arazi et al., 2019), indicating that attention may reduce the noise within the neural response in addition to increasing the neural signal associated with attended stimuli. While context (invariant vs. random) did not modulate the trial-by-trial variability during the learning phase, significant, lateralized variability reductions were observed during the relocation phase for previously encountered distractor layouts, but not for novel ones. Attentional modulation of neural variability thus does not simply arise from the same mechanisms as lateralized evoked potentials, signifying the spatial allocation of attention. Instead, they may reflect separate neural mechanisms that are only observed when additional demand is placed on the subject, such as when the misguidance through memory-guided attentional signals needs to be overcome. [This work was supported by Deutsche Forschungsgemeinschaft Grants GE 1889/4-1 and GE 1889/4-2.]

Talk Session 5: Illusions

What is the source of the perceptual error in the double-drift illusion?

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The double-drift illusion is a remarkably strong illusion that dissociates the perceived position of a Gabor from its physical position by more than a degree of visual angle. This is achieved by making the Gabor's grating move in a direction that is not its envelope's motion direction. If the Gabor is in the periphery, the two conflicting motion directions are combined into an illusory motion direction resulting in an accumulation of positional errors over time. However, because of the effect of the Gabor's aperture on the carrier when only a few bars are visible, the brightest (or darkest) point of the Gabor actually moves in the illusory direction. Does the illusion stem from a low-level motion response to this signal or is it caused by a combination of the two motion vectors? We extended the double-drift illusion to a type 2 plaid with external motion, pitting the two hypotheses directly against each other. In a type 2 plaid there are two component motions (for example 0° and 45°) that are different from the motion of the pattern and the brightest point (in the example above that would be -35°). By adding external motion along the 0° component, the resulting illusion could be a combination of the external motion and either the other component motion or the pattern motion. We found component motion to dominate the percept, suggesting that vector combination is more likely than a low-level motion response to the motion of the brightest point. [This material is based upon work supported by the National Science Foundation under Grant # 1632738. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.]

Seeing things that aren't there: investigating non-retinal (phantom) vision in aphantasia (no visual imagery)

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Why do we see things when our retinae are not stimulated (i.e. non-retinal vision)? and why are some of us more prone to seeing these things than others? Here we assess how individual differences in voluntary visual imagery

correlate with the experience of other non-veridical phantom visual experiences (specifically visual illusions) through investigating a special population who have no visual imagery (aphantasia). In our first study we presented aphantasic individuals (N = 16) with seven different visual illusions (Hermann grid, Ponzo illusion, Kanizsa triangles, Ebbinghaus illusion, watercolour effect, neon colour spreading and rotating snakes). Compared to both a large group of undergraduate students (N = 169) and an age matched sample (N =16), the only illusion in which aphantasic individuals showed a consistent significant reduction in was the neon colour illusion. In a large online follow up study we used the method of adjustment to obtain an objective measure of the strength of the neon colour illusion in aphantasic individuals compared to those with visual imagery. We found that this objective measure of neon colour in aphantasic individuals was lower than those with visual imagery, as was their subjective ratings of the illusion. Importantly there was no difference in either the objective strength or subjective ratings between the two groups when viewing a catch/mock neon colour 'illusion'. Taken together these data provide evidence that individuals with aphantasia experience less vivid neon colour illusions, highlighting a potential link between two forms of non-veridical perception (neon colour illusion and voluntary visual imagery).

The long and short of it? A novel geometric illusion

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Here we present what we believe to be a novel geometric illusion where identical lines are perceived as being of differing length. Participants were asked to report which of two parallel rows of horizontal lines contained the longer individual lines (2 lines on one row and 15 on the other). Using an adaptive staircase we adjusted the length of the lines on the row containing 2 to estimate the point of subjective equality (PSE). At the PSE the 2 lines were consistently shorter than the row containing the fixed length 15 lines demonstrating a disparity in perceived length such that lines of identical length are perceived as longer in a row of 2 than in a row of 15. The illusion magnitude was unaffected by which row was presented above the other. Additionally, when the line stimuli on both rows were presented in alternating polarity the illusion magnitude decreased but was not abolished. The data indicate a robust geometric illusion that may be modulated by perceptual grouping processes. [Australian Research Council - DP190100491.]

Negative Affect Impedes Perceptual Filling-in in the Uniformity Illusion

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The notion of cognitive penetrability, i.e., whether the contents of perception can in principle be influenced by non-perceptual factors such as onés mood, has sparked a significant debate over methodological concerns and the correct interpretation of numerous existing findings on this topic. In this study, we combined predictive processing models of visual perception as well as of affective states to investigate potential influences of affective valence on perceptual filling-in in extrafoveal vision. We therefore tested whether the induction of positive and negative affect would influence the probability of perceptual filling-in occurring in the uniformity illusion (N=50). Overall occurrence rates of reported uniformity but not reported onset times were significantly reduced in negative compared to positive affect condition. The effect was selectively observed in trials in which perceptual filling-in was taking place and not in control trials where visual uniformity was the veridical percept, ruling out biased motor responses or deliberate judgments of participants as confounding variables. The observed results suggest an influential role of affective status on subsequent perceptual processing, specifically on how much weight is ascribed to perceptual priors as opposed to sensory evidence.

Human Vision Reconstructs Time to Satisfy Causal Constraints

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The goal of perception is to infer the most plausible source of sensory stimulation. Unisensory perception of temporal order, however, appears to require no inference, since the order of events can be uniquely determined from the order in which sensory signals arrive. Here we demonstrate a novel perceptual illusion that casts doubt on this intuition: in three studies (N=607) the experienced event timings are determined by causality in real-time. Adult observers viewed a simple three-item sequence ACB, which is typically remembered as ABC (Bechlivanidis & Lagnado, 2016), in line with principles of causality. When asked to indicate the time at which events B and C occurred, points of subjective simultaneity shifted so that the assumed cause B appeared earlier and the assumed effect C later, despite full attention and repeated viewings. This first demonstration of causality reversing perceived temporal order cannot be explained by post-perceptual distortion, lapsed attention, or saccades. [Data presented in this submission has been accepted for publication in Psychological Science.]

The effects of wearing special glasses that cut yellow light on rotating illusions

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In this study, we investigated the effects of wearing special glasses (NeoContrast, Mitsui Chemicals) that cut yellow light on the color-dependent Fraser–Wilcox illusion (Kitaoka, 2014) and Rotating snakes (Kitaoka, 2003). Previous studies reported that these glasses increased contrast sensitivity (Sakamoto, 2010) and made all colors appear more vivid (Nishikawa, Kitaoka, & Nishimoto, 2021). The color-dependent Fraser–Wilcox illusion and Rotating snakes are motion illusions observed in stationary images. When we observe printed images of the color-dependent Fraser–Wilcox illusion, the direction of illusory motion is reversed depending on illuminance (Kitaoka, 2014) and color temperature (Kitaoka, 2019). Ten participants observed these illusions with and without these glasses. Then we conducted experiments both under bright illumination (590 lx, 4000 K) and under dark illumination (20 lx, 4000 K). As a result, although there was little or no effect on the color-dependent Fraser-Wilcox illusion, the illusory rotation of Rotating snakes tended to be enhanced by using these glasses under bright illumination.

Tuesday August 24th

Talk Session 6: Eye Movements

On the relation between microsaccadic and EEG-alpha signatures of selective spatial attention in visual working memory

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Selective covert attention within the spatial layout of working memory is associated with spatial modulations of 8-12 Hz EEG-alpha activity as well as with directional modulations of fixational eye-movements known as microsaccades. A recent study in non-human primates concluded that attentional modulation of neural activity by covert spatial attention occurs only in the presence of microsaccades toward the attended location. We investigated this link between microsaccades and attentional modulation of 8-12 Hz alpha activity in humans, in a task in which participants selected internal visual representations in working memory. We show that the two signatures are functionally overlapping. Alpha lateralisation is stronger in trials with microsaccades toward vs. away from the to-be-attended visual memory item. Moreover, the alpha lateralisation occurs earlier in trials with earlier microsaccades toward the memorised location of the cued memory item. At the same time, however, in trials in which we did not detect any attention-driven microsaccade, we nevertheless observed clear spatial modulation of alpha activity. Taken together, these results suggest that directional biases in microsaccades are functionally related to alpha signatures of internally directed spatial attention, but they are not necessary for neural modulations by covert spatial attention to occur. [This research was supported by a Marie Sklodowska-Curie Fellowship from the European Commission (ACCESS2WM) and ERC Starting Grant from the European Research Council (MEMTICIPATION, 850636) to FvE.]

Modeling the influence of objects on saccadic decisions in dynamic real-world scenes

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While the prediction of fixation locations on static scenes is an active research area, neither the sequencing of saccades nor dynamic stimuli have received much attention in computational modeling. Here we present a new framework for the simulation of human exploration behavior in dynamic real-world scenes. Saccades are modeled as a sequential decision process where evidence for moving the eyes towards potential targets accumulates over time. Between saccades, the model shows fixation or smooth pursuit, depending on the motion of the currently foveated object. To model saccadic decisions in space and time, we extend the drift-diffusion model towards multiple options. Semantic objects, over which visual information is integrated, define potential saccade targets. The probability to explore a target is based on the visual sensitivity at its

location, on bottom-up features of the object, as well as object-based inhibition of return. A saccade is executed to an object when its decision threshold is crossed. With a small set of well-interpretable parameters, this mechanistic model suffices to reproduce saccade and fixation statistics of human eye-tracking data. Our modular framework can be adapted to explore the effects of various attentional mechanisms on scene exploration behavior. Comparison to a model accumulating evidence in a pixel-based fashion showcases the importance of object-level attentional units. Without object representations, the model shows more exploration of the background and fewer refixations of semantic objects than observed in human scanpaths. We hope that this framework will motivate new hypotheses and experimental work on attention allocation in dynamic real-world scenes. [Funded by the German Research Foundation under Germany's Excellence Strategy – EXC 2002/1 "Science of Intelligence" – project number 390523135.]

The Effect of Smooth Pursuit Eye Movements on the Visibility of Low-Contrast Chromatic Stimuli in the Presence of Contextual Motion

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A drifting inducer modulates the sensitivity to a low-contrast achromatic target abutting the inducer when the eyes are steady. Moreover, the contrast sensitivity to chromatic stimuli increases during the smooth pursuit eye movements. Here, we investigated the changes in the chromatic contrast sensitivity during fixation and pursuit for abutting target gratings in the presence of an inducer. Two high-contrast dynamic inducer gratings (height-width: 1-6.67deg, SF:1cpd) were presented 1.5deg above and below a fixation centered on the screen. A target grating with the same drift speed as the inducers (4deg/sec) was positioned to the left or right of one of the inducers in a phase-congruent or incongruent configuration. The sinusoidal gratings were either modulated alongside of the isoluminant magenta-cyan axis of the DKL color space or raised on the luminance axis. During the pursuit, the envelope of the gratings moved horizontally with a speed of either 4.26 or 9deg/sec. The contrast sensitivity was measured with a 2AFC task using the method of constant stimuli. In blocked trials, the gratings drifted either in the same as or in the opposite direction to the eyes. The task was to report whether the target was presented above or below the fixation. Results revealed a phase-dependent motion-induced sensitivity modulation at the trailing edge during the fixation for both isoluminant and luminance-defined chromatic stimuli (50% luminance contrast). Additionally, for isoluminant stimuli, there was a direction-selective suppression for the targets trailing the inducer relative to the pursuit trajectory, which indicated a pursuit-induced contextual surround suppression effect. [Our project is funded by TÜBİTAK (Scientific Technological Research Council of Turkey), Project no: 218K282.]

The Contribution of Temporal Analysis of Pupillometry to Pupillometry Studies

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Reaction time (RT) is one of the most frequently used measures to detect cognitive processes. When tasks require more cognitive processes / resources, reaction is slower. However, RTs may provide only restricted information regarding the temporal characteristics of cognitive processes. Pupils respond reflexively to light but also to cognitive activation. The more cognitive resources a task requires, the more the pupil dilates. However, despite being able to use temporal changes in pupil size (advanced devices measure changes in pupil diameter with sampling rates of above 1,000 samples per second), most past studies using pupil dilation have not investigated temporal changes in pupil response. In the current paper we discuss the advantage of the temporal approach to analyze pupil changes compared to more traditional perspective, specifically singular value methods such as mean value and peak amplitude value. Using data from two recent studies conducted in our laboratory we demonstrate the difference in findings arising from the various analyses. In particular we focus on the advantage of temporal analysis in detecting hidden effects, investigating temporal characterizations of the effects and validating the experimental manipulation.

The pupil responds spontaneously to perceived number of items

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Although pupil size is mainly determined by luminance, the amplitude of pupillary light responses is modulated by stimulus appearance and attention. Here we asked whether the pupil light response is modulated by the perceived numerosity of visual arrays of constant luminance. We recorded pupil size while adult participants viewed clouds of white or black elements presented in central vision against a gray background. The total number of pixels in

the elements (and hence luminance), as well as the area covered by them (convex hull) were kept constant. Either 18 or 24 dots were displayed in a given trial. In half the patterns, pairs of dots were connected with lines to create dumbbell-like shapes, inducing an illusory underestimation of perceived numerosity. In the others, the isolated-dots condition, the same lines were displayed in random positions. Participants simply observed the stimuli without performing any task. Both pupil constriction and dilation were stronger for patterns with higher perceived numerosity, either physical or illusory, so the strength of the pupillary luminance response scaled with the perceived numerosity. Differences in perceived brightness, spatial frequency content or eye movements across stimuli could not explain the results. Overall, this study shows that even without an explicit task, numerosity spontaneously modulates a simple automatic reflex, suggesting that numerosity is a spontaneously encoded visual feature. [This research has received funding from the European Union's Horizon 2020 research and innovation program under the Marie Skłodowska-Curie grant agreement no. 885672 – DYSCEYE-7T and from the European Research Council (grant agreement no. 801715 – PUPILTRAITS and no. 832813 – GenPercept).]

Polygenic Risk Scores for Schizophrenia Are Associated with Oculomotor Endophenotypes

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Since schizophrenia is a heterogeneous disorder with substantial heritability, the use of endophenotypes may help clarify its aetiology. Findings from twin and family studies suggest that measures from the smooth pursuit and antisaccade eye movement tasks may be suitable endophenotypes for schizophrenia. The endophenotype status of those oculomotor measures suggests overlap in genetic basis with schizophrenia, which is, however, largely unknown. Here, we tested whether polygenic risk scores for schizophrenia were associated with eye movement performance in the general population. We based our analyses on data of 2,956 participants (aged 30-95) of the Rhineland Study, a community-based cohort study in Bonn, Germany. Omni-2.5 exome arrays were used for genotyping. We quantified genetic risk for schizophrenia by creating polygenic risk scores at different p-value thresholds for genetic markers using summary statistics from a recent meta-analysis based on the two largest schizophrenia genome-wide association studies to date. We used multivariable regression models to examine associations between polygenic risk scores and oculomotor performance. Higher polygenic risk scores were associated with higher antisaccade error rate and latency, and lower antisaccade amplitude gain. Patterns of association between polygenic risk scores and smooth pursuit velocity gain were inconsistent. Polygenic risk scores were not associated with saccade rate during smooth pursuit or performance on a prosaccade control task. We found evidence for a genetic overlap between schizophrenia and oculomotor endophenotypes in the general population. The mechanisms that underlie schizophrenia also seem to affect oculomotor function. [None.]

Talk Session 7: Perceptual Organisation & Symmetry

Visual symmetry in the human brain: attentional modulation of fMRI symmetry responses in the visual cortex

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Interaction with the environment surrounding us relies on the ability to efficiently process visual information. For instance, image segmentation, i.e., extracting shapes from background, and grouping, i.e., combining local information into wholes, are generally achieved effortlessly. Previous studies have shown that these abilities are facilitated by the presence of symmetry, a feature reported to be automatically processed. Here, we present dot patterns with 4-fold reflections, 45° rotations, and random configurations in a rapid event-related design while measuring fMRI responses. Crucially, attention was manipulated by performing a 1-back task on the category (regularity task) or on the luminance (non-regularity task) of the dot patterns. In agreement with previous studies, we observe symmetry selective responses in extrastriate visual cortex (V3, V4, LO1, and LO2). These neural responses are observed when attention is directed towards a non-regularity feature (luminance), suggesting that symmetry is processed automatically. Moreover, focussing attention on the pattern regularity resulted in increased symmetry-selective neural responses. We exploit the design implemented using multivoxel pattern analysis (MVPA) to investigate the

representations of different symmetry types (i.e., reflection and rotation) across the visual cortex. Our results suggest that it is possible to differentiate between neural representations of different regularity types and that this information-based representation is modulated by attention. [This work is funded by ESRC grant to ADJM, MB, ABM. The authors declare no conflicts of interest.]

Scientific and meta scientific lessons from a complete SPN catalogue

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EEG studies consistently find that amplitude is more negative at posterior electrodes when participants view symmetrical compared to asymmetrical images. This difference wave is called the Sustained Posterior Negativity (SPN). Many of our published papers report systematic influences on SPN amplitude. However, we are conscious of many alleged limitations with publication as a mode of scientific dissemination. We are also optimistic about new horizons in open science. We thus organized and catalogued 6674 individual SPNs from 2215 participants on open Science Framework (https://www.bertamini.org/lab/SPNcatalogue.html). The SPN catalogue is easy to use, modular, and scalable. Analysis of the full data set provided new insights into symmetry perception which could never be obtained from a single experiment. We found that quantitative measures of perceptual goodness and task relevance are both significant predictors of SPN amplitude. We also found that the SPN is right hemisphere dominant, although the laws of perceptual organization - that determine SPN amplitude - are implemented in a similar way in both hemispheres. Finally, the catalogue supported meta-scientific evaluation of our own research practices. Amongst other things, we used it to estimate statistical power and vibration of the effect under different analysis pipelines (spatiotemporal clustering vs. a priori electrode choice, BESA vs. eeglab). The SPN catalogue showcases the value of complete public databases and open science. We hope other labs will be inspired by this approach. [Economic and Social Research Council (ES/S014691/1).]

Deep convolutional neural network trained on natural images matches human symmetry perception characteristics

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Deep convolutional neural networks (DCNNs) are increasingly effective models for human visual processing. Here we compare the capability of a pre-trained visual DCNN (the ImageNet-trained VGG) to detect abstract symmetry with the symmetry perception in the human brain, where symmetry signals are found only in upper levels of the visual hierarchy (Tyler et al., 2005). The DCNN computed the average L2 distance from zero symmetry for 500 random-dot symmetry images with one, two, and four axes of reflection symmetry, relative to the L2 distances for zero-symmetry random-dot images, compared to a novel control for local histogram correlations introduced by the symmetry manipulation. Results: Significant symmetry response were found in the upper layers of the DCNN, but absent in the lower layers. We further found 1: increasing pure symmetry response with number of axes relative to control; 2: a significant response for partial symmetry down to 20% ; 3: increasing symmetry effect with image size, saturating for larger images in the mid-level layers; 4: vertical axis predominance for 1-axis symmetry; an 5: an initial reduction in the 1-axis symmetry response for small gaps around the symmetry axis, but a surprising robustness of the DCNN symmetry response in the upper layers to large gaps. These findings demonstrate that the natural-image-trained DCNN replicates the human ability to perceive abstract symmetry, even in random-dot patterns devoid of recognizable objects, suggesting that symmetry is an emergent property of DNN networks trained to capture regularities in the natural environment, even when controlled for local histogram correlations.

Early sensory processing of a feature is modulated by the feature's relevance to high-level object perception

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Sensory processing of low-level, local features is known to be affected by high-level, global representations. However, previous studies disagreed on whether high-level percepts enhance or suppress sensitivity to local features. We propose a resolution to this conflict, suggesting that the effects of top-down modulation are dictated by whether the local feature is relevant to the global percept. In an online psychophysical task, over 300 observers viewed dynamic point-light walkers made of gratings, which induced a global percept of a person walking. Local grating orientations were manipulated to be either relevant to the global walker percept – by being aligned with the walker's limbs – or irrelevant – by being unaligned. Results showed higher

orientation sensitivity when local orientations were relevant to the high-level percept, compared to when local orientations were irrelevant. Control conditions, in which gratings formed no global percept, indicated that this modulation was a top-down effect induced by the high-level representation, and that the presence of a global percept differentially modulated relevant and irrelevant features. Overall, the study provides direct behavioural evidence for predictive coding models and demonstrates the role of global relevance in the dynamic and flexible interaction between high- and low-level visual processing. [Funded by School of Psychology, Cardiff University and the Wellcome Trust.]

Unveiling the temporal dynamics of emotional attentional capture with eye movements: from an automatic to a perceptual component

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Humans are natural emotion detectors and particularly predisposed to attend to emotions conveyed by facial expressions. The compulsory attraction to emotions, however, gets challenging when multiple emotional stimuli compete for attention, as in the emotion comparison task. In this task, participants are asked to choose which of two simultaneously presented faces displays a specific emotion (happiness/anger). When the two faces both express a different emotion intensity, the selection is driven by a purely perceptual attentional component: participants respond faster to the face displaying the strongest emotion (i.e., the emotional semantic-congruency effect, ESC), and this effect is stronger for face pairs that contain globally positive rather than negative emotional faces (i.e., the size-effect). In this experiment, we exploited the temporal dynamics of the emotion comparison task by tracking participants' eye movements using gaze-contingent displays. We expected that a perceptually driven attentional component like the ESC will rise over time following a purely automatic attentional component based on a left-to-right visual asymmetry. Analysis of fixation accuracy and dwell time fully corroborated this expectation. On the first fixation, participants were more accurate and dwell longer on the left face when it was the target, according to an automatic attentional component. The pattern of accuracy and dwell time on the second fixation was instead consistent with the ESC. Overall, our pattern of results indicates that attentional capture in emotion comparison task arises from the linear combination of purely automatic and perceptual (i.e., the ESC) attentional components over time [This research was supported by a founding for the research (RESRIC-FANTONI2018, Department of Life Sciences, University of Trieste) to CF and an international Fellowship within the European Social Fund 2014-2020 programme of Regione Autonoma Friuli Venezia Giulia to GB.]

Closure and Symmetry Perception in Autism

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Background: Symmetry is one of perceptual organization cues that is processed faster that asymmetry but has been little explored in autism; where individuals often have differences in perception. Here, we examined how symmetry detection interacts with another grouping cue, closure; where closed improves perception compared to open shapes. As closure is reduced in autistic adults (Gowen et al, 2020), we predicted that closure would facilitate symmetry detection in the non-autistic group only. Method: 18 autistic and 18 matched non-autistic adults performed a 2-IFC task where they were asked to choose the most symmetric targets, made of Gabor elements forming open and closed trapezium shapes. The symmetry level was varied by changing the angle of the sides of the trapezium. Symmetry detection thresholds were compared between closed and open contours to determine the closure effect, with a lower value indicating better performance. Results: Repeated-measures ANOVA showed a significant groupXstimulus interaction with a smaller effect of closure on symmetry detection found in the autistic compared to the non-autistic group. In addition, the autistic group has better symmetry detection than the non-autistic group for open stimuli only. Conclusion: In summary, a reduced benefit of closure on symmetry detection was found in the autistic group, driven by better performance in symmetry detection for open stimuli. This implies that different mechanisms might be used to process visual information in this group; suggestive of enhanced perceptual functioning (EPF). [The study was part of S.S PhD and was funded by Majlis Amanah Rakyat, Malaysia (MARA: People's Trust Council) during the course of the study.]

Talk Session 8: Arousal & Decision Making

Orientating and decisional processes are both involved in the reflexive shift of attention

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People's attention cannot help being affected by what others are looking at. The dot-perspective task has been devised to investigate this "Reflective Shift of Attention" phenomenon. It consists of a virtual scene in which an avatar is facing a direction. Participants are asked to judge as quick as possible how many targets can be seen from their perspective or the perspective of the avatar. Typically, this task shows an interference pattern with participants recording slower RTs and more errors when the avatar and the participants are seeing different targets. Two accounts have been advanced to explain this interference. The mentalizing account focuses on the "social relevance" of the avatar; whilst the domain-general account focuses on the directional features of the avatar. To investigate the relative contribution of these two accounts, we developed an avatar which social features were isolated from its directional features. Specifically, a dragon with an arrowed-shaped tail pointing opposite to the muzzle was used and a dragon without tail served as control. RTs 'analysis showed interference only in the control condition whilst it disappeared in the dragon with tail condition. However, error's analysis showed interference in both conditions, suggesting that RTs and errors may measure different cognitive processes. We suggest that two processes are involved in the dot perspective task: an orientating process - affected by the directional features of the avatar, measured by the RTs – and a decisional process - affected by both the social and directional features and measured by the error rate.

Deep hierarchical sensory processing accounts for effects of arousal state on perceptual decision-making

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An organism's level of arousal strongly affects task performance. Yet, what level of arousal is optimal for performance depends on task difficulty. For easy tasks, performance is best at higher arousal levels, whereas arousal levels show an inverted-U-shaped relationship with performance for difficult tasks, with best performance at medium arousal levels. This interaction between arousal and task difficulty is known as the Yerkes-Dodson effect (1908) and is thought to reflect sensory decision-making in the locus coeruleus and associated widespread release of noradrenaline. Yet, this account does not explain why perceptual performance decays with high levels of arousal in difficult, but not in simple tasks. Recent studies suggest that arousal may also affect performance by modulating sensory processes. Here, we augment a deep convolutional neural network (DCNN) with a global gain mechanism to mimic the effects of arousal on sensory processing. This allowed us to reproduce the Yerkes-Dodson effect in the model's performance. Investigating our network furthermore revealed that for easy tasks, early network features contained most task-relevant information during high global gain states, resulting in model performance on easy tasks being best at high global gain states. In contrast, later layers featured most information at medium global gain states and were essential for performance on challenging tasks. Our results therefore establish a mechanistic account of the Yerkes-Dodson effect, where the interaction between arousal state and task difficulty directly results from an interaction between arousal states and hierarchical sensory processing. [This work was funded by a Research Talent Grant (406.17.554) from the Dutch Research Council (NWO) awarded to all authors. There are no conflicts of interest.]

Confidence judgments reveal that the effect of stimulus speed on perceived duration is not entirely perceptual

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It was recently suggested that the way confidence judgments map onto performance in perceptual tasks might contribute to disambiguate between perceptual biases and decision biases (Gallagher, Suddendorf & Arnold, 2019). Here, we used the same approach to investigate the relationship between the speed of a visual stimulus and its perceived duration. Duration biases were previously reported for identical intervals containing stimuli with different speed profiles. Participants performed a two-interval forced choice task, in which the comparison and standard stimuli were luminance-modulated Gabor gratings. The comparison had variable duration across trials (200-800 ms) and drifted at a constant speed (5 °/s), whereas the 500-ms standard could be stationary, linearly accelerating or decelerating (average speed: 5 °/s), or drifting at the same speed as the comparison. Participants reported, first, which stimulus had the longer duration, and, second, whether their confidence in that judgement was high or low. The point of subjective equality (PSE) for performance and the uncertainty peak for confidence were our measures of central tendency. Participants' performance revealed duration compression for the stationary,

accelerating and, to a lesser degree, decelerating stimuli. However, only for deceleration the compression derived from the PSE was not reflected in a simultaneous shift of the uncertainty peak, suggesting that performance was subject to a decisional bias in this case. Generally, in all the conditions, the confidence estimates of perceived duration were more shifted towards the actual duration than the performance estimates, indicating that the contribution of decisional processes to these effects was not negligeable. [Funded by the Wellcome Trust (individual fellowship to A.B., Award ref: 213616/Z/18/Z).]

Interaction of context congruence on object processing in natural scenes without awareness

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It has been shown that some high-level visual processing may occur without conscious awareness. It has also been shown that scene context can influence object recognition; however, it is still not clear if such object/context interactions exist in the absence of awareness. By conducting experiments with and without continuous flash suppression (CFS), we examined whether context (background) congruency affects target recognition and response time. We used animal and vehicle images in natural or man-made scenes, which formed congruent/non-congruent image groups (100 images each). Experiment 1 was a 2AFC task. Our results indicate that the response time in the congruent scenes (633ms) was significantly faster than in the incongruent scenes (660ms). In Experiment 2, we used b-CFS to suppress awareness of the image. The trial ended when the observer pressed a key to indicate the detection of any part of a scene. Here, we found the congruency effect only in the vehicle group. In order to further investigate the reasons for this result, we conducted Experiment 3, combining 2AFC and CFS. The results replicated the congruency effect from Experiment 1 (2893 vs. 3020ms). This indicates that the congruency effect does not emerge at the lowest levels of perception, but requires additional processing. [This work was supported by the National Natural Science Foundation of China (61263042, 61563056).]

Presence in an immersive-360 theatre auditorium: the influence of immersion, emotional arousal, and overall experience enjoyment

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Presence and immersion are two of the central goals of virtual reality (VR), quantifying the extent that a user feels as though they are "really there" within the virtual environment, and the trade-off regarding an awareness of the external world beyond the headset. Developments in immersive technologies have seen an increase in novel platforms for digital story-telling in the arts, and during the pandemic there has been a significant shift of archived performance material to remote viewing from home. Despite progressive digitisation of theatrical content, we are yet to develop a baseline understanding of presence in VR theatre environments. In the present study, 167 participants watched one or more 3D live-action theatre performances using VR headsets, providing feedback via online surveys and interviews. Both presence and immersion are largely polarised in immersive-360 theatre -experienced by half of participants- and for most participants presence "comes and goes" during a performance. Moreover, immersion and presence are positively associated, and both are greater when enjoyment of the experience is higher. Data also show a vast spread of emotional arousal, where higher arousal scores are associated with greater reports of both enjoyment and presence, but are not significantly associated with immersion. Findings provide a preliminary understanding of presence in immersive-360 theatre, showing (i) its close association with immersion, and (ii) the importance of overall enjoyment and emotional arousal for maximising presence in emotive theatrical environments. Findings also raise important questions regarding sub-facets of presence that may be elicited at the emotional- or empathic-level. [Project funded by the UKRI Impact Acceleration Account (2020). The authors do not have any conflict(s) of interest to declare.]

Unreliable feedback affects metacognitive but not perceptual decision making

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A number of studies have shown that unreliable feedback in perceptual decision making impairs performance, which has been taken as evidence for the critical role of external feedback in perceptual learning. However, these studies did either not inquire or not control for the subjective awareness of the feedback manipulation. Here we present two studies (N=60 and N=66) in which we minimized the awareness of the feedback manipulation by i) double-blinding the experiment, ii) creating a dot kinematogram stimulus that substantially reduced the dissonance between perception and invalid feedback and iii) matching the

apparent performance between conditions of reliable and unreliable feedback. Both studies comprised three groups which received either reliable, unreliable, or no performance feedback in a pre-test/intervention/post-test design. In both studies, debriefing verfied that subjects were largely unaware of the feedback manipulation and the level of awareness did not differ between the reliable and the unreliable feedback condition. We found that an impairment of perceptual performance due to unreliable feedback could not be replicated under these conditions. However, unreliable feedback reduced the overall level of confidence, an effect that was mostly driven by reduced confidence in correct trials. As a consequence, metacognitive sensitivity was reduced following a phase of unreliable feedback. The no-feedback condition clarified that these metacognitive effects were due to negative effects of unreliable feedback and not due to positive effects of reliable feedback. In sum, when carefully minimizing subjective awareness of the feedback manipulation, unreliable feedback primarily impacted metacognition and not perception.

Talk Session 9: Visual Cognition I

Sequential decisions reveal systematic under-confidence biases in judgments of absence

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In visual detection tasks confidence ratings are typically less useful for discriminating correct rejections from misses (that is, correct vs wrong 'signal absent' decisions) than they are for discriminating hits from false alarms (correct vs wrong 'signal present' decisions). While signal detection theory (SDT) can account for this asymmetry by postulating a larger variance in signal-present trials (relative to noise-only trials), it remains unclear whether SDT provides an accurate description of confidence in detection, partly because rating experiments do not allow identifying confidence biases (over/under confidence relative to the objective probability that the decision was correct) but only measuring confidence sensitivity. Here we used a dual-decision method (Lisi, Mongillo, Milne, Dekker & Gorea, 2020) to infer confidence biases in detection decisions. In each trial human observers (N=38) performed a sequence of two decisions about the presence/absence of a Gabor superimposed on white noise. Crucially, the second stimulus contained always a signal after correct first decisions (hits and correct rejections) but only noise after wrong ones (false alarms and misses). Performance was higher in the second decision relative to the first, and the improvement was larger after 'signal present' first decisions, in good agreement with an optimal SDT model with unequal-variance. However, in second decisions following 'signal absent' responses, observers responded 'signal present' less frequently than they should have, indicating an under-confidence bias. This suggests that the meta-cognitive asymmetries observed in rating experiments may be driven by a systematic under-confidence bias specific to judgments of absence.

Evidence of Serial Dependence from Decoding of Visual Evoked Potentials

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Previous studies have shown that decisions in visual tasks are influenced by prior information. To study the physiological mechanisms underlying this process, we employed support vector machine (SVM) classifiers to decode EEG responses to visual target locations in 17 participants. Two vertically aligned gratings were presented to either the left or right hemifield, and participants reported the position (top or bottom) of the higher spatial frequency. Trained on the EEG time course of the current trial, the classifier successfully decoded both the horizontal position and the response to the current stimulus. More surprising, when trained on the activity of the current stimulus, the classifier also decoded successfully the horizontal position and the response of the previous trial. Decoding was possible only after onset of the current stimulus, and reached full significance 500 ms later, suggesting reactivation of a memory trace. Furthermore, the accuracy of decoding of past stimuli correlated with the strength of serial dependence of individual participants, consistent with the idea that the neural representation of the current stimulus incorporates a representation of previous stimuli. Taken together, our findings suggest that past experience, even if irrelevant to the current task, leaves a memory trace that facilitates the configuration of serial processes ideal for natural perception. [GenPercept— ERC Advanced Grant (832813).]

Is memory 'flushed' by the start of a new event, or by the end of an old event?

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We experience the world not as a continuous stream of incoming stimulation, but as a sequence of discrete events — and this event segmentation has profound downstream

consequences on our mental lives. Perhaps most famously, working memory is impaired by walking through doorways (independent of time and distance traveled). But when exactly does this memory 'flushing' occur? At the start of the new event? Or at the end of the previous event? This question may be theoretically consequential, but it never arose in past work — since these two moments were always effectively indistinguishable. (When you cross a doorway, you enter the new room just as you leave the old room.) Here we pulled these apart, with novel virtual animations. Observers saw themselves virtually walk from one room to another, while passing not just through a doorway, but an extended featureless tunnel — a 'limbo' between one room and the next. During the animation, faces appeared at three key moments — at the start, as soon as observers left the first room, and as soon as they entered the second room. Observers then reported which of two faces appeared more recently, where the pair spanned either the end of the previous room or the beginning of the new room. The results were clear: recency memory was disrupted at the beginning of the new event, but not at the end of the previous one. Thus memory flushing is driven not by event *segmentation* per se, but by (new) event *onsets*. [This project was funded by ONR MURI #N00014-16-1-2007 awarded to BJS.]

State-dependent computations mediate serial dependence in time perception

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What we currently perceive is not only based on the present sensory evidence, but also on the recent history of stimulation. Perceptual history plays indeed a clear role in vision: a current stimulus can be biased by its preceding one in an attractive fashion. While these serial dependencies seem ubiquitous in vision, the mechanisms mediating them are still unclear. Here we focus on time perception, and test whether serial dependence in this context may be a property of temporal computations in sensory areas. Indeed, according to the state-dependent network (SDN) model, sensory networks must return to their baseline state before being able to precisely encode a duration. If two intervals are too close in time, their duration may be partially integrated, potentially resulting in serial dependencies. To address this possibility, we measured serial dependence in a duration discrimination task, where the bias was induced by a task-irrelevant "inducer" stimulus preceding the task-relevant ones. Crucially, we modulated the inter-stimulus interval between the inducer and its subsequent stimulus (250 vs. 750ms), to assess whether this might affect their integration. Our results are consistent with the predictions of the SDN theory, showing that a longer inter-stimulus interval significantly reduces serial dependence. Conversely, applying the same manipulation to numerosity perception yielded a markedly different pattern of results. Overall, our results suggest that the effect of perceptual history in duration perception represents an emergent property of state-dependent temporal processing, and that serial dependence in different perceptual domains is mediated by at least partially independent mechanisms. [This work has been supported by the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation program grant agreement No. 682117 BIT-ERC-2015-CoG to Domenica Bueti, from the Italian Ministry of University and Research under the call FARE (project ID: R16X32NALR) to Domenica Bueti, and from the European Union's Horizon 2020 research and innovation program under the Marie Sklodowska-Curie grant agreement No. 838823 "NeSt" to Michele Fornaciai.]

The nature of magnitude integration: contextual interference vs. active magnitude binding

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In everyday life, time and numerosity often interact with each other influencing perception and expectations (i.e., the higher the number of people queuing at the supermarket till, the longer we expect to wait). Evidence from several studies indeed demonstrates the existence of mutual biases between duration and numerosity. However, there is a fundamental question that so far remains unanswered: is the magnitude integration phenomenon just a "contextual" effect, emerging as a sort of interference when two different types of information are available at the same time? Or does it represent an active integration of the different dimensions of the same stimulus? Here we directly address these possibilities, making duration and numerosity to either belong to the same visual stimulus, or to separate stimuli. The results show that an attractive effect (i.e., the higher the numerosity, the longer the perceived duration) emerges only when duration and numerosity are conveyed by the same stimulus. Conversely, when two different stimuli convey duration and numerosity information, we found a strong repulsive effect, emerging in a spatially-selective fashion. Our results thus provide evidence for an active magnitude "binding" process, hinging upon whether different dimensions belong to the same stimulus. Instead, when this magnitude binding fails, the perception of one magnitude is pushed away from the other. Overall, these results suggest that an active binding process represents a fundamental component of magnitude perception, determining the nature of the interaction between different visual dimensions. [This work has been supported by the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation program grant agreement No. 682117 BIT-ERC-2015-CoG to Domenica Bueti, from the Italian Ministry of University and Research under the call FARE (project ID:

R16X32NALR) to Domenica Bueti, and from the European Union's Horizon 2020 research and innovation program under the Marie Sklodowska-Curie grant agreement No. 838823 "NeSt" to Michele Fornaciai.]

Spatial anisotropies in orientation summary statistics

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Ensemble coding is the ability to estimate the statistical properties of an ensemble of stimuli, including their average size, orientation, and direction of motion. Recent work has shown that ensemble coding operates in an anisotropic visual space. For example, the estimated average size is biased toward the individual sizes of stimuli near the center and left portion of the visual field. The functional role of these anisotropies and whether they generalize to features other than size remain unknown. Here we investigated spatial anisotropies in orientation summary statistics. We presented an ensemble of 25 oriented Gabor stimuli arranged in a 12x12° square at the center of the screen. Observers were asked to reproduce the average orientation by adjusting a circular response tool. We used spatial weighted average models to recover the weight of the Gabor at each location in the final report. Our results reveal larger weights for stimuli near the central and leftward part of the ensemble, confirming previous findings with size averaging. Interestingly, spatial anisotropies increased with the increasing uncertainty in the ensemble mean (e.g., for average orientations near the obliques). This latter finding suggests that the nature of these anisotropies may be compensatory: under uncertainty, the perceptual system relies more on the statistics of stimuli falling within high-resolution regions of the visual field. [This research was supported by funding from the Swiss National Science Foundation (grant no. 415 PZ00P1_179988 to DP).]

Talk Session 10: Objects & Shape

EEG decoding of the inferred real-world size of multiple objects

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High-level vision is frequently studied at the level of either individual objects or full scenes. An intermediate level of visual organisation that has received less attention are "object constellations", defined here as familiar configurations of conceptually-related objects (e.g., plate + spoon). Recent work has shown that information from multiple objects can be integrated to support observers' high-level understanding of a "scene". Here we used EEG to test whether/when the visual system integrates information across objects to infer their real-world size. To this end, we presented object constellations consisting of either large (e.g., chair + table) or small (e.g., plate + spoon) object silhouettes, while independently varying retinal size. As a control, observers also saw each object silhouette presented in isolation. Behavioral results showed that observers recognized the objects' real-world size much more easily when the silhouettes appeared in pairs than when they appeared in isolation. Using representational similarity analysis of EEG data, we found that real-world size was reflected in neural activity patterns from around 200ms after stimulus onset. Importantly, mirroring the behavioral results, this representation of real-world size arose only for paired objects, and not for objects presented in isolation. Finally, real-world size representations remained significant after regressing out visual similarity models derived from computational models. These results reveal the neural time-course of inferred real-world object size. More generally, they provide evidence that processing two objects concurrently gives rise to a qualitatively different high-level representation than that evoked by the same objects in isolation. [This work was supported by funding from the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement No 841909 (GLQ) and the European Research Council grant agreement No 725970 (MVP).]

Scene-object congruency modulates N300/400 EEG components, but does not automatically facilitate object representations

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In the real world, objects rarely appear in isolation, but often within a semantically related scene context. Previous studies reported that semantic congruency between objects and scenes improves the speed and accuracy of object perception, and that semantically congruent and incongruent object-scene combinations evoke different N300 and N400 components in EEG recordings. Here, we used univariate and multivariate EEG analyses to investigate whether differences in the N300/N400 waveforms are related to differences in the representation of objects. In two experiments, we recorded EEG signals while participants viewed semantically consistent or inconsistent

objects within a scene. In both experiments, we replicated previously reported ERP effects, with greater N300/N400 components for inconsistent scene-object combinations, compared to consistent combinations. To probe the quality of object representations, we performed multivariate classification analyses, in which we decoded the category of the objects contained in the scene. In the first experiment, in which the objects were not task-relevant, object category could be decoded from around 100 ms after the object presentation, but no difference in decoding performance was found between consistent and inconsistent objects. In the second experiment, we made the objects directly task-relevant. Under such conditions, we found enhanced decoding of semantically consistent, compared to semantically inconsistent, objects. These results show that differences in N300/N400 components related to scene-object consistency do not index changes in cortical object representations, but rather reflect a generic marker of semantic violations. Further, they suggest that facilitation effects between objects and scenes are task-dependent rather than automatic. [D.K. and R.M.C. are supported by the Deutsche Forschungsgemeinschaft (DFG) grants (CI241/1-1, CI241/3-1, KA4683/2-1). R.M.C. is supported by the European Research Council (ERC) grant (803370). L.C. is supported by the Chinese Scholarship Council (CSC).]

Disentangling dimensions of animacy in human brain and behaviour

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The perception of animate things is of great behavioural importance to humans. Despite the prominence of animate/inanimate distinctions in brain and behaviour, however, it remains unclear which object properties cause the distinct responses. Here, we investigate the importance of five dimensions of animacy: "being alive", "looking like an animal", "having agency", "having mobility", and "being unpredictable". We used a genetic algorithm to create a stimulus set of 128 images that disentangles the five animacy dimensions well. The resulting set spanned 100 categories, e.g. containing humans, human fetuses, human organs, shadows, plants, corals, forces of nature, games items, toys, and vehicles. One set of 19 subjects performed two behavioural tasks (how animate an object image was and how similar object images were in relation to each other), EEG, and fMRI experiments. We found that most animacy dimensions explained variance in brains (fMRI patterns in the ventral visual stream and EEG patterns from 100ms onwards) and in behavioural judgments. Despite its prominence in neuroscience literature, the living/non-living distinction ("being alive") did not explain variance in brain representations. The "having agency" dimension explained more variance in higher-level visual areas, consistent with higher cognitive contributions. The "being unpredictable" dimension captured representations in both lower and higher-level visual cortex. One interpretation is that unpredictable things require attention. A large proportion of explainable variance was captured by each animacy dimension in animacy and similarity judgements. These results show that animacy is represented by several distinct dimensions in the human brain and behaviour. [This research was supported by the Wellcome Trust [grant number 206521/Z/17/Z] awarded to KMJ; the Alexander von Humboldt Foundation postdoctoral fellowship awarded to KMJ; and DFG grant [CI 241-1/1, Emmy Noether Programme] to RMC. The authors declare that they have no competing interests.]

Distal functional connectivity indexes high-level representations in human occipito-temporal cortex

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Human object recognition is a crucial visual ability that depends on occipito-temporal cortex (OTC), as shown by converging functional magnetic resonance imaging (fMRI) evidence. However, a complete understanding of the complex functional profile of OTC must account for how this broad region is connected to (and is influenced by) the wider brain. Here, we show that the discriminability of visual information (e.g. accurately discriminating between neural responses evoked by tool-, face-, & place images) in OTC is strongly related to, and is reliably identified by, distal functional connectivity between OTC and the wider brain. Specifically, we show superior discriminability of information in OTC voxel sets (i.e. sets of volumetric pixels in MR images) that show strongest connectivity to the wider brain, compared to sets that are least-strongly connected. In several cases, superior discriminability is also shown for these 'most-connected' voxel sets compared to 'most-activated' voxel sets (that are defined by local activation amplitude, rather than connectivity strength). Importantly, these results demonstrate that complex visual responses in OTC can be reliably identified by connectivity to the wider brain, and that connectivity does not merely index the same information as local response magnitude does. This approach may further serve as a principled means of voxel selection for future fMRI studies

Global Object-Level Representation of Symmetry in the Brain: Beyond Pairwise Local Correspondences

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Symmetry is a ubiquitous property of objects and the brain is highly sensitive to it. By definition, symmetry is characterised by rigid transformations: to find symmetry the visual system must detect non-accidental spatial relationships between elements of an object. This view presents important ecological limitations: perfect symmetry is rarely projected to the retina in the natural visual environment. Here we describe a series of EEG/ERP studies showing that neural representation of symmetry (indexed by a specific Sustained Posterior Negativity, SPN) can be achieved beyond information presented in the retinotopic frame of reference. We employed both dynamic and static occlusion to reveal only portions of shapes (either symmetric or asymmetric) at any given point in time or space. Results showed a symmetry-SPN generated (i) through non-retinotopic spatiotemporal integration of parts and (ii) through amodal completion of occluded shapes that had been previously experienced as wholes. Our findings cast new light on how the visual system adjusts for noisy and ambiguous retinal inputs to achieve object representation. Moreover, we highlight the need for the development of new models of symmetry perception that take into account global coding of symmetric correlations. [This work was partially supported by a ESRC grant awarded to Marco Bertamini (ES/K000187/1) and an ESRC grant awarded to Alexis Makin (ES/ S014691/1).]

The contribution of stimulus motion to interocular grouping in binocular rivalry and its relationship with high-level stimulus content

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Binocular rivalry occurs when two different stimuli (A and B) are presented to each eye: rather than perceiving a mixture of the two stimuli, an observer's experience typically alternates between percepts of the two monocular inputs. Interestingly, when stimuli are presented as a patchwork such that each eye receives half of stimulus A and half of B, and the other eye views the respective other halves, the alternation between full percepts remains unchanged because the two halves of each stimulus are integrated across the eyes in a process called interocular grouping. Here, we investigated how stimulus motion contributes to interocular grouping, and whether this contribution is influenced by high-level stimulus content. Observers experienced binocular rivalry between halves-split images of textures, faces, and houses. We manipulated the amount of high-level information conveyed via the stimuli by presenting images both intact and distorted (phase-scrambled or flipped upside-down). In order to induce motion independently of image distortion, we used a dynamic image-transformation to elicit the 'motion without movement' effect. Results indicate that interocular grouping is strong when it is driven by both motion and image content, and weak when the two factors are pitted against each other. These effects are only weekly modulated by stimulus type and by the presence of image distortions. Taken together, our results demonstrate that motion contributes to interocular grouping in binocular rivalry and that this contribution is largely unaffected by high-level stimulus processing. [This study was funded by the Preludium grant (2018/31/N/HS6/01032) awarded to M. P. by the Polish National Science Centre.]

Wednesday August 25th

Talk Session 11: Face Perception

Human face categorization is influenced by the expectation of common configural properties in a dynamic visual stream

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Face categorization is supported by configural processing. If the configuration of the parts is disturbed, then recognition and categorization become harder. However, how prior expectations influence the extraction of configural face properties is not well known. Using the Eidolon Factory (an image-manipulation algorithm based on the scale-space representation of the early visual cortex; Koenderink et al., 2017), we introduced random disarray fields across spatial scales to manipulate the appearance of the stimuli. We used electroencephalography (EEG) combined with a sweep Fast Periodic Visual Stimulation paradigm to study implicit categorization mechanisms. Specifically, participants (N=28)

observed a wide range of images (human faces and objects) embedded in their natural background in 14 steps of decreasing disarray at a presentation rate of 6 Hz for 140 seconds. At a 1 Hz rate, different human face stimuli were presented with the same level of disarray as the other images. To investigate how expectations influenced face recognition, we also reversed the sweep with the disarray increasing over time instead. We compared the growth and decline of the face-specific EEG amplitudes (1 Hz) in both presentation orders and found a steeper reduction in amplitude when the disarray decreased over time compared to the reversed order. Feature sampling is slow and inefficient when there are no prior expectations in the decreasing disarray condition. In the increasing disarray condition, when the unaltered face stimuli are seen first, an implicit expectation is built, which improved the sensitivity to the presence of relevant feature information even if spatially disarrayed. [We would like to thank Jonathan Van Den Berckt and Ward Deferm for their help with data collection. Funded by a grant to J.W. by the Excellence of Science programme (EOS-30991544).]

Dynamic Emotion Prediction and the Role of Expression Intensity

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The ability to use prior information to accurately predict others' future emotional states can facilitate emotion perception. Predictive information plays a particularly important role in resolving uncertainty. Recent (unpublished) research in our lab using static faces shows greater reliance on predictive information to recognise emotions when the expression signal is weak/subtle. However, expressions more naturally unfold over time. Here we used faces which dynamically changed from neutral to angry or happy to examine emotion prediction effects when peak expression intensity was weak versus strong. Participants saw a neutral face and a sentence next to it describing an anger- or happiness-provoking event to induce a prediction of how the face may change expression. The neutral face then transformed into an angry or happy expression, reaching peak expression intensity either at 20% or 80% before returning to neutral. Participants categorised the expression as angry (key A) or happy (key H; Experiment 1a), or indicated with a space bar when they could conceptualise which expression was emerging before labelling the emotion (Experiment 1b). In both experiments, correct responses were faster when the expression was congruent versus incongruent with the preceding sentence cue, but this effect was not modulated by expression intensity. Furthermore, emotions were accurately categorised by only 48% intensity in the 80% condition. Expressions in the 20% condition reached peak intensity earlier (by 633ms) than in the 80% condition (by 1632ms). Further ongoing studies are equating the timing of the peak intensity expression to resolve this potential confound on intensity effects. [Funding: This work is supported by an ESRC PhD studentship to Vilma Pullinen (Project reference 2272808).]

Acuity for face recognition varies systematically across the visual field

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Low-level vision varies predictably across the visual field, with acuity better along the horizontal vs. vertical meridian and in the lower vs. upper visual field. In contrast, research for faces – which typically involves judgements of appearance (e.g. identity/gender) for faces of the same size – suggests that face perception varies idiosyncratically. To investigate this discrepancy and bridge the gap between methodology used to measure spatial resolution in low and high-level vision, we developed an acuity test for face recognition. Participants reported the gender of upright or inverted faces at 8 locations, 10° in the periphery. Face size was varied at each location with an adaptive QUEST procedure, with acuity thresholds calculated as the smallest size necessary to judge gender. For both upright and inverted faces, thresholds were lower – indicating better gender acuity – along the horizontal vs. vertical meridian. Some evidence was found for better gender acuity in the lower vs. upper visual field. However, this effect may have been driven by eye position within face stimuli as it reduced when eye position was controlled for. Inversion effects were found across the visual field and did not differ significantly according to location. These results provide evidence that face perception varies systematically across the visual field in a pattern mirroring low-level vision, e.g. with the horizontal-vertical anisotropy. This ties in with a hierarchical model of face recognition, whereby face-selective brain regions inherit the spatial properties (e.g. resolution) of earlier visual areas, causing face perception to be influenced by location. [Supported by the Biotechnology and Biological Sciences Research Council [BB/M009513/1].]

Neural Underpinnings of Negative Emotional Expressions Evoked by Audiovisual Stimuli

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Behavioral and neural underpinnings of emotional expressions are valuable for understanding the cognitive processes during social interactions. People encounter these expressions in a multisensory nature and receive the emotional charge at varying levels of intensity. The current study aimed to examine the perception of audiovisual emotional expressions with different intensity levels by using a 20 channel EEG. We used sad and angry facial and vocal expressions. Data were collected from 23 participants while both visual and auditory stimuli were presented with 50% or 75% level of intensity. Angry expressions lead to an increased trend in the amplitude of the N300 ERP component compared to sad ones. N300 is involved in the processing of emotional stimuli and selectivity of this component towards different emotions was expected. Our results show that this characteristic of N300 also applies for audiovisual emotional expressions. The amplitude of the N170 and P200 ERP components decrease with decreasing intensity level of the expressions. This suggests that the awareness regarding the emotional intensity changes in behavioral results are followed by the N170 and P200 components. These results are in line with studies which have demonstrated N170 as a selective component for facial stimuli. Interestingly, the P200 component, which is known for its responsiveness to cross-modal interaction effects also followed the intensity change in facial emotions. Our results shed light on the neural underpinnings of two different accounts of emotional processing mechanisms, which are emotion type and emotion intensity, by revealing selective and modular processing patterns in the brain.

A computational explanation for the unreasonable human ability to detect faces in things

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The human visual system has a remarkable ability to detect and process faces across a broad range of sensory experiences. Face pareidolia is an impressive example of this ability allowing us to see illusory faces in things. While the neural processing of face pareidolia has been well studied, it is still unclear why the visual system employs such a broadly-tuned face detection mechanism. Here, we hypothesize that the initial coarse tuning is part of a two-stage process, in which faces are initially detected as such and then processed in a domain-specific stream. To test this, we used a convolutional neural network (CNN) trained to recognize a wide range of face and object categories with emerging domain-specific subsystems in late layers of the CNN. Using representational similarity analysis, we compared the representational similarities of a validated stimulus set of illusory faces, matched objects and real faces in progressive layers of the CNN. Representations in this network showed a, qualitatively and quantitatively, high similarity to representations in the brain (Wardle et al., 2020): In earlier layers, illusory faces were represented closer to real faces than to matched objects ($p<0.01$, bootstrap test), whereas later layers showed a shift of representations in which illusory faces and matched objects both separated from real faces ($p<0.01$). Our results show that an early, coarse face detection mechanism emerges in a CNN with domain-specific subsystems for faces and objects, thereby providing a computational explanation for the unreasonable effectiveness of the human visual system to detect faces in things.

A computational account of the role of context in facial expression perception

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Previous research on the perception of facial expressions has highlighted the importance of context. For instance, affective body postures influence perception of facial expressions, such that observers are more likely to perceive a disgusted face as angry when presented in an angry body context. Using psychophysical testing combined with formal mathematical modelling, we provide the first detailed account of the computational mechanisms underlying such context effects in emotion perception. We index naturally occurring individual differences in the precision of facial expression and body posture representations, and the extent to which body acts as a prior on facial expression perception. Modelling this behavioural data indicates that the human visual system treats body posture as a prior that is integrated with facial expression cues to generate a final facial expression percept, where the extent to which body influences face perception is determined by the precision of both facial expression, and body posture representations. Importantly, however, the influence of

the body-prior is substantially down-weighted compared to what would be expected based on an optimal observer. At the group level, the body-prior exerts its influence regardless of the difference in emotion between the face and body. Yet, individual model fits suggest substantial variability, with some observers' perception being best explained by an inference model; in these observers, the body-prior is discounted when face and body emotion become too incongruent. This computational account underscores the importance of real-world individual differences in processing of social signals and highlights the role of social priors in face perception.

Talk Session 12: Adaptation & Aftereffects

Divisive inhibition model explains the orientation-specific lateral modulation effect in center-surround sinusoidal stimuli in the periphery

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Ample evidence shows that the context effect of the surround pattern to the central stimulus is subject to a normalization process determined by the surround feature. We investigated such feature-specific center-surround interaction by measuring how the tilt-aftereffect (TAE) induced by adapters of different surround orientation can affect the orientation percept of a subsequent Gabor target. The sinusoidal adapter contains two parts: a central patch having the same spatial extend as the target and a surround annulus. The center and surround orientations varied independently from horizontal to vertical, yielding 25 orientation combinations in total. After the adapter presentation, participants were to judge the orientation of the target tilted either in clockwise (CW) or counterclockwise (CCW) away from the vertical direction. We estimated the orientation shift (OS) needed to cancel the TAE as the dependent variable. All stimuli were presented in the upper right visual field 10° from the fixation point. We found that OS peaked when the adapter center orientation was between 10-20° regardless of the surround orientation and that the overall OS was modulated by the surround orientation, suggesting an orientation-specific lateral modulation effect. We fitted our data with a divisive inhibition model with population coding in which the response of an orientation channel to a stimulus is determined by the excitatory input divided by the inhibitory input plus a normalizing constant, σ. The adaptation effect is captured by the increase in σ, whereas the lateral modulation is represented by two multiplicative parameters that modulate the excitatory and inhibitory sensitivity. [This study is supported by DAAD (German Academic Exchange Service/Deutscher Akademischer Austauschdienst) ResearchGrants – Doctoral Programmes in Germany, 2017/18 (Forschungsstipendien - Promotionen in Deutschland, 2017/18).]

An observer model of the tilt aftereffect, precision changes and confidence

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Humans experience levels of confidence in perceptual decisions that tend to scale with the precision of their judgments. But not always. Sometimes precision can be held constant while confidence changes, and vice versa. This has led researchers to assume precision and confidence must be shaped by different types of information (e.g. perceptual and decisional). We decided to examine these issues using visual adaptation, as this modulates sensitivity in a context that can understood through modelling. We examined how visual adaptation to oriented inputs changes tilt perception, the precision of decisions, and confidence. Some adaptors had a greater detrimental impact on measures of confidence than on precision. We could account for this using an observer model where precision and confidence rely on different magnitudes of sensory information. Our data therefore reveal that differences in perceptual sensitivity and confidence can emerge, not because these factors rely on different types of information, but because they rely on different magnitudes of sensory information. [Australian Research Council - Discovery Project Grant.]

Format-dependent representations of time intervals

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Humans and animals utilize temporal cues expressed in a variety of formats. For example, time intervals can be

informed by the time differences between onset and offset of a single continuous event (i.e., filled interval) or by the intervals marked by two brief events (i.e., empty interval). However, it is still controversial whether the time interval is represented in a format-dependent manner or a more abstract format-independent manner. To address this issue, we examined the effect of adaptation to filled and empty intervals on the perceived intervals of stimuli of the same or different format, using a psychophysical adaptation paradigm. In the adaptation phase, participants were adapted to filled or empty intervals of visual stimuli (200 or 700 ms), repeatedly presented forty times. Following the adaptation phase, an auditory reference and visual test stimulus were presented in the same or different format as the adapting stimuli. Participants were asked to judge which interval of the two stimuli lasted longer. The results showed that perceived time intervals of the test stimuli shifted away from the adapted intervals when the adaptor and test stimuli were presented in the same format. The aftereffect was evident even when the contrast polarity was inverted between the adaptor and test stimulus. By contrast, the aftereffects were absent when adaptor and test stimuli were presented in different formats. These findings indicate that filled and empty intervals may be represented by different populations of neurons, although a similar coding scheme (e.g., population coding by interval-tuned cells) is involved. [Japan Society for the Promotion of Science (Grant-in-Aid for Scientific Research JP18H01101, Grant-in-Aid for Scientific Research on Innovative Area JP21H00315) and Japan Science and Technology Agency (PRESTO JPMJPR19J8).]

Perceptual history propagates down to early levels of sensory analysis

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One function of perceptual systems is to construct and maintain a reliable representation of the environment. To this end the brain can incorporate information from previous presentations, a phenomenon known as serial dependence. It is still unclear however whether serial dependence biases sensory encoding, or only perceptual decisions. We leveraged on the "surround tilt illusion" – where tilted flanking stimuli strongly bias perceived orientation – to measure its influence on the pattern of serial dependence. When a neutral stimulus preceded by an illusory one maximal serial dependence occurred when the perceived orientations matched, suggesting that the sensory history embeds contextual biases of previous presentations. However, when an illusory stimulus was preceded by a neutral stimulus, maximal serial dependence occurred when their physical orientations matched, suggesting that sensory history interacts with incoming sensory signals before they are biased by flanking stimuli. The evidence suggests that priors are high-level constructs incorporating contextual information, however these interact directly with early sensory signals, not with highly processed perceptual representations. It also suggests that serial dependences arise at a network rather than local level. [European Union (EU) and Horizon 2020—Grant Agreement No. 832813—ERC Advanced "Spatio-temporal mechanisms of generative perception—GenPercept"; Flag-ERA JTC 2019 (grantDOMINO); Italian Ministry of Education, University, and Research under the PRIN2017 program (Grant Number 2017SBCPZY).]

Multistability: Perceptual history alters shape (not just the mean) of dominance phase distribution

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Very different multistable displays produce time series of dominance phases that are qualitatively and quantitatively similar, including the characteristic right-skewed distribution and subtle but consistent dependence on prior perceptual experience. Prior work examined how recent perceptual experience alters the mean of the distribution. However, for an asymmetric right-skewed distribution such as Gamma that is commonly used to fit time-series for multistable displays, the same change in the mean can come about through different changes in one or both its parameters. We investigated this by employing a Gamma distribution with both parameters being (under the log link) linearly dependent on prior perceptual experience and further factors (age of participants, contrast). Five datasets were fitted with a multilevel Bayesian model that included different multistable displays with constant strength (binocular rivalry, kinetic-depth effect, Necker cube), binocular rivalry with varying contrast, and developmental data. For all data sets, we found that only the shape parameter depended on a prior perceptual history being compatible with the idea of an interplay between adaptation and noise. Specifically, longer accumulated perceptual history assumed to reflect higher levels of adaptation resulted in a more "normal-like" distribution associated with an adaptation-driven oscillatory regime. Conversely, lower accumulated perceptual history (as a proxy for adaptation) produced a more "exponential-like" distribution consistent with noise-driven alternations. Our results provide useful constraints for computational models of multistability, as, for example, they cannot be easily reproduced by a classic spiking neuron model by Laing and Chow.

The Size Aftereffect: A Contrast Gain Control Model for Retinal Image Size

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At ECVP 2012 we presented a novel adaptation aftereffect: the perceived sizes of grating patches are repulsed by the size of a circular adapting pattern. Because the adapter was spatially jittered over time, the effect could not be attributed to shifts in perceived contour position caused by local adaptation. And because the spatial frequency (SF) of the adapter and test were the same, neither could it be attributed to the SF shift aftereffect (Blakemore & Sutton, 1969). Instead, our results provided strong support for the population coding hypothesis of retinal-image size (Meese and Baker, 2011). Here we develop our contrast gain control model (previously fitted to dipper functions) for the size aftereffect. Each spatial pooling mechanism in Layer 1 receives divisive surround suppression from the largest mechanism in the pool. This maintains the contrast code and provides the basis for size coding. In Layer 2, subtractive inhibition between mechanisms of adjacent sizes (differentiation) picks out the relevant mechanisms and interpolation delivers an estimate of retinal image size. Adaptation is implemented by stimulus desensitisation (the only free parameter) in Layer 1, distorting the population code and predicting our results. Unlike other aftereffects, human data displays two asymmetries: effects are larger for small tests than large tests relative to the adapter, and on the small side, results do not return to baseline with distance from the adapter. Both features are emergent properties of our model. This work provides new insights into how information is aggregated beyond the earliest stages of visual processing. [EPSRC grant: EP/H000038/1.]

Talk Session 13: Mid-Level Vision

Patterns of covariation co-specify the 3D shape and material properties of translucent substances

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Surface perception is difficult because it involves recovering two unknown variables – 3D shape and material – from a single image. Most computational work has attempted to infer either the 3D shape of a known material or the material qualities of a known 3D shape. It is currently unclear how the human visual system extracts both 3D shape and material without this a priori knowledge. Here, we show that images of light permeable (translucent) substances contain information that co-specifies both material and 3D shape. The image structure generated by translucent substances is composed of specular reflections generated at the surface, intensity gradients generated by sub-surface scattering, and self-occluding contours generated where surfaces curve behind themselves. We show that these three sources covary because they all depend on a common environmental source: surface curvature. We experimentally demonstrate that the particular forms of covariation that emerge between these sources are required to perceive the 3D shape and material properties of translucent substances. We show that a compelling illusion of translucency arises from artificial images in which we paint the hypothesised patterns of covariation directly onto surface geometry instead of rendering the images using a physically-correct simulation of sub-surface scattering. These results together with our earlier work on opaque surfaces suggest that the concepts of covariation and co-specification pursued herein will offer insights into the perception of shape and material for a broad class of surfaces. [This work was supported by grants awarded to B. L. Anderson from the Australian Research Council.]

The role of color in the perception of the 3D shape of light-permeable materials

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A fundamental goal of mid-level vision is to understand how the visual system recovers the 3D shape and material properties of surfaces. Although many have studied the role of color in material perception, it is currently unclear what role color might play in the perception of 3D shape, if any. Here, we show that different wavelengths of light undergo different amounts of sub-surface light transport and hence different wavelengths carry different cues to 3D shape. Specifically, our physical simulations show that wavelengths absorbed at shallow depths generate shading-like patterns linked to local 3D surface orientation, whereas wavelengths that penetrate deeply generate patterns of sub-surface scattering that are linked to surface curvature. Our psychophysical experiments tested whether the perceived 3D shape of chromatic translucent substances depends on just shading, just sub-surface scattering, or both of these cues that reside in different color channels. Observers adjusted the 3D orientation of a 'thumbtack' shaped gauge probe to match apparent 3D surface orientation, which was integrated to build 3D models of apparent surface geometry. The results show that the chromatic surfaces elicit more relief than achromatic surfaces irrespective of whether the achromatic surfaces are specified by patterns of surface shading or patterns of sub-surface scattering. Our physical simulations and

psychophysical experiments indicate that color carries information about 3D shape that the visual system relies on to perceive the solid shape of light-permeable materials. [Australian Research Council.]

Mapping between the color appearance of different material classes in VR

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Studies on the color appearance of materials have determined factors that underlie the color of a single material type, as well as the visual modes that classify materials into different groups. A few studies have expanded upon these findings and began matching colors across different materials, such as the work by Xiao & Brainard (2008) and Giesel & Gegenfurtner (2010). However, it is not clear if color matching tasks are easier when materials are more similar. For example, Lambertian and glossy materials are both in surface mode, whereas a glass object is in volume mode, but due to the presence of specular highlights, the glossy material is more similar to glass than the Lambertian material is. Does color constancy improve when materials appear more similar? We have made use of physically-based renderings in VR over the web, so that observers could freely move around and perform a color matching task for glass, glossy, and Lambertian objects under different illuminants. We have determined that when manipulating the color of a Lambertian or glossy surface to match the color of a glass object, observers do not match the mean color, most saturated color, or the most frequent color, suggesting that observers are making mappings between the colors of different material classes rather than matching first-order image statistics. Matches were not significantly different between a Lambertian or glossy test object, suggesting that visual mode is more decisive than similarity in visual appearance.

Unique hues as non-uniformities in the neural geometry of colour

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The idea of colour opponency maintains that human colour vision arises through the comparison of two chromatic mechanisms, red versus green, and yellow versus blue. The four unique hues, red, green, blue, and yellow, are assumed to appear at the null points of these two chromatic systems. Here, we begin with the hypothesis that if unique hues do represent a neural reality, then they must elicit different, more robust neural activity compared to other non-unique hues. We test this hypothesis by employing a spatiotemporal decoding approach on electroencephalographic (EEG) signals. Our findings are: 1. EEG responses carry robust information about isoluminant unique hues within a 100-350 ms window from stimulus onset. This is observed in both active and passive tasks, suggesting that the effects are driven by the stimulus, and not the task. 2. Addition of luminance contrast to isoluminant stimuli progressively disrupts this encoding – supporting the idea that luminance and hue share a joint encoding in the cortex. 3. The neurometric space which encodes hue percepts shows a distinct anisotropy in the neighbourhood of unique-hue representations, suggesting that the structure of the hue-encoding space correlates directly with the perception of unique hues. Furthermore, the neural code for hue temporally coincides with the neural code for luminance contrast, thus explaining why potential neural correlates of unique hues have remained so elusive until now.

Groupitizing modifies neural coding of numerosity

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When objects are grouped within clusters, participants can enumerate their numerosity more rapidly and accurately, a phenomenon termed "groupitizing". Evidence suggests that it relies on subitizing and simple arithmetical skills. Here, we investigated whether spatial clustering of arrays drives specific neural responses during numerical estimation, reflecting strategies such as exact calculation and fact retrieval. Fourteen adults underwent fMRI scanning while observing arrays of items that were either randomly scattered or arranged in four spatially segregated groups. All but one item were squares, the other randomly diamond, triangle or circle of the same size. Participants performed one of two tasks (separate sessions): estimate the total numerosity of the items, or identify the odd shape. The results showed that numerosity estimation of ungrouped and grouped stimuli elicited common activation of a right

lateralized fronto-parietal network. Estimation of grouped stimuli additionally recruited regions in the left hemisphere and the angular gyrus bilaterally. Multivariate pattern analysis showed that classifiers trained with the pattern of neural activations read out from parietal regions, but not from the primary visual areas, can decode different numerosities both within and across spatial arrangements. Finally, the behavioural numerical acuity correlated with the decoding performance of the angular gyrus and to a minor extent with the one of the inferior-lateral part of IPS but not with lower regions. Overall, the results support the hypothesis that the estimation of grouped stimuli relies on the approximate number system for numerosity estimation, but additionally recruits regions involved in calculation. [This research was supported by the European Union's Horizon 2020 research and innovation program under the Marie Skłodowska-Curie grant agreement No 885672 - DYSC-EYE-7T; the Italian Ministry of Education, University, and Research under the PRIN2017 program (Grant number 2017XBJN4F—'EnvironMag' and Grant number 2017SBCPZY— 'Temporal context in perception: serial dependence and rhythmic oscillations'); the European Union (EU) and Horizon 2020 – Grant Agreement No 832813 - ERC Advanced "Spatio-temporal mechanisms of generative perception — GenPercept". Author M.W.G. was supported by the German Research Foundation (DFG, INST 89/393-1 and GR988/25-1). Author P.A.M.M. was supported by the Erasmus+ Exchange Program of the EU during her stay in Regensburg, Germany.]

The dynamics of grouping-induced biases in apparent numerosity revealed by a continuous tracking technique

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Continuous tracking is a technique where participants track continuously the position or some other aspect of a randomly moving or changing target, then cross-correlating the cursor with the stimulus changes. We used this technique to study numerosity, asking participants to track the numerosity of a dynamic cloud of dots by continuously moving a cursor on a number-line. Some of the dots were connected by thin lines, known to cause an illusory reduction in perceived numerosity. The number of dots, and the proportion connected by lines, varied over time, following two independent random walks. Cross correlograms showed that responses were driven by both the physical numerosity and the proportion of unconnected dots, validating the technique, and the connectedness effect on perceived numerosity. The amount of under¬estimation was calculated to be about 15% on average, agreeing with some previous studies. Interestingly, the lag in the cross-correlograms associated with connectedness was about 150 ms longer than for physical numerosity, suggesting that connectedness requires an extra 150 ms of processing time to come into effect. In further experiments, we varied the time in which the stimuli changed, from very slow (800 ms) to very fast (200 ms), showing that the connectedness-induced bias, but not the effect of physical numerosity, vanished at fast refresh rates. We conclude that continuous tracking is potentially a fast and efficient new technique to study numerosity, including its dynamic properties. [ERC- Grant No 832813 (GenPercept).]

Talk Session 14: Attention II (Salience)

Global visual salience of competing stimuli

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Current computational models of visual salience accurately predict the distribution of fixations on isolated visual stimuli. It is not known, however, whether the global salience of a stimulus, that is, its effectiveness in the competition for attention with other stimuli, is a function of the local salience or an independent measure. Further, do task and familiarity with the competing images influence eye movements? Here, we investigated the direction of the first saccade to characterize and analyze the global visual salience of competing stimuli. Participants freely observed pairs of images while eye movements were recorded. The pairs balanced the combinations of new and already seen images, as well as task and task-free trials. Then, we trained a logistic regression model that accurately predicted the location —left or right image—of the first fixation for each stimulus pair, accounting too for the influence of task, familiarity, and lateral bias. The coefficients of the model provided a reliable measure of global salience, which we contrasted with two distinct local salience models, GBVS and Deep Gaze. The lack of correlation of the behavioral data with the former and the small correlation with the latter indicate that global salience cannot be explained by the feature-driven local salience of images. Further, the influence of task and familiarity was rather small, and we reproduced the previously reported left-sided bias. Summarized, we showed that natural stimuli have an intrinsic global salience related to the human initial gaze direction, independent of the local salience and little influenced by task and familiarity. [The authors thank Deutsche Forschungsgemein-schaft (DFG) and Open Access Publishing Fund ofOsnabrück

University.Supported by BMBF and Max Planck Society.This project has received funding from the EuropeanUnion's Horizon 2020 research and innovationprogramme under the Marie Sklodowska-Curie Grantagreement No 641805.]

The Salience Bias in Ensemble Decision-Making

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When comparing two sets of items based on size or position, we should be able to make a decision without influence from irrelevant visual features. However, across a collection experiments that asked subjects to compare the average value of two sets, seemingly arbitrary visual features biased which set a subject chose. Each experiment had over 800 trials. For each trial, subjects were shown two sets of 20 items and asked which set had the higher average vertical position. Each experiment had a distractor feature that varied the appearance of one set: including luminance (100% vs 50%), set size (20 vs 12), or item width (100% vs 66%). Comparing points of subjective equality showed a strong bias towards the more visually salient set as having a higher average position. Despite subjects getting feedback after every trial for hundreds of trials, the bias persisted. To counter the possible explanation that the bias is caused by subjects conflating the two features, additional experiments asked subjects to report the lower average position. Subjects were still biased towards the more salient set. The consistent direction of this bias even when inverting the task suggests a decision-making bias rather than a perceptual illusion.

Combining salience and temporal diffusion to model spatial attention

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Computational models of attention allow us to instantiate theories in ways that can be directly tested by experiment data. Salience and diffusion models use very different approaches, but they have each made significant contributions to our understanding of attention and orienting. Salience models predict shifts of overt attention based on bottom up features of visual input, and have been implemented with feature integration and deep convolutional networks. Diffusion models, meanwhile, mimic the neural accumulation of evidence toward a perceptual decision, and their strength lies in how the model's parameters inform us of underlying cognitive mechanisms. A new temporal onset diffusion model will be presented to demonstrate how the timing (early/late) or impact (bias/drift rate) can be used to distinguish various theories of cued facilitation. This model is a full simulation of human participants in a classic attention experiment, and begins with the same visual input and display changes over time. The model builds a salience map based on low level image features and uses peak salience and salience changes over time to inform accumulation in the drift diffusion. I compare multiple versions of the model using a standard cuing paradigm with forced choice discrimination responses to determine when and how responses are impacted by a non-informative exogenous cue. While reaction time distributions fit multiple theories of attention, patterns of errors and anticipations suggest that the cue increases the rate of information accrual at the validly cued location.

Theory of Visual Salience Processing

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A saliency map was defined by Koch and Ullman (1985) as a dynamic topographical map that combines information from individual feature maps into a real-number scalar measure of conspicuity. Originally it was used to predict the priority of locations in visual search. Lu and Sperling (1995) proposed that third-order motion was computed on the contents of a salience map. Gan, Sun, and Sperling (2021) report that frontal plane distance judgements between two disks are completely independent of the feature-composition of disks and whether the two features are the same or different. The representation of location, independent of feature, is the definition of a salience map. Centroid judgments (average positions of multiple-item arrays), which are representative of statistical summary representations, are substance independent (Sun, Wright, Chubb, Sperling, 2018). Moreover, in a 0.30 sec exposure of a 24-dot array containing a random mixtures of 8 dots of each 3 colors, subjects can make accurate centroid judgments of all three centroids, indicating at least 3 salience maps (Sun, Chu, and Sperling, 2021). Subjects can easily read colored isoluminant text indicating that letter shape is interpretable on a salience map. Salience processing is extremely efficient because the same maps can serve numerous different kinds of items and because different output processes (e.g., priority, motion computation, distance judgments, estimates of averages, shape recognition) can, in principle, operate on the same maps. Hypothesis: The brain salience processing stream is parallel to and essential to the feature (what) and location (where) brain processing streams.

Oculomotor training to re-reference the saccades in simulated central vision loss: effect of different scotoma conditions

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Individuals with central vision loss rapidly adopt an unaffected region, the preferred retinal locus (PRL), as a new fixation location. However, adopting the PRL as a saccade target, i.e., saccadic re-referencing to the PRL, typically develops more slowly. Recent studies suggested that training can expedite this process but accounts on how the scotoma conditions affect training are still incomplete. For instance, training with a clearly defined scotoma might lead to faster formation of PRL, and training with a semi-transparent scotoma might lead to longer-lasting PRL-use. Here, we compared the training with a semi-transparent and an opaque scotoma. Participants searched for a single C-target among 48 O-distractors in the presence of a 4° radius scotoma. The task was gaze-contingent, observers indicated the location of the target by peripherally fixating it with a pre-defined, forced retinal location (FRL), in the lower visual field below the scotoma. All participants completed pre- and post-tests with both scotoma conditions but were divided into two groups for a 3-session training. We compared observers' performance before, during and after the training. Participants in both groups showed improvement in performance (e.g., faster trial completion times) with the progression of the training, and between the pre- and post-tests. Similar to previous studies, our results indicated that participants peripherally fixated the targets with a FRL more precisely with opaque compared to semi-transparent scotoma, suggesting a benefit for training with a clearly defined scotoma. We further discuss the effectiveness of the training with respect to the progression of central vision loss. [This project was funded by DFG grant PO548/14-2. The authors declare no competing interests.]

Attention and working memory during multiple object tracking with and without binding of target identities

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Humans can flexibly allocate attention to keep track of multiple independently moving objects. When tracking unique objects, participants may often correctly report target locations, despite not knowing which of them is which. We directly compared multiple object tracking (MOT) when only locations of targets were tracked to when location-identity binding of tracked targets was required. Participants tracked a group of three disks of different colors moving among three distractors of the same colors in either the left or right visual field. In 'location' blocks, participants indicated the location of one target at the end trials. In 'location+identity' blocks, participants also indicated the color of the probed target. We measured steady-state visual evoked potentials (SSVEPs) elicited by the flickering objects and the contralateral delay activity (CDA) during tracking to assess attention and working memory, respectively. Accuracy in reporting target locations did not differ between location and location+identity conditions, but the color of correctly localised targets was often misreported in location+identity trials. The CDA did not differ between location and location+identity conditions. SSVEPs elicited by target stimuli were enhanced, and this enhancement was further increased in location+identity conditions. The processing of distractors differed neither between location and location+identity conditions, nor between the visual field in which targets were tracked and the ignored side. These findings suggest that additional attentional resources are recruited when location-identity binding is required and that target enhancement, but not distractor suppression, is utilised during MOT. The CDA does not seem to reflect feature-binding during tracking.

Talk Session 15: Multisensory Perception

Multisensory cortical representations of space and time

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Clear evidence demonstrates a supra-modal organization of primary sensory cortices. For instance, recruitment of the auditory areas by visual input has been reported in complex temporal tasks. At the same time, the visual cortex plays a crucial role in the development of complex acoustic spatial representations. The early recruitment of primary sensory areas seems necessary for the development of fine domain-specific, i.e., spatial or temporal, skills regardless of the sensory modality involved. Given these considerations, we hypothesized a domain-specific early activation of primary cortices to multisensory stimuli. Thus, we measured the ERPs and psychophysical responses of 16 participants while performing a spatial and temporal bisection task. Audiovisual stimuli occurred at three different spatial positions and time lags. Participants had to evaluate whether the second stimulus was spatially (spatial

bisection) or temporally (temporal bisection) farther from the first or third stimuli. We focused on the ERPs response in an early time window (50–90ms) generally involved in the earliest stages of multisensory integration. As predicted, audiovisual stimuli during spatial bisection elicited a more substantial early occipital ERP component selective for the spatial stimulus position. On the contrary, the temporal bisection task's early cortical response was more evident in the temporal areas. These findings support the pivotal role of visual and auditory circuits in multisensory spatial and temporal representations and suggest a domain-specific supra-modal organization of the brain. [The research is partially supported by the MYSpace project, which has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement No 948349).]

Impact of audio-motor training on spatiotemporal representations in long-term late blindness

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Vision plays a pivotal role in the development of spatial representations. Research has shown that, in some cases, blind people build auditory spatial maps by relying on temporal properties of the environment. In particular, late blind (LB) adults with more than 20 years of visual deprivation (i.e., long-term LB) represent space based on temporal coordinates. In the present study, we investigated whether audio-motor training providing auditory feedback of body movements would improve spatial representation strategies in long-term LB adults. Three long-term LB adults performed a battery of spatial tasks before and after one month of training with the ABBI device. The battery included: i) EEG recording during a spatial bisection task with coherent and conflicting spatiotemporal information, ii) auditory frontal and transverse localization tasks, where participants indicated the final position of a moving sound source, iii) proprioceptive-motor tasks, where participants discriminated the ending point of arm movements. The training consisted of spatial exercises in peripersonal and extrapersonal coordinates, respectively. The activities were based on upper-limb movements with auditory feedback positioned on the wrist. Results showed that the training improved both auditory and proprioceptive competencies and produced early recruitment of visual and auditory areas sensitive to spatial instead of temporal auditory information. [The authors would like to thank the MYSpace project, which has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation program (grant agreement No 948349), for the support to this study. The research presented here has been supported and funded by Unit for Visually Impaired People, Istituto Italiano di Tecnologia (Genoa, Italy).]

Susceptibility to a multisensory illusion is linked to differences in cognitive function in older adults

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The ability to perceive multisensory information is known to be affected by the ageing process but it is unclear how it relates to cognitive function. One way to measure multisensory integration in the audiovisual domain is via the Sound Induced Flash Illusion (SIFI), where presenting one visual flash with two auditory beeps produces the perception of two flashes. In young adults this illusion typically occurs only when stimuli are presented close in time (at short Stimulus Onset Asynchronies, SOAs), however older adults remain susceptible over longer time intervals suggesting the SIFI probes the temporal dynamics of multisensory function. Here, we explored the relationship between SIFI performance and cognition in 2920 older adults aged over 50 years from The Irish Longitudinal Study on Ageing (TILDA). As expected, age was associated with increased susceptibility to the illusion at long SOAs, suggesting older adults were more likely to integrate stimuli presented with larger temporal discrepancies. Moreover, across individuals, increased SIFI susceptibility at long SOAs was associated with a number of cognitive measures including slower Choice Reaction Times, slower completion of the Colour Trails Task and more errors of omission (but not commission) in a Sustained Attention to Response Task (SART). Using k-means clustering we then identified groups showing differing longitudinal trajectories for immediate recall, delayed recall and verbal fluency. Across measures, healthier cognitive trajectories were associated with lower susceptibility to the SIFI at long SOAs. Our findings support global links between the temporal dynamics of multisensory perception and cognitive function in ageing. [This work was supported by the Health Research Board (HRB), Ireland.]

Audiovisual interaction for spatial attention

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We reported asymmetry of audiovisual interaction of spatial attention: auditory attention enhanced visual responses whereas visual attention suppressed auditory responses under unimodal attention conditions (VSS, 2021). To investigate this asymmetrical attention effect, we conducted an experiment under conditions where attention is paid to both audio and visual stimuli simultaneously. There are two attention conditions: in one condition, the task was to detect audio or visual target at the same location (same condition) and in the other condition, the task was to detect audio or visual target at different locations (different condition). We measured attentional modulation in visual/auditory processing at 11 stimulus locations along a horizontal line, using a technique with Steady State Responses (SSRs) of electroencephalogram signals. At each of the 11 locations, a letter on a flickering disc and an amplitude modulated sound were presented. The SSRs were extracted based on the temporal frequency tagged to each location. The results showed that the auditory response decreased more in the same condition than in the different condition. This is similarly to the previous unimodal attention experiment, which showed a decrease of the auditory response at the location of the visual attention. The auditory attention, on the other hand, did not show statistically significant effect on the visual responses, also consistently with the unimodal attention results. We conclude that visual attention suppresses auditory response at the focus of visual attention independently of task requirements for auditory stimuli, either ignoring or attending to auditory stimuli. [KAKENHI 19H01111.]

Visual and tactile signals to duration of object-contact are not integrated statistically optimally

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Vision and touch both signal when the hand makes contact with objects, providing important input to hand function. Based on previous work (e.g. on visual-haptic integration), we might expect visual and tactile object-contact signals to be integrated, improving performance beyond that with either signal alone. Previous studies have asked whether vision- and touch-derived estimates of the duration of object contact are integrated, with equivocal results. These studies may, however, have reduced the likelihood of observing integration; they presented 'structurally' different visual and tactile stimuli (e.g. a light vs. vibro-tactile stimulation), in different spatial locations, increasing the likelihood of the brain inferring that the signals were unrelated, and so should not be integrated. We measured subjects' (n=20) ability to discriminate the duration of contact signals presented in tactile only, visual only, and visual-plus-tactile conditions (2-IFC). To maximise the likelihood of integration, we delivered both visual and tactile stimuli using the same device (a solenoid). In the vision-only condition, the solenoid touched a model finger designed to equate the visual information to the visual-plus-tactile condition, in which the real finger was touched. We measured duration discrimination thresholds in each sensory condition, at 500, 650 and 800 ms base durations. We used the single-modality data to predict optimal visual-tactile performance (using an MLE model). Our results showed no consistent pattern of improved performance with visual-plus-tactile stimulation compared to with one sense alone. We conclude that the brain does not integrate visual and tactile signals to finger-contact duration, despite the redundancy in signals.

Self-reported vividness of tactile imagery for object properties and body regions: an exploratory study

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Mental imagery has been explored mostly in the visual domain, with comparably less attention paid to tactile imagery. Given evidence for a distinction between active and passive touch, an outstanding question is whether object-based tactile imagery is associated with body-based somatosensory imagery. Here, we explored mental imagery in object-based (tactile mental imagery; TMI) and body-based (somatosensory mental imagery; SMI) contexts in a sample of 215 participants. For TMI, participants imagined touching five objects (bubble wrap, ice cube, sandpaper, velvet, wet sponge) along four object properties (force, surface compliance, texture, weight). For SMI, participants imagined being stroked by a paintbrush across 21 body locations. Participants reported the vividness of their imagery in both tasks on a 7-point Likert scale. Our results showed variations in imagery vividness across objects and

object properties, with highest ratings to a wet sponge and texture and lowest ratings to velvet and weight. The face was rated as most sensitive and the lower body as least sensitive to imagined stroking. Ratings were higher to glabrous compared to hairy skin sites. Imagery vividness was more pronounced for TMI than SMI and ratings on both tasks were weakly, positively correlated. Our findings provide evidence for the ability to imagine tactile experiences and for variations in object- and body-based tactile imagery vividness. Our findings also suggest a limited generalisation of tactile imagery abilities across different active and passive tactile experiences, consistent with findings on tactile perception. [This work was supported by a TCD postgraduate scholarship to AO'D, by the European Union's Horizon 2020 grant agreement No. 732391 and Science Foundation Ireland, grant no. 19/FFP/6812 awarded to FNN.]

Thursday August 26th

Talk Session 16: Depth, Stereo & 3D

Seeing reversed depth in contrast-reversed random-dot stereograms in central vision

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In contrast-reversed random-dot stereograms (CRRDSs), a black dot in one eye matches a white dot in the other eye. Disparity tuned neurons in primary visual cortex (V1) respond to CRRDS as if reporting reversed depth. However, humans generally perceive reversed depth only in peripheral vision (Zhaoping & Ackermann 2018, Perception), because feedback from higher visual areas to V1, to aid recognition and/or veto misleading V1 signals, is stronger in central vision. When contrast-reversed and contrast-matched random dots are mixed in a random-dot stereogram (RDS) that is presented so briefly that feedback is ineffective, the reversed depth signals are not vetoed in central vision. These signals then enhance or degrade depth perception depending on their agreement with normal depth signals from the contrast-matched dots (Zhaoping 2021, Vision Research). Here, we show that observers can perceive the reversed depth of a disk surface made entirely of contrast-reversed dots in central vision, likely because feedback is sufficiently compromised or downweighted during perceptual decision making. We achieved this by backward masking the (200 millisecond) RDS and, in some trials, making the RDS dynamic by replacing the random set of dots with an independent random set every 10 millisecond (without changing the disk's disparity). In each trial, the random dots for the disk were all contrast-reversed or all contrast-matched, the RDS was static or dynamic. Observers reported the reversed depth order between this disk and a surrounding ring more frequently than chance for both dynamic and static RDSs, but far more frequently for the former. [Supported by University of Tübingen and the Max Planck Society.]

The stereoscopic orientation anisotropy decreases with increasing temporal frequency

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In stereovision there is a well-known orientation anisotropy: the sensitivity for sinusoidal corrugations of low-spatial frequencies is much higher for horizontal than for vertical orientations (Bradshaw & Rogers, 1999). Previous studies have shown that the response of the visual system is faster to horizontal than to vertical slanted surfaces (Guillam, et al, 1988; Bradshaw et al., 2002). Here, using Bayesian staircases in a 2iFC task, we estimate the strength of the stereo anisotropy measuring stereo thresholds for vertical and horizontal stereo gratings of four spatial frequencies (SF=0.1, 0.2, 0.4, 0.8c/deg) and five temporal frequencies (TF=0, 1, 2, 4, 8Hz). Stimuli were presented using a PROPixx projector (120 Hz), circular-polarized glasses, and mode RB3D. Sinusoidal corrugations were constructed using white random dots updated every frame and were presented inside a circular window of diameter of 24deg. Results show that the spatial frequency where we have maximum sensitivity, independently of the TF and orientation, is 0.4c/deg. The log-ratio between vertical and horizontal thresholds (i.e. strength of the anisotropy) decreases with the increasing of the SF. Disparity thresholds as a function of the TF shows in general a low-pass shape, where thresholds are higher as the TF increases. However, for 0.1c/deg and vertical orientation, thresholds were almost independent of the TF. The strength of anisotropy for SF higher than 0.2c/deg is constant for all temporal frequencies. However, for 0.1c/deg, we found that the log-ratio strongly decreases with increasing TF. Our results shows that the orientation-anisotropy depends strongly on the temporal frequency.

The zone of good stereo in 3d displays: tolerance of stereoscopic depth perception to vergence-accommodation conflicts does not depend on age-related changes in the ability to accommodate

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Vergence-accommodation conflicts in conventional stereoscopic displays not only cause discomfort, but also degrade stereoscopic depth perception (impaired stereoacuity, stereoscopic fusion), with potential functional consequences. Factors that predict tolerance to conflicts remain relatively unexplored, yet could be used to optimise content for different user groups. We measured the tolerance of stereoscopic depth perception to stimuli presented in-front-of and behind the screen. We also examined the relationship between this 'zone-of-good-stereo' and factors that would be expected to predict it, in particular age-related changes in the ability to accommodate (presbyopia). We measured the zone of good stereo at screen distances of 1.3, 0.7 and 0.1 dioptres, in 45 observers aged 18-75 years. To do this, we varied the magnitude of vergence-accommodation conflict (using an adaptive staircase), determining the conflict required to produce a criterion reduction in stereoacuity (compared to a no-conflict baseline). Stereoacuity was assessed by 2-AFC orientation judgements of random-dot defined sinusoidal corrugations-in-depth. We characterised observers' accommodation ability using the slope of the linear portion of their accommodation stimulus-response functions. The zone of good stereo was largest nearer than the screen (rather than farther), resembling estimates of the 'zone of comfort' at the same distances. Tolerance to vergence-accommodation conflicts was, however, not systematically related to the ability to accommodate (or to age per se). If anything, zones of good stereo were worst in observers with emerging presbyopia (intermediate accommodation ability). Overall, our results suggest that tolerance to vergence-accommodation conflicts is idiosyncratic, making it difficult to optimise stereoscopic content for particular user groups. [Funded by European Union's Horizon 2020 research and innovation programme under the Marie-Skoldowska-Curie Grant Agreement No. 765911.]

Top-down effect on pupillary response: Evidence from shape from shading

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Shaded 2D images often create an illusion of depth, due to the shading information and assumptions regarding the location of the light source. Specifically, 2D images that are lighter on top usually appear convex while images that are darker on top, usually appear concave, reflecting the assumption that light is coming from above. The process of recovering the 3D shape of a shaded image is called Shape-from-Shading. Here we examined whether the pupil responds to the illusion of depth in a shape from shading task. In three experiments we show that pupil size is affected by the percept of depth, so that it dilates more when participants perceive the stimulus as concave, compared to when they perceive it as convex. This only happens if participants make a judgment regarding the shape of the stimulus or when they are made aware of the different shapes. No differences in pupil size were found with passive viewing if participants were not aware of the illusion, suggesting that some aspects of shape-from-shading require attention. All stimuli were equiluminant, and the percept of depth was created by manipulating the orientation of the shading, so that changes in pupil size could not be accounted by changes in the amount of light in the image. We posit, and confirmed it in a behavioral control experiment, that the perception of depth is translated to a subjective perception of darkness, due to the "darker is deeper" heuristic and conclude that pupillary physiological response reflects the subjective perception of light.

Sequential dependencies in the perception of 3D shape-from-shading are driven by age-sensitive heuristics

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Ambiguous images of shaded objects can produce stable 3D shape percepts, a phenomenon thought to reflect prior assumptions about the light source direction. However, shading is not always associated with consistent judgements of 3D shape, suggesting that other contingencies may affect 3D perception. We analysed sequential effects on participants' 3D shape judgements in young (aged 18-35) and older adults (aged 60+) using a shaded stimulus whose orientation varied randomly from trial-to-trial. No feedback was given to participants. Young adults made the most convex judgements when the bright edges of the stimulus faced above and to the left, consistent with an above-left light source prior. Furthermore, greater convexity scores were obtained on the current trial when the previous stimulus faced down and to the right. Older adults were more likely to have an overhead assumed light source direction and showed a smaller effect of the current and previous stimulus orientation.

Both groups showed a comparable tendency to report the same 3D shape as the previous trial. Older adults showed a greater tendency than young adults to report, on the current trial, the same shape as previous trials when both trial's orientations were similar, and the opposite 3D shape when the current and previous trial orientations were dissimilar. We conclude that (1) the perception of shape-from-shading is driven by both light priors and processes that exploit the recent sensory and perceptual history of the observer and (2) that ageing shifts the balance toward the latter.

A new perspective on the Ames Room

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Ames (1952) created his trapezoidal-shaped room to make the point that there can be many different 3-D scenes that create exactly the same pattern of light at the eye. When viewed through a peephole, an Ames Room looks like a normal, rectangular room, which is not surprising. However, peephole viewing means that observers can only view the room from a single, stationary viewing position meaning that the disparity and motion parallax information that would normally be present, is not available. We investigated whether the presence of either binocular disparities or monocular motion parallax would allow observers to see the true 3-D shape of an Ames trapezoidal room. Our virtual Ames Room was displayed on a large 40° x 35° non-depolarising screen, 320cm from the observer, and viewed either stereoscopically or with monocular motion parallax. Observers viewed either a normal room with disparities or parallax appropriate to a rectangular room or an Ames room with disparities or parallax appropriate to its trapezoidal shape. The perspective characteristics of the room were also varied from those of a real room to just the room's contours. All six observers reported that the Ames Room looked like a normal, rectangular room, despite the presence of contradictory disparities or motion parallax. These results show that the perspective information provided by the walls, floor and ceiling of an Ames Room can override disparities and parallax and hence provide further evidence of the importance of perspective in the perception of the 3-D world. [Supported by the Leverhulme Trust, UK.]

Talk Session 17: Social Perception

Social-affective features drive representations of human actions

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Everyday actions vary along many visual, social, and action-related dimensions, such as the scene where the action takes place, the degree of social interaction it involves, and the semantic category of the action. Which of these dimensions organize human action representations? To answer this, we curated naturalistic videos of everyday actions from the Moments in Time dataset (Monfort et al., 2019). Using image properties, behavioral ratings, and experimenter labels, we characterized the stimuli in terms of visual features (e.g. action setting and activations from a convolutional neural network), social-affective features (number of agents, sociality, valence, arousal), and action features (action category, transitivity, activity, and body parts involved). In two multiple arrangement experiments, participants arranged two sets of 152 and 65 videos according to their broadly-defined similarity. Using cross-validated variance partitioning, we found that social-affective features explained behavioral similarity judgments better than, and independently of, visual and action features in both experiments. In a separate experiment, we recorded electroencephalography (EEG) data while participants viewed 500 ms segments of the 152 videos from the first stimulus set. EEG patterns reflected behavioral similarity between 100-800 ms after video onset. While much of the early variance in this behaviorally relevant signal was explained by visual features (100-200 ms), the later portion of the variance (400-800 ms) was best explained by social-affective features. Together, our results suggest that socially relevant dimensions play a critical role in how we represent others' actions in naturalistic settings. [This material is based upon work supported by the Center for Brains, Minds and Machines (CBMM), funded by NSF STC award CCF-1231216.]

People prefer retuning trajectory rather than speed to avoid collisions with others

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People need to avoid collisions with other pedestrians during walking. To achieve that, people use visual information to estimate the possibility of a collision and either adjust their walking trajectory, speed, or both. It is unclear which strategies people use to avoid collisions. In this study, we conducted two experiments to examine participants' strategies. In Experiment 1, 25 participants were asked to wear a VR HMD and steer towards a target 13 meters away from them in a virtual environment. After walking for 3 meters, a walking virtual human appeared in their visual fields. The speeds of the virtual humans were 0.8, 1, or 1.2 times the average walking speed of each participant. Participants were asked to bypass the virtual human from either the left or right side and reached the targeted position. In Experiment 2, the same group of participants performed the same task except they were asked to freely choose the side to bypass the virtual human. In both experiments, we found that participants were more likely to retune their walking trajectories rather than their speeds to avoid possible collisions. Our findings illustrate the rules governing human locomotion in a dynamic scene and provide insight for developing more human-like navigation algorithms for social robots. [National Natural Science Foundation of China (No. 31771209); National Natural Science Foundation of China (No. 32022031)./No conflict of interest declared.]

Asymmetry disrupts the self-prioritization effect

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It is well established that individuals can create strong and reliable associations between an arbitrary stimulus, such as a geometrical shape, and the self. Here, in two experiments we tested whether such an association can be modulated when the symmetry of the shape is considered. Participants were first asked to associate, in one condition, the 'self' with symmetrical shapes and a 'stranger' with asymmetrical shapes, while, in another condition, the association was inverted (i.e., self-asymmetrical vs. stranger-symmetrical). The two conditions were manipulated either within (Experiment 1, lab-based) or between (Experiment 2, online) participants. In both experiments, participants were involved in a speeded classification task requiring to classify a given shape (symmetrical vs. asymmetrical) and a label ('you' vs. 'stranger') as matching or nonmatching with the previously learned association. In both experiments, faster responses and greater accuracy emerged when both the shape and the label matched with the self-identity with respect to all other conditions, but this was true only for the condition in which the self was associated with symmetrical shapes. Indeed, when the self was associated with asymmetrical shapes, no evidence of such a self-prioritization effect emerged at all. These results will be then discussed with reference to possible differences in valence (positive vs. negative) that can be ascribed to symmetry/asymmetry dimension.

Experiencing Face Masks. About the impact face masks have on perception and action

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Wearing face masks was one of the essential practices to mitigate the COVID-19 pandemic and it will certainly be applied in the future to reduce the risk of acute infections. The everyday usage comes at a price in terms of changed perception and behavior. Within the first wave of COVID-19 in April 2020, when masks were mostly unfamiliar to Western people, we started our series of experiments which continues until recently. In a first study (N=88) we showed that acceptance of wearing masks depends very strongly on the Umwelt's wearing behavior. Furthermore people were assessing the mere outward appearance of so-called community masks as less strange than FFP2 masks or (black) loop scarfs. In a 2nd study (N=36), we showed that facial emotions are very hard to read when opponents wear masks, especially reading disgust was hardly possible. In a 3rd study (N=57), school kids aged 9-10 years did quite well in reading emotions in masked faces, but they showed dissociative confusion matrices of emotions—and kids did even better in recognizing anger and the neutral state in masked faces. In Study 4, we analyzed the physical locomotion pattern of adults (N=24) when approaching a mannequin with a fully balanced mask on/of design for participants and the mannequin. Although participants were fully free how

they approach the mannequin when listening to recorded messages emerging from the site of the mannequin, they took distances dependent on the masks-configuration. As soon as the mannequin wore a mask, they consistently reduced social distancing.

Contrast effect of emotional context on interpersonal distance regulation

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In social interactions, valence-based judgements represent an important component of interpersonal distances regulation. However, valence-based judgments are sensitive to the emotional context in which social interactions take place. More precisely, the Range-Frequency model (Parducci, 1965) predicts a contrast effect of the emotional context when judging the valence of an emotionally neutral stimulus (i.e., a negative correlation between the valence rating of a neutral target and the valence of the emotional context). In the present study, we investigated whether the induction of a contrast effect on valence rating of emotionally neutral social stimuli could lead to congruent interpersonal distances regulation. In an online experiment, two groups of participants were presented with human-like virtual characters showing either a neutral facial expression (target-stimuli) or an emotional facial expression (contextual stimuli) in two successive sessions (angry then happy emotional context or vice-versa). During each session, the participants were exposed to the virtual characters and then rated them in terms of valence and judged the appropriateness of different interpersonal distances. The results showed a contrast effect of emotional context on valence rating of neutral characters, which extended to interpersonal distance judgments, although sparingly. Overall, the data suggest that although the emotional context influenced perceptual-related valence-based judgments of social stimuli, it had a parsimonious effect on action-related interpersonal distance regulation, presumably because the latter relied more on emotional facial expression information of the social stimulus.

Learning from illusions : from ambiguity to alterity

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Visual illusions are fascinating. Beyond scientific and academic purposes, two main interests of visual illusions deserve to be developed. First, they help developing consciousness that our sensory systems do not capture reality. This is precisely what the concept of illusion is meant to express. This first step contributes to being more open to the other's perception, i.e. other interpretations of the reality. The second level concerns the understanding that perception is intrinsically tied to one's point of view, which is most striking with 3D illusions. The embodied experience of this law of perception ideally requires seeing an ambiguous object from one point of view and confront it to another's point of view. Prof Kokichi Sugihara's illusions provide the optimal material for this set-up : one may undoubtedly see a square while the opposite pair unequivocally sees a circle. Swapping physical point of view leads to a striking realization that may even lead to a kind of embodied shock. Participants get an embodied experience of changing perception. Additionally, they gain a full experience of what the other was seeing and which description initially did not make any sense to them. They embrace the limitations, validity and complementarity of one's point of view at once, and by experience rather then by explanations. We will present theoretical bases and experimental setup and experiments in healthy subjects and patients showing the unique efficacy of Sugihara's ambiguous objects on developing openness to others, and their implications for the development and the rehabilitation of social cognition.

Talk Session 18: Crowding & Spatial Vision

Cross-language comparison of semantic and phonological priming from crowded words: The case of Chinese vs. Hebrew

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Visual crowding refers to the failure to consciously perceive objects that are closely clustered together, especially in the periphery; nevertheless, a semantically-related Chinese character crowded by flankers generates a robust semantic priming effect. It remains unknown if semantic information can be extracted from crowded words in other language systems and whether phonological information can also be extracted under visual crowding. We investigated whether semantic priming and phonological priming survive visual crowding with Chinese and Hebrew—language systems that regard semantics and phonetics differently. In two experiments, participants were instructed to conduct a lexical decision task with a crowded or isolated prime presented in the upper visual field. The subsequent target was either semantically related or phonologically related to the prime. Primes and targets were single Chinese characters or 3-letter Hebrew words. Semantic priming effects were found with Taiwanese participants in both isolated and crowded conditions, whereas Hebrew speakers showed no priming effect and slower reaction times in the crowded condition. In contrast, phonological priming effects were found with Hebrew speakers in both isolated and crowded conditions, whereas Taiwanese participants only showed phonological priming effects in the isolated condition. Our results show that language systems shape our visual processing in the periphery, which may influence reading behaviors. As the crowded primes were unrecognizable, this study also suggests that semantic processing and phonological processing rely on different encoding mechanisms from those serving identification and that the involved mechanisms are highly dependent on language experience. [This study was supported by the Ministry of Sciences and Technology in Taiwan (MOST 107-2410-H-002-129-MY3).]

Temporal Crowding at the Fovea: Online and Lab studies

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One limitation of our visual system is that target identification is impaired when other distractors appear in spatial proximity to the target. Target identification is also impaired when the distractors appear before- and after the target at the same location – crowding in the temporal domain. Importantly, such impairment exceeds the classical time-course of masking. Yet, the exact nature of this impairment is not clear. In the current study, we used a continuous-report task with a Mixture-Model Analysis to examine which aspect(s) of visual processing is impaired, and the degree of interference generated by each distractor. Participants were shown a sequence of three orientated lines, separated by relatively long inter-item intervals (200 – 400 ms). Critically, unlike previous studies, the sequence of stimuli was presented at the center of the screen. Participants adjusted a probe to match the orientation of the second line (the target). The experiments were conducted online. Experiment 1 included high-contrast stimuli embedded in noise, and Experiment 2 included low contrast stimuli without noise. The results of both experiments replicated previous results (at the periphery) of decreased precision of target report and increased substitution errors, but in Experiment 2 we also found an increase in guessing rate. Interestingly, unlike peripheral presentation, the last distractor had a more detrimental effect than the first one. We further replicated these results at the lab. We conclude that temporal crowding can occur even with foveal presentation and that temporal crowding can be studied reliably with online experiments. [This research was funded by the Israel Science Foundation (ISF) grant to Y.Y. (No. 1780/19).]

Population receptive field size in (un) crowding: to isolate or to combine?

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Traditional models posit that visual processing is local and feedforward. In this vein, crowding is explained to be the result of pooling of target and flanker features in early visual areas. Specifically, it has been suggested that when the target and flankers fall within the same receptive field, their features are pooled together, resulting in an irreversible loss of information and degraded performance. A recent fMRI study investigated the relation between crowding strength and population receptive field (pRF) sizes (He et al., 2019). The authors reported that stronger crowding coincides with larger pRF sizes in V2, suggesting that pooling occurs in V2. Here, we investigated pRF size in crowding, no crowding and uncrowding, in which adding flankers leads to improvements in target discrimination, contrary to what traditional models of crowding predict. We replicated previous findings of increased pRF size in crowding as compared to no crowding, with pronounced differences throughout early visual areas (V1 to V4, not only V2). Surprisingly, uncrowding coincides with the smallest pRF size, even compared to the no crowding condition, in which behavioral performance is best. Thus, pRF size is modulated by global context and the relationship between pRF size and behavioral performance is non-monotonic. Our findings suggest that pRF size is modulated by top-

down feedback, which goes against the classic, purely feedforward models of crowding. We propose that pRFs are the means by which the brain either combines or isolates the target and the flankers – reflected in behavioral performance as crowding and uncrowding, respectively. [We would like to thank our funding sources: Swiss National Science Foundation (176153, http://p3.snf.ch/Project-176153; NCCR Synapsy, project grant numbers 32003B_135679, 32003B_159780, 324730_192755 and CRSK-3_190185), Leenaards Foundation, ROGER DE SPOELBERCH and Partridge Foundations.]

A common cortical basis for variations in visual crowding

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Crowding disrupts our peripheral vision. Variations in crowding strength are well documented, with stronger performance decrements in the upper (vs. lower) visual field and for flankers on the radial (vs. tangential) axis around fixation. Crowding also induces variable perceptual effects – target and flanker objects appear more similar (assimilation) in some instances and more dissimilar (repulsion) in others. Although appearance variations have been attributed to the cortical distance between elements, performance variations are more often linked with receptive-field properties. Could a common factor drive all these effects? We first demonstrate that variations in performance and appearance follow a common pattern, using the upper-lower and radial-tangential anisotropies. When observers judged the orientation of a crowded target Gabor, both threshold elevation (performance) and assimilative errors (appearance) were higher in the upper vs. lower field. Similarly, radial flankers produced high threshold elevation and assimilation, while tangential flankers gave lower elevation and repulsion errors. We replicate this pattern with a population-coding model of crowding that varies the weighted combination of target/flanker responses. Further simulations reveal that cortical distance incorrectly predicts these variations, making it an unlikely common factor. This role could however be served by receptive field overlap, which determines the spatial distribution of target/flanker responses. By varying receptive field size and shape, we demonstrate high overlap between response distributions where crowding is strong and assimilative, and low overlap where errors are low and repulsive. Overlap could thus determine the weighted combination of target/flanker responses, driving variations in both appearance and performance in crowding. [Funded by the UK Medical Research Council.]

Temporal dynamics of visual population receptive fields

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A wealth of previous research has investigated the spatial profile of receptive fields in the human visual cortex, with receptive fields generally considered to increase in size along the visual hierarchy. In contrast, little is known about the temporal dynamics of information transmission through the visual cortex. In this exploratory study, we investigated how receptive field size might vary over time as information flows through the visual hierarchy. Participants (n=9) viewed a circular stimulus sequentially flashed across the visual field while electroencephalogram (EEG) data were recorded. We used forward encoding modelling to map the visual field and investigate the temporal dynamics of population receptive fields. First, we showed that the precision of position representations (in polar angle) was roughly equal across eccentricities. This indicates that neurons responding to regions of visual space closer to the fovea have receptive fields covering a smaller visual angle than peripheral visual neurons, consistent with previous studies that used invasive recordings or functional magnetic resonance imaging. In addition, we observed that population receptive fields transiently narrowed 100ms and 200ms after stimulus onset. This timing is consistent with activation of early visual cortex during an initial feedforward sweep of activity, and a subsequent reactivation following a feedback sweep. Our study demonstrates how EEG can provide unique insight into the temporal dynamics of spatial information processing in the visual system.

Sustained attention operates via dissociable neural mechanisms across different eccentric locations

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In primates, foveal and peripheral vision have distinct neural architectures and functions. However, it has been debated if selective attention operates via the same or different neural mechanisms across these different eccentric locations. We hypothesized that the discrepancies between past results arose in part from the differences in neural signals used to index attentional modulations and the differences in task difficulty across eccentricities. Here, we measured three EEG indices of visual processing, while human subjects performed a visual attention task, where they either attended to the fixation or to the visual stimuli presented at different eccentricities. These EEG indices include the amplitudes of the steady-state visually evoked potentials (SSVEPs), the sustained negative deflection (SND), and the alpha band activity. Critically, we equated task difficulty across the different attention conditions and eccentricities. Overall, the amplitudes of these neural markers reduce as a function of eccentricity, reflecting changes in cortical magnification. However, they expressed totally different patterns of attentional modulations across eccentricities. The SSVEP exhibited prominent attentional gain modulations at the peripheral locations, but attentional modulations were significantly reduced at the parafoveal locations. In contrast, the SND showed relatively similar levels of attentional modulations across the parafoveal and the peripheral locations. On the other hand, alpha band activity exhibited significant attentional modulations only at the peripheral locations, which relied primarily on the relative differences between the contralateral and ipsilateral signals. Taken together, these results suggest that sustained visual attention comprises multiple biophysical processes that differentially impact sensory information processing across eccentricities. [This project was funded by NEI R01 to GW. This project was also funded by the National Research Council of Thailand grant (fiscal year 2021), the Thailand Science Research and Innovation Basic Research grant (fiscal year 2021 under project numbers 64A306000016 and fiscal year 2020 under project number 62W1501), the Asahi Glass Foundation grant, the research grant from the Research & Innovation for Sustainability Center, Magnolia Quality Development Corporation Limited, Thailand, the KMUTT Partnering initiative grant (fiscal year 2021), and the startup fund for junior researchers at King Mongkut's University of Technology Thonburi (KMUTT), and the KMUTT's Frontier Research Unit Grant for Neuroscience Center for Research and Innovation to SI.]

Talk Session 19: Visual Cognition II

The Level of Processing Modulates Visual Awareness

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How does a stimulus transition to awareness? Does it occur gradually or in an all-or-none manner? The level of processing hypothesis (LoP) recently proposed that awareness is graded for low-level stimulus characteristics (i.e. energy, features) whereas dichotomous for high-level (i.e. letters, words, meaning) stimulus perception. Here, we explored the behavioral patterns and neural correlates associated to different depths (i.e. low vs. high) of stimulus processing. In the low-level condition, participants had to identify the color (i.e. blue/blueish vs. red/reddish) of the target, whereas in the high-level condition they were asked to identify stimulus category (animal vs. object). Results showed that the level of processing manipulation produced significant differences in behavioral performance, the low-level task producing more intermediate subjective ratings and linearly increasing accuracy performances. Electrophysiological recordings revealed the two typical correlates of visual awareness, an enhanced posterior negativity in the N200 time window (Visual Awareness Negativity, VAN), and an enhanced positivity in the P3 time window (Late Positivity, LP). Interestingly, ERP analyses showed a double dissociation between awareness and the LoP manipulation: whereas awareness modulated VAN amplitudes only in the low-level color task, LP amplitude modulations were observed only in the higher-level category task. These findings are compatible with a two-stage microgenesis model of conscious perception, where VAN would index an early elementary phenomenal sensation of the stimulus (i.e. the subjective perception of color), and stimulus' higher-level properties (i.e. the category of the target) would be reflected in the later LP latency range.

It makes sense, so I see it better! Contextual information about the visual environment increases its perceived sharpness

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Predictive coding theories of visual perception postulate that expectations based on prior knowledge modulate the processing of information by sharpening the representation of expected features of a stimulus in visual cortical areas. This would facilitate the processing of expected visual stimuli, in terms of processing speed or accuracy. However, little is known about how expectations affect perception. Our study investigated the influence of expectations based on prior experience and contextual information on the perceived sharpness of objects (Experiment 1) and scenes (Experiments 2 and 3). In Experiments 1 and 2, we used a perceptual matching task. Participants were presented with two blurred images depicting the same object or scene and had to adjust the blur level of the right object or scene to match the blur level of the left one. We manipulated the availability of relevant semantic information to form expectations about the image's content via scrambling of the object background or scene inversion so that one of the two images contained meaningful information while the other one was meaningless. Results revealed that at an equal level of blur, meaningful objects and scenes were subjectively perceived as sharper than meaningless ones. This was confirmed by results of Experiment 3 involving explicit sharpness judgments on stimuli. These findings support the sharpening account of predictive coding theories by showing that expectations increase the perceived sharpness of the visual signal. Expectations about the visual environment not only help us to understand it more easily, but also makes us see it better.

Learning and retention of the gist of abnormality in mammograms after perceptual training of naïves

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Gist extraction processes global image statistic from scenes, allowing us rapid categorization into kitchens or forests, or, for medical experts, from medical images into those with or without cancer. We investigated whether and how naïve observers learn a novel gist category (medical abnormality) through 9 sessions of rapid exposure perceptual training with only categorical feedback (cancer present/developing or absent) on 6480 unilateral mammograms of 5 image types: normal, obvious abnormal, subtle abnormal, normal contralateral to abnormality, and prior to abnormality. Performance was compared between pre-, post-training, and retention tests with 180 cases and 500 ms exposure. At post-training, most participants (7 out of 8) improved their detection of abnormality in mammograms acquired years prior to onset of visible cancer, while 4 improved for obvious, 6 for subtle lesions, and 5 for normal contralateral to abnormality. D' prime increased by .15±.063SE across image type after training. At retention, however, it dropped back down to near-baseline levels (retention-pre-test: .05±.063SE). Training a V1-based computational model (19 orientations, 9 frequencies) adapted from Petrov, Dosher, and Lu's multi-channel Hebbian reweighting Perceptual Learning Model (2005) on the same images did not induce learning, suggesting that learning must occur in higher processing areas. Findings show that training with categorical feedback is sufficient to induce learning of a novel gist category, likely through statistical learning, but more long-term or even continuous exposure might be required for a new category to be preserved. Learning likely involves global image statistics since it is more evident in mammograms without localizable abnormalities.

Location uncertainty does not boost unconscious processing under CFS

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Previous research suggests that selective spatial attention is a determining factor for unconscious processing under continuous flash suppression (CFS), and specifically, that inattention toward a stimulus location facilitates the unconscious processing of this stimulus by reducing the depth of CFS (Eo, Cha, Chong, & Kang, 2016). The aim of our study was to further examine this modulation-by-attention model of CFS using a number priming paradigm. Participants (N=26) performed a number comparison task on a visible target number ("compare target to five"). Prime-target pairs were either congruent (both smaller, or both larger than five) or incongruent. Spatial attention toward the primes was varied by manipulating uncertainty of the primes' location. Based on the modulation-by-attention model, we hypothesized: In trials in which the location of the primes was uncertain, reaction times (RTs) for congruent prime-target pairs should be faster than for incongruent ones. The Bayes Factor analysis of our data shows no effect of location uncertainty on unconscious priming under CFS. We discuss our findings in the context of recent MVPA-fMRI data from our lab and argue that location uncertainty is probably not the key factor capable of

reconciling the divergent CFS results. [No conflict of interest.]

Is conscious perception gradual or binary?

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According to the global neuronal workspace theory, conscious perception requires a large all-or-none change in neural activity. In contrast, for the last several decades, the most prominent mathematical models of perceptual tasks have assumed that perceptual representations are gradual and binary patterns of behavioural reports originate from the decision stage. In the present study, we used cognitive modelling to evaluate the evidence for an all-or-none process underlying conscious perception in a series of experimental paradigms that have previously been argued to provide evidence for either gradual or binary conscious perception. In a masked orientation discrimination task, a masked colour discrimination task, a masked numerical discrimination task and an attentional blink paradigm with a word detection task, fitting cognitive models revealed that binary models were conclusively outperformed by gradual models in accounting for the distribution of visibility judgments. Moreover, we reanalysed audibility judgments from an auditory detection experiment that had previously been presented as evidence for a binary threshold underlying conscious perception. Again, model fitting showed that the data was best accounted for by gradual models. Overall, we find no evidence for an all-or-none process underlying conscious perception.

Contextual Cueing May Not Be Unconscious

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Contextual cueing often aims to demonstrate that participants learn contextual cues implicitly, or unconsciously. We propose a method to test whether learning was indeed unconscious or not. Our method—the Sensitivity Comparison—is needed because the standard method is flawed: It seeks to demonstrate a reaction time (RT) effect in a visual search task and a close-to-chance performance in a subsequent recognition task. The RT effect shows that participants have recognized the contextual cues, which is considered unconscious due to the close-to-chance direct recognition performance. But this interpretation is flawed because the close-to-chance (yet above chance) direct recognition performance indicates residual conscious awareness that may fully explain RT effects. To test whether the RT data truly provides evidence for implicit recognition beyond what participants report explicitly, one should classify (predict) repeated vs. new cues based on the RTs. Only when the resulting sensitivity from this classification is larger than the sensitivity in the awareness task, there can be evidence for implicit learning (for a related argument see Meyen, et al., in press, Journal of Experimental Psychology: General). We present reanalysis methods for two variants of the awareness task (the cue recognition task and the target generation task) and discuss alternative arguments involving correlations between performances in the awareness task vs. visual search task. Using our method, we reanalyze multiple influential studies in the field. We conclude that there is little to no evidence for recognition beyond what participants are consciously aware of. [This project is supported by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) through the CRC 1233 "Robust Vision", project number 276693517; the Institutional Strategy of the University of Tübingen (DFG, ZUK 63); and the Cluster of Excellence "Machine Learning: New Perspectives for Science", EXC 2064/1, project number 390727645.]

Talk Session 20: Color

Different temporal integration of rod signals in luminance and chromatic pathways

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To understand the integration of rod input (R) in luminance (L+M+S) and chromatic [L/(L+M)] pathways in the temporal dimension, we measured reaction times (RTs) to rod-isolating and/or pathway specific signals. A four-primary photostimulator based on the overlapped images of two spectrally-modified CRTs, which allowed independent stimulation of R, L, M and S photoreceptors, was used to generate rod (R), luminance (L+M+S) and chromatic [L/(L+M)] stimuli or the combination of rod and postreceptoral stimuli [L+M+S+R and R+L/(L+M)]. Light levels were from 0.5 cd/m2 to 6 cd/m2. The stimulus was a "C" target presented until participant's response or up

to 4 s, measuring 4° of mean diameter. The target differed from the background only by its selected stimulation in a range of 3 or 4 positive and negative contrasts. Participants had to discriminate the position of the aperture of the C-Landolt ring while they fixate at a cross in the center of the "C", and respond as soon as they could. The reaction time (RT) was computed from the stimuli onset to the participant's response for each trial. RTs for L+M+S+R were higher than that for R or L+M+S stimuli. On the other hand, RTs for R+L/(L+M) were lower than that for R and L/(L+M) stimuli. Integration of rods signals differs in both pathways. For the luminance pathway, rod input reduced the processing speed, suggesting a suppressive rod-cone interaction. Surprisingly, the responses of the chromatic pathway were faster when rods were involved, suggesting a major role of rods in mesopic color perception. [CONICET PUE 0114 ILAV. Ministerio de modernización de Argentina – Fulbright Commission BEC.AR Program.]

Newly-learned shape-colour associations show signatures of reliability-weighted averaging without forced fusion or a memory colour effect

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Reliability-weighted averaging of multiple perceptual estimates (cues) improves precision. Research suggests that newly-learned statistical associations (e.g. new cues or priors) are rapidly integrated in this way for efficient decision-making. Yet, it remains unclear if integration of newly-learned statistics into decision-making directly influences perception. Do newly-learned statistics influence how participants perceive stimuli, as well as how they make decisions? In two experiments, we implicitly taught observers novel associations between shape and colour. Observers made colour matches by adjusting the colour of an oval to match a simultaneously presented reference. As the colour of the oval changed across trials, so did its shape according to a novel mapping of axis ratio to colour. Observers showed signatures of reliability-weighted averaging – a precision-improvement in both experiments and reweighting of the newly-learned shape cue with changes in uncertainty in Experiment 2. To ask whether this was accompanied by perceptual effects, Experiment 1 (N=34) tested for "forced fusion" by measuring colour discrimination thresholds with and without incongruent shape cues. Experiment 2 (N=30) tested for a "memory colour effect", observers adjusting the colour of ovals with different axis ratios until they appeared grey. There was no evidence for forced fusion and the opposite of a memory colour effect. These results suggest that while people rapidly learn new statistical regularities to optimise their perceptual decisions, these are not immediately (with short training) accompanied by familiar perceptual effects. How much experience is needed to see familiar perceptual effects with newly-learned cues is an open question for future research. [This project has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement No. 820185) and a Leverhulme Trust Research Project Grant (RPG-2017-097).]

Living with colour-vision deficiency at school: a thematic analysis of accounts of colour-deficient adults, children, and their parents

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Background: Colour-vision deficiency (CVD) is an X-linked condition affecting 8% of males (0.4% females). Depending on the type and severity, individuals' ability to discriminate between colours can be significantly compromised. In the UK, compulsory screening for CVD at primary school entry stopped when a 1958-birth-cohort study concluded that CVD has no measurable impact on educational attainment (Cumberland et al., 2004). However, there has since been a drastic increase in the use of colour resources in educational environments, especially since the introduction of digital screens. Here we explore the day-to-day experiences of CVD individuals and ask whether a revision of the current screening policy should be considered. Method: We conducted a qualitative study using online interviews and focus groups with 26 CVD adults, 12 CVD children and 12 parents of CVD children. Transcripts were subject to thematic analysis combining reflexive (Braun and Clarke, 2006) and codebook approaches. Results and Conclusion: Four themes relating to individuals' experiences at school were identified; (1) "lack of societal awareness", (2) "importance of early diagnosis", (3) "barriers to learning within education" (4) "careers" (part of a "wider impacts" theme). These themes highlight the value of an early diagnosis of CVD and the need for increasing educators' awareness of the academic limitations that CVD may impose on affected individuals, particularly in early education. Our findings will inform the development of a new questionnaire to measure the impact of CVD on school-aged children in the UK on a larger scale to quantify the need for early screening. [Part of a PhD funded by the Leverhulme Trust.]

A machine-learning approach to illuminant estimation using statistical regularities in photoreceptor signals from real-world surfaces

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In natural scenes, illuminant colour can provide biologically relevant information about time-of-day, and local conditions of shade and heading. Illuminant estimation is also a vital step in many models of colour constancy, in which surfaces maintain stable colour appearance under changing illumination. Yet, in a world without physical constraints, a single sample of reflected light from a surface could in principle be produced from an infinite set of possible surface-illuminant pairs, and illuminant estimation is mathematically under constrained. Here we use a machine-learning approach to quantify, for a dataset of real-world surface and illuminant spectra, the limits that can be placed on illuminant estimation from photoreceptor signals. We reduced the radiance spectra to five photoreceptor coordinates (the three cone classes, the rods, and melanopsin), which are in principle available to a human observer. Algorithms were trained on the combination of photoreceptor signals associated with 49,667 real-world surfaces labelled by the illuminant under which the surfaces were placed. We evaluate the properties of the surfaces, illuminants, and photoreceptor signals that impact performance of the algorithms to predict illuminant chromaticity. For example, when trained using real-world surfaces under five daylight illuminants of different colour temperature, and using a combination of all five photoreceptor signals, we find our classifiers have high accuracy, precision, and recall at correctly identifying the illuminant from an unseen set of photoreceptor signals from a single surface. The approach also allows us to quantify the advantage gained from combining signals from multiple surfaces, and the optimal strategy of combination. [This project has received funding under the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 765911 (RealVision). T. Morimoto is supported by a Sir Henry Wellcome Postdoctoral Fellowship from the Wellcome Trust (218657/Z/19/Z) and a Junior Research Fellowship from Pembroke College, University of Oxford.]

Visual discomfort and the chromatic content of natural scenes

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Visual discomfort can arise when viewing certain stimuli and is thought to be linked to hypermetabolism. Being able to predict the discomfort a visual stimulus can cause is important to pre-empt adverse effects in design and architecture, and to further our understanding of the condition. Algorithms based on the theory of efficient coding that measure how a stimulus departs from the statistical regularities found in natural environments offer a robust prediction of observers' discomfort (Penacchio & Wilkins, 2015). To date, all algorithms focus on the role of luminance contrast, yet, visual discomfort can also arise from the colour content of a scene (Haigh et al., 2013). Here we addressed this gap. We constructed a metric that averaged the local chromaticity differences in an image to simulate cortical activation in response to colour contrast. High chromaticity differences were associated with visual discomfort, accounting for part of the judgements not accounted for by metrics based on luminance. Our metric sets a link between visual ecology and discomfort: using several sets of calibrated natural images, we showed that the local chromaticity differences found in uncomfortable stimuli are high with respect to natural stimuli. The only natural stimuli with high chromaticity differences are those considered to have played a central role in the evolution of the human visual system, namely arrangements of colourful fruits against foliage. Our work offers a new theoretical perspective on visual discomfort whereby stimuli that rarely appear in natural environments overload adaptive perceptual mechanisms in the early visual cortex.

Perceptual scale for transparency with combinations of geometrical and color cues

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Transparent color filters have a unique perceptual quality, closer to light than surfaces. Despite our eyes receiving light that is a multiplicative composite of surface,

illumination, and filter properties, we can simultaneously perceive surface and overlay layers differing in colors, patterns, motions, etc. How neurons separate the information to extract the transparent layer remains unknown. Physical characteristics of transparent filters generate stereotypical geometrical and color features in retinal images, for example, X-junctions, multiplicative contrast changes, 3-D diagonal color transforms in cone space, and revealing motion, which could provide cues for scission. We estimated the relative importance of such cues in a perceptual scale for transparency, using stimuli in which X or T-junctions, consistent or inconsistent motions, and consistent or inconsistent colors, combined or competed in forced-preference psychophysics experiments. Bayesian Thurstone scaling revealed some new results: Moving X-junctions increased transparency compared to static X-junctions, but moving T-junctions decreased transparency compared to static T-junctions by creating a moving patch. However, if the motion of a filter uncovered a pattern different from the background but with the same motion (common fate), thus forming T-junctions, transparency was as high as for static X-junctions. In addition, geometric cues overrode color inconsistency to a great degree. The perceptual scale provides a way to probe extra-striate neurons for the ability to extract transparent layers by correlating relative responses to the ordinal scale. Finally, we present a probabilistic graphical model that provides quantitative estimates of the influence of different combinations of geometric and color cues on perceived transparency. [This work was supported by National Institutes of Health Grants EY13312 and EY07556. The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.]

Friday August 27th

Talk Session 21: Motion & Biological Motion

Salient motion detection and representation using efficient projection kernels

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Biological perception systems are very skilled in processing efficiently and effectively a huge amount of visual information, bringing the attention on attractive regions for further processing. This is related to the notion of visual saliency, which, in the computer vision community, is commonly associated with center-surround differencing, formulating saliency detection as a classification problem where we look for features that help in distinguish an item (center) from its neighbors (surrounds). When the interest, in particular, is on motion information, from a biological standpoint we rely on perceptual grouping in order to determine which parts of the scene belong together, related to a higher-order perceptual unit, like a coherent moving pattern. The aim of this work is to quickly identify visually salient parts of the scene characterized by motion and focus on that to perform classification. Our method is based on the Gray-Code Kernels (GCKs), a family of filters which, under specific circumstances, can be used as an highly efficient projection scheme. By filtering videos with GCKs, we end up with a set of projections that, if properly pooled, are able to convey motion information at different granularity, coupling efficiency with representation power. The assessment included videos coming from various contexts, from benchmark datasets for action recognition to videos captured by robots' visual systems. Results show that we managed to 1) efficiently detect salient motion, at the expense of a slightly reduced accuracy if compared to instantaneous segmentations, and 2) create a representation able to characterize inter-class and intra-class variability.

Bayesian observer takes a dim view of perceived speed at low luminance

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Most Bayesian models assume that initial sensing is unbiased: perceptual distortions arise from the interplay between prior expectations and sensory evidence that is imprecise yet accurate. Motion perception has been a fertile testing ground for this framework, partly because the prior for movement seems self-evident: most objects are stationary, therefore the prior distribution should be centred on 0. The slow-motion can explain how perceived speed declines with lower visual contrast, eye movement and auditory noise, all of which decrease sensory precision – motion discrimination gets worse – leaving the prior to dominate. However, the increase in perceived speed at low luminance seems contradictory because most motion thresholds also get worse in the dark. We tested this apparent contradiction using moving sinusoidal gratings and standard 2AFC. We found the increase in perceived speed at low luminance is in fact accompanied by better speed discrimination, as predicted by the Bayesian framework. Further experiments showed that the link between luminance, perceived speed and speed discrimination did not depend on light adaptation, but did depend on perceived contrast. Perceived speed remained as fast at low luminance when perceived contrast was controlled for, while the effect of luminance on discrimination disappeared.

Lights out for the Bayesian observer? A final experiment introduced external noise, which restored the Bayesian link: as noise increased, speed discrimination became worse and perceived speed. This suggests a hybrid model, in which a Bayesian observer interprets imprecise sensory evidence that can be biased.

Non-rigidities from motion-energy are turned rigid by salient features

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How does the brain make objects appear rigid when retinal images are deformed non-rigidly by observer or object motion, especially where motion parallax and correspondence between perspective views are not sufficiently informative? We studied rotating rigid objects that can appear non-rigid, to understand how tracking of salient features can counteract motion-energy signals. When two 3-D circular rings are rigidly linked at an angle and rotated around an axis oblique to both, illusory non-rigid rolling and wobble are striking enough to have been used in shop windows and movies. Using pyramids of direction-selective V1 cells, we show that the pre-dominant motion energy supports a percept of the rings wobbling non-rigidly against one another instead of rotating rigidly. The illusion of rolling is not supported by motion energy, but also occurs when the rings are physically wobbled, suggesting a higher order illusion that makes the wobbling appear physically feasible. By asking observers to judge if the link is rigid or non-rigid, we quantify that rigidity increases at slower speeds, and if the link is painted or replaced by a gap, or the rings are polygonal with vertices. The motion of painted segments, gaps or vertices provides cues against rolling, which in turn eliminates the now unfeasible illusion of wobble. Pyramids of MT pattern-motion cells detect the rotational motion of the vertices of polygonal rings. A generative model that combines motion-energy signals with signals from MT pattern cells tracking salient features, explains the rigidity and non-rigidity of the rings and other rotating objects. [NIH EY07556 & EY13312.]

Life motion signals induce perceptual mislocalization

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Recognizing the motion of other biological entities is vitally important, which presumably shapes the specialized processing of biological motion (BM). For example, the displacement of biological entities may be specially represented in the brain. Here we report a novel phenomenon in support of this hypothesis. A point-light walker with no translation on the screen was perceived to be ahead of a physically aligned flash, which resembles a classical motion illusion, the flash-lag effect (FLE), where a moving object is judged as leading a flash. This result seems to hint that an illusory forward displacement is represented in the visual system. More intriguingly, the BM-induced FLE was observed on local feet motion without any global configuration. In contrast, non-biological motion could not yield this effect. Likewise, the effect diminished when BM was shown inverted and vanished when the motion's critical biological characteristics were disrupted. Furthermore, neither implied motion nor attentional shift was responsible for these effects. Taken together, our results agree with the view that the visual system automatically forms an overall displacement representation of biological entities solely from their global or local articulated movements. The potential benefit of this nature is to facilitate fast detection of biological entities' displacement even when they are distant or obscured. Our novel findings point to a special mechanism of spatiotemporal perception tuned to life motion signals, and suggest that the FLE does not necessarily entail retinal or spatial motion. [The authors declare no conflicts of interest.]

Human perception of the realism of locomotion across different species

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People can efficiently recognise many complex, human-performed actions such as running, tennis serves and facial expressions. This is the case even when static shape cues are minimised to force the use of motion information, for example in point light walker stimuli. We investigated whether our expertise at perceiving human walking generalises to other modes of locomotion, namely dogs walking and birds flying. Specifically, we tested whether participants were sensitive to two key factors determining typical and energy-efficient locomotion: speed of forward movement and frequency of limb cycles (legs striding for humans

and dogs; wing flapping for birds). In a series of online studies participants rated the naturalness of brief animations of simulated animal locomotion. The kinematics of the baseline animation were based on experimental data collected from real animals moving. Forward motion and limb cycle frequency were then manipulated systematically. Naturalness ratings were similar across the three species and were sensitive to variation in both the speed of locomotion and the rate of limb cycling for humans, dogs and birds. Our results indicate that our expert perception of biological locomotion is not narrowly constrained to human body movements.

Biological Motion Perception in Perceptual Decision-Making Framework

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Neurophysiological studies with non-human primates show that perceptual decision-making processes can be characterized in two stages: sensory evidence accumulation and response selection. Recently, human EEG studies with the random dot motion paradigm suggest that the sensory evidence accumulation process can be tracked with the CPP component and can be distinguished from the response selection stage with the LRP component. Although these studies have improved our understanding of perceptual decision-making processes, it remains unknown whether these processes could be generalized to more complex and socially important stimuli. Sixteen participants were presented with point-light displays of biological motion for 2 sec and asked to respond whether the walker moves towards left or right while EEG was recorded. Four levels of noise dots were added to the biological motion stimuli to manipulate the coherence. The biological motion stimulus was preceded by scrambled motion with the same level of noise dots for a variable duration to allow continuous stimulation and to detect biological motion-specific activity. Our behavioral results show that reaction times and miss rate decrease as the coherence is increased. Importantly, our EEG results show that the peak rate of the CPP component tracks the coherence of the biological motion stimuli, albeit with a later onset compared to the studies that use the random-dot motion paradigm. It was also dissociated from the LRP component, which is associated with the response selection. These results suggest that similar perceptual decision-making mechanisms are in place even if the stimulus is more complex and socially valid.

Talk Session 22: Art & Aesthetics

Aesthetic attention: what is the role of eye movements, personality and cognitive style on responses to artworks?

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Previous research has investigated the role of eye movements, personality, and cognitive style on aesthetic responses to artworks. However, the relationship between these dimensions remains unclear. Here we examined whether observers' eye movements mediate the influence of personality and cognitive style on responses to artworks. Fifty-six participants viewed seven artworks at their own pace in the gallery space of TATE Liverpool, while their eye movements were recorded. Participants completed a set of rating scales measuring their aesthetic response to the artwork and wrote a narrative description of their thoughts on finishing viewing each artwork. Narrative descriptions were analyzed in terms of word count and frequency of use of aesthetic descriptors. Participants completed a battery of individual difference measures, including Openness to Experience and Need for Cognitive Closure before viewing artworks. Eye movements were analyzed in terms of total dwell time and spatial distribution of fixation made to the artworks. Critically, we found that the duration of looking at artworks mediated the relationship between Openness to Experience and the frequency of use of aesthetic descriptors, and (2) the spatial distribution of fixations mediated the relationship between both Openness to Experience, Need for Cognitive Closure, and the count of words used in response to viewing artworks. The results are discussed in terms of the functional role of visual exploration when adopting an aesthetic mode of attention in real-world settings. [We are grateful to the Liverpool TATE gallery for the opportunity of conducting this research as part of the TATE Exchange Programme 2020.]

Lost In Projection – Implicit Features Experience of 3D Architectural Forms and Their Projections

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The subjective experience of objects is usually investigated on photographs shown on a computer screen. Even when research is done on architectural objects, as stimuli researchers usually use their photographs. According to that, we might ask, would our subjective experience of certain objects change if we observe it as a real three-dimensional object or its two-dimensional projection on a photograph? In our experiment 46 psychology students estimated their subjective experience of 10 objects shown in four different presentations. As a subjective experience measure, we used 12 bipolar adjective scales, grouped into four factors (attractiveness, regularity, arousal, and calmness) and 3 unipolar scales constituting the aesthetic experience factor. Stimuli were designed by architecture students, who created 3D objects and their drawings as projections from four different viewing directions. After that, we photographed those objects from the same four viewing directions and created their virtual reality copies in Unity software for Oculus Rift. Results show significant differences between four types of object presentations on all scales of subjective experience (attractiveness, arousal, calmness, and regularity) while no differences in aesthetic experience were detected. Real 3D objects were experienced as more attractive and calmer than all other presentations, while VR presentation reduced arousal in comparison to all other presentations. Only on regularity VR and real 3D objects were experienced as same and more regular than drawings and photographs. Findings suggest that presentation type (real or virtual object, photograph, and drawing) doesn't affect the aesthetic experience, but it does change other dimensions of subjective experience. [This research was supported by the Ministry of education and science of the Republic of Serbia, project number ON179033.]

Effects of the COVID-19 lockdowns on hedonic evaluations of natural and urban scenes

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The UK lockdowns triggered by the COVID-19 pandemic restricted people's access to urban spaces and outdoor natural environments. The consequence of changes in human navigation led to reduced crowding in social hubs and reduced traffic in urban centres. It is likely that the lockdowns altered the way people evaluated outdoor environments. In this online study we investigated hedonic (aesthetic) and emotional responses (liking, openness, relaxation ratings) to images of paintings and photographs depicting landscapes and urban scenes in three cohorts: Winter/2020 pre-lockdown, Spring/2020 lockdown, and Winter/2021 lockdown in the UK. As expected, the liking, openness and relaxation ratings of 334 participants to landscapes and urban scenes were higher during the Spring/2020 and Winter/2021 lockdown periods than in the pre-lockdown Winter/2020 period. The evaluations in the Spring and Winter lockdown cohorts were influenced by the types of places most frequently visited. These findings confirmed the popular belief that the lockdowns affected positively the overall evaluations of outdoor environments and are relevant to the development of policies that promote human wellbeing in urban environments and include the design of more open and relaxing spaces in urban centres.

Emotions are predictable from abstract colour and line drawings made by artists and non-artists

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Through the manipulation of colour and form, visual abstract art is often used to convey feelings and emotions. How specifically are colours and lines used to express emotion through art? And do artists and non-artists express emotions through art in similar ways? In our study, 46 artists and 45 non-artists each created abstract colour drawings and line drawings depicting six emotions (i.e., anger, disgust, fear, joy, sadness, and wonder). To test whether emotions were accurately depicted by artists and non-artists, we computationally predicted the emotion of a given drawing by comparing it (i.e., pixel-wise correlation) to a set of reference drawings created by averaging across all other participants' drawings within each emotion category. Prediction accuracy was higher for colour drawings (accuracy = 43.8%) than line drawings (23.6%, $p < 0.001$), and for non-artists' drawings (36.9%) than artists' drawings (30.6%, $p < 0.05$). In a separate experiment, we found that people ($N = 242$) could also accurately infer emotions, showing the same pattern of results as our

computational predictions. Overall, colour seemingly provides more emotion information than black-and-white line drawings. Further computational analyses of the drawings revealed that there are systematic differences in colour and line usage when depicting different emotions (e.g., anger is redder and more densely drawn than other emotions), but that artists tend to use fewer colours than non-artists to depict emotions. Taken together, these results imply that abstract colour and line drawings suggest certain emotions based on their visual features, which are also used by human observers.

Art experience in VR vs. real-world context: A question of ecological validity

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The recent developments of digital technologies in the field of virtual reality (VR), like virtual museums and galleries, have opened up innovative ways to study art experience in realistically simulated art-related contexts while keeping experimental control. The results of our previous study suggested that the aesthetic experience of paintings is more intense and artworks are experienced as being more impressive in VR museum compared to laboratory (computer screen) context (Janković, Jevremović & Carbon, 2019). In the present study we compared VR with real-world setting to test the VR for ecological validity. More precisely, we compared the structure and intensity of aesthetic and affective experiences of artworks exhibited in real gallery with the experience of the same artworks exhibited in the simulation of the same gallery in the (fully immersive) VR environment. Participants (N=43) rated their aesthetic and affective experience of twelve paintings presented in a VR gallery and a real gallery. Half of the participants visited the exhibition in the real-world setting first and then in the VR, the other half assessed the paintings in the opposite order of contexts. The results showed high positive correlation of aesthetic and affective experiences in VR and real-world setting. There were no differences in the intensity of the aesthetic and affective experiences of artworks in two different contexts. These findings suggest that VR galleries can be an ecologically valid environment for exhibiting visual art and useful tool for future research of art experience in the field of empirical aesthetics.

A computational model of aesthetic value

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People constantly evaluate what they see, and these evaluations determine their choices from small (Where do I look next?) to large (Where do I want to live?). The pleasure associated with a sensory experience, namely its aesthetic value, is perhaps the most frequent and important evaluation. Yet, we have a poor understanding of how sensory experiences gain aesthetic value. We propose a model of aesthetic value that is based on the premise that observers maintain and adapt the states of their cognitive-sensory system in a way that allows them to process stimuli effectively in both the present and the future. Two interlinked components generate value: stimulus processing fluency and the change in fluency with regard to likely future stimuli. In our model, processing fluency is quantified precisely as the likelihood of the stimulus given an observer's state and constitutes immediate sensory reward. The change in fluency with which likely future stimuli will be processed, quantified by the change in the average likelihood of expected future stimuli, constitutes the reward of learning. Simulations show that a simple version of our model can account for empirical data on the effects of exposure, complexity, and symmetry on aesthetic value judgments. Its application offers insight as to how mechanisms that improve long-term processing efficiency give rise to aesthetic value judgments. [This work was supported by the Max Planck Society and the Alexander von Humboldt foundation.]

Talk Session 23: Clinical Aspects of Vision

Towards visual neural prosthetics: Real-world indoor mobility with simulated phosphene vision

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Neuroprosthetic implants are a promising technology for restoring some form of vision, via electrical neurostimulation in the visual pathway. Although the artificially generated prosthetic percept is relatively limited compared

normal vision, it may provide some elemental perception of the surroundings, re-enabling daily living functionality. For mobility in particular, various studies have investigated the benefits of visual neuro-prosthetics in a simulated prosthetic vision paradigm with varying outcomes. Previous literature suggests that scene simplification via image processing, and particularly contour extraction, may potentially improve the mobility performance in a virtual environment. In the current real-world behavioral study, we assessed both traditional edge detection and a deep learning-based boundary detection method and manipulated the environmental complexity to explore different levels of scene simplification. Our results suggest that for a lower number of implanted electrodes, the removal of background textures and within-surface gradients may be beneficial in theory. In practice, however, the deep learning-based implementation for surface boundary detection did not improve mobility performance in the current study. Furthermore, for a higher number of electrodes removal of within-surface gradients and background textures may deteriorate, rather than improve mobility. Therefore, finding a balanced amount of scene simplification, requires a careful tradeoff between informativity and interpretability that may depend on the number of implanted electrodes. [NWO.]

Eye-Movement Abnormalities among Patients with Schizophrenia

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Neurophysiological studies have shown that information processing among patients with first-episode and chronic schizophrenia (SZ) is abnormal and probably related to the core pathology of SZ. Therefore, SZ is ultimately about how a patient's brain processes information. Currently, with the support of modern eye-tracking technology, scientists can mirror cognitive deficits among clinical populations more precisely. For example, while visually exploring a picture, SZ patients show restricted scanning patterns characterized by smaller eye-movements (saccades) and fewer eye fixations, featuring returns to already explored regions. 'Prevention is better than cure,' therefore it is necessary to undertake a detailed investigation of eye-movement abnormalities and draw scientific communities' attention to explore visual information processing patterns among SZ patients. This work undertakes a brief review of research on exploratory eye movement deficits among patients with SZ. To answer the question – What is known about eye movement impairments in patients with SZ, and what viewing tests disclose their presence? – the authors gather promising pieces of evidence of eye movement abnormalities in attention-demanding tasks on the SZ spectrum that have mounted in recent years (e.g., Wolf et al., PCN, 2021). Furthermore, gaze metrics that identify the process of SZ are being discussed in this talk. Given that cognitive impairments appear before the official diagnosis is made, identifying individuals at risk and in the early phases of SZ is crucial. Notably, eye-tracking technology has the potential to contribute to the process of early intervention. [This work was funded by KAKENHI grant ID JP19F19307 under the Postdoctoral Fellowship scholarship (A.W.) from the generous Japan Society for the Promotion of Science (JSPS).]

I cannot even look at it! The spatial and chromatic attributes of the pupillary aversive reaction to gratings and text images

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Text is usually printed in a black color over a white page and resemble a monochromatic high-contrast square wave grating. These gratings are well known to elicit pupillary constriction, the so-called pupillary grating response (PGR) that increase for higher spatial-frequency. They are also known to give rise to visual discomfort, unpleasant sensation, glare, and illusory motion, especially in clinical populations. Hence an image of text might elicit an immediate aversive response because of its appearance, leading to reading avoidance. To test this hypothesis, we had observers (n=103) watch a slide show of flashed square wave gratings or text images with different spatial-frequency, contrast, and iso-luminant background color, and report their subjective rating of aversion or free-view the images while their pupil size was recorded. We found that spatial-frequency, background color and total stimulus size had a significant effect on pupil size change as well as on the subjective aversion ratings. Importantly, these two measures were significantly correlated, consistent with the known tendency of the pupil to constrict following aversion or disgust. Different iso-luminant colors caused markedly different subjective aversion and a correlated pupil constriction, while low plus-add lenses had no significant effect. Dark but not bright Plano filter lenses had a significant effect on both ratings and pupil size, despite having the same wavelength cutoff. These findings are in line with suggestions that traditional text displays might give rise to an immediate aversive response, and how those sensations could be alleviated by text design and clinical intervention.

Objective and Subjective Methods to Measure Fusional Vergence: An Agreement Study

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This study was designed to compare an objective method to evaluate positive and negative fusional vergence ranges at near with the subjective test typically used in optometric clinical practice. A total of 34 typical adults (23.11±3.06 years of age) participated in the study. Participants' positive (base-out, BO) and negative (base-in, BI) fusional vergence ranges were measured subjectively using the Risley prism of the phoropter. Participants reported double vision as the amount of prim increased (break point), and recovery of single vision as it decreased (recovery point). The objective method was carried out in an haploscopic set-up and eye movements were recorded with an Eyelink 1000 Plus (SR Research) at 500Hz. Break and recovery points were determined offline using a custom Matlab code based on the analysis of eye movements. Bland-Altman analysis showed a bias towards wider BO ranges but narrower BI ranges with the objective than the subjective method. The mean of the differences between methods ±SD (95% limits of agreement) were 4.25±3.23 PD (-10.60 PD, 2.08 PD) for the BI break point, 2.76±4.30 PD (-11.19 PD, 5.67 PD) for the BI recovery point, 9.37±9.92 PD (-10.08 PD, 28.82 PD) for the BO break point and 12.26±10.96 PD (-9.22 PD, 33.74 PD) for the BO recovery point. This study showed the possibility to measure fusional vergence ranges objectively. Although the objective method offers numerous advantages, the two methods cannot be used interchangeably due to the poor agreement between them. [Financial support: Spanish Ministry of Economy and Competitiveness grant DPI-2017-89414-R; European Union, Generalitat de Catalunya by Predoctoral grant FI-DGR (CR).]

Ponzo illusion in schizophrenic patients before and after treatment

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A wide variety of results have been reported in the literature showing either higher or lower susceptibility to visual illusions in schizophrenic patients. In order to examine whether perception of the Ponzo illusion is related to mental status, cognitive function, and treatment, we examined changes in Ponzo illusion strength using the verbal response correction method in schizophrenic patients at subacute inpatient admission and 2 months after treatment. The majority of patients (64.5%, n = 20 patients) had a significant decrease in Ponzo illusion strength after treatment (Wilcoxon t-test, p-value = 0.001), and 35.5% of patients (n = 11) had a higher Ponzo illusion strength after treatment (Wilcoxon t-test, p-value = 0.016). Patients whose Ponzo illusion strength decreased after treatment had significantly higher scores on the PANSS Positive Syndrome Scale (Wilcoxon t-test,p-value = 0.021) and lower scores on the Comp. T by BACS (Wilcoxon t-test,p-value = 0.021) compared to patients whose Ponzo illusion strength increased after treatment. Improvement in condition, assessed as a difference between PANSS scores before and after treatment, correlated with changes in Pozo's illusion strength before and after treatment(in the high illusion strength group before treatment: r = 0.6, p-value = 0.041, and in the low illusion strength group: r = 0.5, p-value = 0.042). No significant association was found between illusion strength and chlorpromazine equivalents dosage of an antipsychotic. Thus, perceptions of Ponzo's illusion in schizophrenic patients are related to severity of mental state, cognitive deficits and varies with response to treatment. [This work was supported by RFBR 19-013-00036.]

Animacy Perception in Virtual Reality: A Pilot Study

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Autism has been previously linked to differences in social cognition and sensory processing (Simmons et al, 2009). A classical measure of low-level social cognition is the Frith-Happé animations task which measures perceived animacy and "mentalizing" ability (mentalizing is the attribution of thoughts and feelings to others) (Abel et al., 2000). We have adapted this classic psychological paradigm to Virtual Reality (VR) and evaluated its feasibility. 3D versions of the Frith-Happé animations were constructed using the software package Unity. The animations had the appearance of solid triangles of different sizes moving on a ground plane. Participants viewed these animations in our VR lab wearing a standard Head-Mounted Display. White et al.'s (2011) multiple choice scoring system was used to categorize animations based on the perceived interaction of 3D geometrical shapes. Questionnaires were used to assess autistic traits and sensory sensitivities of the 33 participants (aged 18-45). It was found that increased sensory hypersensitivity, particularly visual,

tactile, and olfactory, predicted the degree of intentionality ascribed to the animations. The link between sensory hypersensitivity and perceived animacy establishing in this study is only possible with the use of VR as it adds crucial sensory input not available in the 2D version of this task. Participants' verbal feedback also indicated that the increased level of immersion available in VR helped them appreciate the animacy more. VR has thus been found to be an appropriate tool for investigating animacy and mentalizing ability in neurotypical participants. [ESRC collaborative studentship with Sublime Ltd.]

Talk Session 24: Attention III (Visual Search)

Mirror Blindness: Our Failure to Recognize the Target in Search for Mirror-Reversed Shapes

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It is well-known that visual search for a mirror target (i.e., a horizontally flipped item) is more difficult than search for other-oriented items (e.g., vertically flipped items). Previous studies have attributed costs of mirror search to early, attention-guiding processes. However, they could not rule out contributions from later, object identification processes. In the present study we used eye tracking to distinguish between early, attention-guiding processes and later processes of target identification. The results of 4 experiments revealed a marked human weakness in identifying mirror targets, in that we are likely to mis-classify a mirror target as a nontarget and continue with search even after we have directly looked at the target. This mirror blindness effect explained a large proportion (45-87%) of the overall costs of mirror search. Awareness measures corroborated that the location of a mirror target could not be reported above chance level after it had been fixated and the search continued. Mirror blindness was attenuated but not eliminated when the target and nontarget items were kept constant, suggesting that mirror blindness is in part due to hard-wired neuronal limitations, which may have evolved to aid efficient object recognition. The finding that mirror blindness was significantly reduced with constant nontargets also indicates the need to revise current models to include context-dependent target identification mechanisms. Moreover, observing very different results patterns for early and late processes indicates that attention-guiding and target identification processes are not based on the same target template, but rely on different procesess and mechanisms.

A Generative Model of Target Switching Behaviour in Visual Foraging

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There has been increasing interest in visual foraging, a type of visual search task where participants must find multiple targets sequentially. Studies typically have two different target types that participants must find, as well as distractors. A key result has been that for easy target discriminations (feature search), participants switch frequently between target types; however, if the targets are more difficult to distinguish from the distractors (conjunction search) the majority of participants tend to forage in 'runs' of the same target type. Each trial is usually characterised by the maximum run length and the number of runs, and these measures are used for analysis. A limitation of these approaches is that the measures used are interdependent and are influenced by the number of targets present in the scene. We present an alternative strategy which involves modelling the process as a generative sampling without replacement procedure, implemented in a Bayesian multilevel model. This allows us to break down behaviour into a number of independent biases that influence target selection, including the proximity of targets, a bias for selecting targets in runs and a bias for a particular target type, in a way that is not dependent on the number of targets present. Our method therefore facilitates direct comparison between different studies using different parameters. We demonstrate the use of our model with simulation examples and re-analysis of existing data. We believe our model will provide deeper insights into visual foraging data, providing a foundation for further modelling work in this area.

Visual search in 360 degree visual space with head rotation

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To characterize the process of visual search, typically, reaction time is measured relative to stimulus onset, when the whole search field is presented in view simultaneously. Salient objects are found faster, suggesting that they are detected using peripheral vision (rather than each object being fixated in turn). This work investigated how objects are detected in the periphery when onset in the visual

field is due to head movement. Is the process of target detection similarly affected by salience? We test this in 360 degree view, using a virtual reality headset with eye tracking. We presented Gabor patches and letters as stimuli in separate experiments. Four clusters were arranged horizontally such that two clusters were visible at onset either side of a fixation cross (termed near) while the other two entered the field of view when the participant made an appropriate head movement (far). We found that the Gabor patch task was more difficult overall. The more salient targets were found faster and this advantage was similar for the near and far clusters. With the easier letter stimuli however, more salient targets were faster to be identified in the near location, but this advantage decreased for the far targets. This suggests that the advantage conveyed by salience at fixation was not the same when the cluster came into view due to a head movement. The role of salience as a guide for eye movements may need to be considered in the light of ongoing task conditions and head movements.

Being conservative and liberal at the same time: Prevalence effects in perceptual decision on complex stimuli

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Suppose you are making decisions about whether a greenish-blue dot is green or not. If truly green dots are rare (low prevalence) and if you receive trial-by-trial feedback, you will be less likely to label ambiguous dots as green (classic low prevalence effect - LPE). If you do not receive feedback, the effect can reverse. You will be more likely to call the same dot green (prevalence-induced concept change – PICC). We replicated this finding with more complex white blood cell images that vary from blast (abnormal) to non-blast cell (normal). Novice observers were trained and then made 2AFC, 'blast' vs 'non-blast' decisions. With feedback, complex stimuli produce robust LPE. Without feedback, there were no significant effects, again showing how feedback can modulate prevalence effects. Complex stimuli are likely defined by more than one feature. What is the effect of feedback on one low prevalence feature but not another? Experiment Two used two-dimensional stimuli that varied in shape from "bouba" (rounded) to "kiki" (spikier) and in color (green-blue). Observers made 2AFC responses ("green-kiki" or "not green-kiki") while receiving feedback about either color or shape. When prevalence was reduced, there was a distinct LPE on the feedback dimension and a PICC effect the no-feedback dimension. This suggests that effects of low prevalence operate on the featural level and that criterion can shift in opposite directions for different features. [NIH-NEI EY017001.]

The role of item similarity in the time course of hybrid search and memory search

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When you look though your visual environment for an item from a list stored in memory, you perform a "hybrid" visual and memory search. It has previously been shown that reaction times (RTs) in hybrid search are a logarithmic function of memory set size (MSS, Wolfe, 2012). In previous studies, this log function was produced using highly distinct items from unrelated object categories as stimuli. Suppose all items were from the same category and, thus, less distinct from each other? Certainly, this will make search more difficult, but is RT still a log function of memory set size? In Experiment 1 (hybrid search), observers looked for a novel item among three old items presented at least once in previous trials. MSS varied from 4 to 64. Search items were either Unrelated objects from different categories or Exemplars from the same category. Although the Exemplar search was slower overall, RTxMSS functions were logarithmic for both types of items. In Experiment 2 (memory search), observers saw items one by one and had to recognize each item as "old" or "new". Again, we found the log function for both item types. Interestingly, the functions were shallower for old stimuli than for new ones. Simulation using a drift diffusion model showed that this log RT pattern with new-old asymmetry is consistent with noisy parallel self-terminating search in memory. Overall, our results show that the logarithmic pattern of memory search is robust across tasks (hybrid search and recognition) and stimuli (similar or dissimilar). [Funding: Basic Research Program at the HSE University to I.U.; Israel Science Foundation, grant no. 1622/15 to NG.]

Influence of expertise on human and machine visual attention in a medical image classification task

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In many different domains, experts are able to solve complex tasks after glancing very briefly at an image (e.g. radiologists, pilots…). However the perceptual mechanisms underlying expert performance are still largely unknown.

Recently, several machine learning algorithms have been shown to outperform human experts in specific tasks such as skin cancer classification. But similarly as humans, these algorithms often behave as black boxes and their information processing pipeline remains unknown. This lack of transparency and interpretability is highly problematic in applications involving human lives, such as healthcare. In this work, we directly compare human visual attention to machine visual attention when performing the same visual task. We have designed a medical diagnosis task involving the detection of lesions in 250 small bowels endoscopic images. We collected eye movements from 22 novices and gastroenterologists with various degrees of expertise while they classified these images according to their pathological status. In parallel, we trained a deep learning algorithm on the exact same task. We show that the post-hoc artificial attention maps (i.e. the image regions most used by the algorithm to take a decision) are significantly closer to human expert attention maps than to the ones of human novices. Interestingly, this is true for pathological images, but not for not pathological ones. Through the understanding of the similarities between the visual decision making process of human and machine experts, we hope to inform both the training of new doctors and the architecture of new algorithms.

Talk Session 25: Lightness, Brightness & Contrast

ipRGCs Contribute to Glare Sensation of Hight-Intensity Lights

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It has been pointed out that intrinsically photo sensitive retinal ganglion cells (ipRGCs) have effects on brightness of light in addition to synchronizing the circadian clock and pupillary control. When we see highly intense light we perceive glare, which might be different sensation from brightness. In this study we aimed at revealing whether ipRGCs contributed to glare sensation of light. In the present experiments two test lights were successively presented for 3sec each with a 3sec ISI in a dark room. The test light subtended 10 deg. An equal-energy white adaptation light of 3,000cd/m^2 was presented before, between and after the test stimulus presentations. The observer performed a paired comparison, in which he selected a more glaring test light by 2AFC. All test lights were produced with a tunable LED light source (SpectralLED RS-7, Gamma Scientific). We adjusted their spectra using several LED channels so that their L, M and S responses were equated to those of an equal-energy white of 10,000cd/m^2 and only their ipRGC responses varied with the constant luminance. We used the melanopsin spectral sensitivity (Tsujimura and Okajima, 2015) to determine the ipRGC response. We obtained glare scale values of the test lights using Thurstone's Case V. The results show that glare scale values of the test lights increase as their ipRGC responses increase despite of their L, M and S responses kept constant. This means that ipRGCs clearly contribute to our glare sensation of high-intensity lights.

Quantifying the gradual transition of illusory effect from White's illusion (WI) to Simultaneous Brightness Contrast (SBC) using 2AFC based psychophysical experiments and modelling it in the framework of an Adaptive Isotropic Gaussian Centre - Surround Receptive Field (AIGCSRF) model

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The perceived lightness of a stimulus depends on the variation of its background intensity. The direction of induction is opposite to background in some stimuli (brightness-contrast), like Simultaneous Brightness Contrast (SBC), and same in some others (brightness assimilation), like White's Illusion (WI). The Oriented centre-surround receptive field model (Oriented Difference of Gaussians or ODOG) has been successful in explaining these bi-directional lightness induction effects. It has, however, been noticed that several observations across a wide range of test patch lengths and spatial frequencies, in WI, shifted-WI, or Checkerboard illusion, cannot be predicted even by ODOG. We propose an adaptive isotropic Gaussian Centre-Surround Receptive Field (aiGCSRF) model to address these anomalies. We start from the classical isotropic centre-surround DOG-based receptive field model, which can explain brightness-contrast. It is assumed that in case of WI or its variants, where the frequency of occurrence of the edges in background are high, smoothing predominates over differential property of the filter depending on the degree of background non-uniformity. Accordingly, the inhibitory surroundings of the classical DOG filter get suppressed, leading to a multi-scale Gaussian filter for WI or shifted-WI. This we test on a series of stimuli representing a transition from WI to SBC through the Howe stimulus. All these stimuli are quantified by 2AFC psychometric experiments. Similar extensive experiments are also carried out on the shifted-WI over a wide range of aspect ratios of test patch (including the

Checkerboard-like 1:1). The proposed aiGCSRF model is found to be effective in predicting these wide-ranging variations. [Cognitive Science Research Initiative, Govt. of India, CSRI/307/2016.]

The greatest the longer: the effect of stimulus contrast on duration perception and pupil dynamics

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The perceived duration of a visual stimulus presented for a short interval of up to one second has been previously proposed to be associated with stimulus-evoked activity in early sensory areas (Eagleman & Pariyadath, 2009). Electrophysiological studies in primates demonstrated a monotonic increase in neural activity in visual areas as stimulus' contrast level increased (Albrecht & Hamilton, 1982; Sclar et al., 1990). In the present within-subject study, we manipulated the contrast level of visual stimuli to modulate neural responses and bias their apparent duration. Unlike previous studies on the relationship between contrast and time perception here we used a variety of temporal tasks (i.e., two reproduction and one perceptual discrimination task) and we monitored subjects' pupil dynamics while they were making temporal judgments. We found that, independently from the nature of the temporal task, stimuli displayed with a higher contrast were judged as longer than those with lower contrast. Furthermore, we reported an effect of contrast on pupil size not only during the encoding of the target stimulus, but also while subjects were reproducing its duration, i.e., when participants were not exposed to any sensory stimulation but they had to recollect the stored memory of the stimulus duration. These results suggest that contrast-induced modulation of activity in early visual areas may contribute to the duration perception of a visual stimulus and that pupil size may be an important measure to predict temporal perceptual biases.

The missing linking functions in computational models of brightness perception

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To perceive reflectances of surfaces, the visual system transforms the physical variable luminance into the perceptual variables of brightness (perceived luminance) or lightness (perceived reflectance). While lightness perception as a whole is barely understood various image-computable models aim to predict brightness differences seen by human observers in a range of classic phenomena. These take stimulus images as input and return the result of model computations as output image. To evaluate model performance this output then needs to be compared to psychophysical measurements of brightness perception. However, there is no principled way of mapping 2D model output to psychophysical brightness judgments (often scalars). Lacking such a linking function, models are said to "predict" brightness effects already when pixel differences in the output are of the same sign as the average brightness judgments across observers. Even for single trials, sign comparisons can only show whether model output is monotonically related to psychophysical measurements; to characterize the shape of the linking function magnitudes of brightness effects should be considered. We present specific cases where quantitative predictions by models to parametric variations of stimuli, are not simply linked to brightness matches for those stimuli. For example, brightness phenomena often "work best" when both targets are at a luminance approximately halfway between the lowest and highest luminances of the stimulus. Psychophysical magnitude can change substantially when deviating from these intermediate luminance values, which models fail to capture. This suggests that the complex nature of human brightness perception requires explicitly including linking functions in computational models. [This work has been supported by research grants of the German Research Foundation DFG MA5127/4-1 and MA5127/5-1

Feedforward cortical edge integration model explains perceptual filling-in of lightness and color

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Three main classes of neural theories have been proposed to account for effects of spatial context on lightness. The first (ODOG) is based on low-level spatial filtering combined with contrast normalization. The second (Grossberg and colleagues) is based on diffusion of brightness signals from edges within a cortical map. The third (edge integration) encodes local edge contrasts and luminance gradients in the image, then spatially integrates the outputs of these local contrast detectors at a higher cortical level. The third model accounts for perceptual data on edge integration that has not been explained by the other models, and it is the only model that includes a mechanism that supports lightness constancy. Here I present computer simulations of a specific cortical edge integration model and show how it produces a "different" kind of perceptual filling-in that simultaneously accounts for a diverse body of data on lightness and color, including

edge integration, assimilation and contrast, and quantitative lightness matches made in the Staircase Gelb paradigm. In the model, difference-of-gaussion (DOG) contrast detectors, existing at different spatial scales, are made directional through half-wave rectification. Different neural gains are assumed for ON- and OFF-DOGs, as estimated from physiological measurements from macaque monkey LGN. This differential weighting of incremental and decremental luminance, combined with edge integration at a subsequent cortical stage, accounts for the exact amount of dynamic range compression that is observed perceptually in the Staircase Gelb effect. Other dimensions of color are incorporated by including additional chromatically-tuned contrast detectors in the model. [Michael Rudd is supported by NIH COBRE grant P20GM103650.]

Lightness of a patch lying midway along a luminance gradient

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Gestalt theories of lightness feature the concept of illumination frames of reference (regions of homogeneous illumination). But not all scenes can be segmented into exclusively different regions of illumination. The case of a patch lying midway along a luminance ramp (due to a gradual change of illumination) provides a challenge to this approach. The following experiment was conducted to explore lightness computation in such a case. A horizontal cylinder (21 cm in diameter and 32 cm long) covered with matte black paper was suspended in midair and presented within an otherwise totally dark environment. A 20-watt florescent tube mounted above and parallel to the cylinder produced a top-down luminance gradient around the front of the cylinder. A square target patch of dark gray paper placed on the left front of the cylinder appeared as Munsell 8.4 in a control condition. In one experimental condition, a white inducing square placed near the top of the cylinder, vertically above the target, darkened the target to Munsell 6.4. In a second experimental condition, the white inducing square was placed horizontally to the right of the target, causing the target to appear even darker, Munsell 5.2, despite the fact that the luminance of the top inducer was both far higher than the side inducer and closer to the target in visual angle. This result supports the claim that, rather than estimating illumination level, the visual system prefers to hold illumination constant by giving more weight to the relationship between equally illuminated patches.

Poster Sessions

Monday August 23rd

Poster Session 1

Action-outcome consistency modulates causality judgments but not temporal judgments

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Causal perception depends partly on the perceived temporal order of events: causes must precede their effects. However, humans do not have a sense dedicated to time. What information does the brain use to estimate the timing of actions and sensations and thus to determine causality? A recent study suggests that the perceived temporal order of action and sensation is modulated by which sensory outcome an individual is expecting to generate with his/her action. Expected outcomes presented before actions were more often erroneously reported to have occurred after action execution compared to unexpected outcomes. However, it remains unclear what process underlying perceptual judgments is modulated by outcome expectations. Outcome expectation may directly influence the perceived temporal order of action and outcome, leading to an illusory reversal of the temporal order, or it might induce a "causal bias", participants might be more inclined to report a temporal order that matches their causal assumptions. The present study aimed at tackling this issue. We designed a task that allowed us to investigate whether outcome expectation induces a change in temporal perception or temporal decision, and to explore the common mechanisms between temporal and causal judgments, in an active and passive – tactile – condition. In a nutshell, we observed that outcome expectation influenced causal but not time perception. These results are of importance since they contribute to the understanding of the relation between time perception and causal inference and shed further light on the mechanisms underlying these two processes.

A new method for analysing trajectories from choice reaching experiments: A submovement decomposition

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Previous studies have shown that reaching movements can be influenced by attentional selection processes. Critical evidence for this effect stems from reach trajectories in colour-oddity tasks. These experiments showed that the modulation of reach curvature is linked to colour priming —i.e., colour repetitions lead to smaller curvatures compared to trials where the target colour switches. Here, we present a new approach to understanding this curvature effect. This approach is based on the well-known assumption that reaching movements are composed of submovements. Submovements are defined as discrete, ballistic movements with predetermined amplitude, direction, and duration prior to their onset. Each submovement is a straight-line trajectory but their superposition can create curved trajectories. To determine submovement decompositions for choice reaching tasks, we develop a novel method to extract submovements from 3D movements. Since these movements exhibit asymmetric velocity profiles we employed submovements with an asymmetric velocity. To avoid overfitting and capturing of biomechanical influences we developed a novel cost function for each fitting step. We also filtered out corrective submovements close to the final target and submovements related to button releases. Results show that our new method can link lower number of submovements with colour repetitions while colour switches are linked to higher number of submovements. Hence, the submovement decomposition reflected attentional selection processes in choice reaching tasks. Future work will aim to analyse the timing of submovements e.g., at what point of time the submovements, which create the curved trajectories, occur. These timings should reflect the timing of attentional selection. [This work was supported by US-NSF BCS-1849169 and UK-ESRC ES/T002409/1.]

Hierarchies in scenes – the role of object functions in shaping semantic networks

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Scene-grammar describes a set of rules regarding the likely identity and position of objects within scenes. In this framework, local objects in scenes cluster around anchor objects forming phrases – meaningful subunits – where anchor objects serve as strong predictors for the spatial layout of scenes. Carrying out actions probably plays a great role in shaping the hierarchical structure of scenes. However, we know little about whether this hierarchical structure of object-object and object-scene relationships assumed within the scene grammar framework is also reflected in the network of actions afforded by objects in the scene. To this end, we conducted two online experiments. In Experiment 1, we compared distributions of actions named for anchor and local objects and found evidence that anchor objects are associated with more actions than local objects. Object clusters based on the similarity of associated actions resembled clusters based on the spatial layout. In Experiment 2, we asked participants to explicitly rate relatedness between objects and actions in an action-primed object recognition task followed by an old/new memory task. There was no evidence that the action priming modulated memory encoding. However, the hierarchical structure assumed under scene grammar with varying levels of relatedness (related = same scene, same phrase; unrelated = same scene, different phrase; semantically unrelated = different scene) was reflected in the relatedness ratings. Our results support the idea that the hierarchical structure of scenes is also reflected by the actions associated with objects in scenes. [Main Campus Stipendiatenwerk; Hessisches Ministerium für Wissenschaft und Kunst (HMWK; project 'The Adaptive Mind').]

Exogenous covert attention does not influence the duration estimation of peripheral stimuli: Replication in a laboratory study

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Studies investigating the effect of stimulus eccentricity on duration estimation have shown a duration underestimation with increasing stimulus eccentricity (Kliegl & Huckauf, 2014). This eccentricity effect might be driven by spatial attention. A number of studies have showed that precueing the subsequent stimulus position prolongs perceived duration (Seifried & Ulrich, 2011), also in the visual periphery (Yeshurun & Marom, 2008). We investigated the effect of exogenous covert attention on the eccentricity effect in an online study. In a duration estimation task (compare Kliegl & Huckauf, 2014) participants judged the duration of a comparison stimulus with varying duration presented in a near or far eccentricity condition as shorter or longer compared to a centrally presented standard stimulus. Exogenous luminance cues (compare Seifried & Ulrich, 2011) either directed spatial attention towards the position of the subsequent comparison stimulus (valid cue) or did not convey information regarding the stimulus position (neutral cue). Results show a duration underestimation when the comparison stimulus was presented in the far eccentricity in both cueing conditions,

therefore successfully replicating the effect of stimulus eccentricity on the duration estimation of short stimuli in the neutral cue condition. In the neutral cue condition participants showed longer reaction times in the far eccentricity condition. This effect was attenuated in the valid cue condition. This suggests, that the cue indeed leads to a covert attentional shift but did not influence duration judgement. The results are to be replicated in a more controlled laboratory setting, also allowing to control for saccadic eye movements.

Investigating affordance effects in people with high traits of developmental coordination disorder (DCD): An online stimulus-response compatibility study

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Automatic motor representations are thought to facilitate object use, a phenomenon termed the affordance effect. Most affordance experiments use the stimulus-response compatibility (SRC) paradigm, which elicits faster reaction times (RTs) when the handle orientation of a stimulus is compatible with the hand used to respond. The present study used an online SRC paradigm to investigate affordance effects remotely and investigated whether SRC effects would be affected by traits of developmental coordination disorder (DCD), given that this neurodevelopmental condition is often associated with sensorimotor deficits. Participants (N = 178) were presented with graspable objects, with handles oriented to the left or right, and completed 4 blocks of compatible and incompatible SRC trials. During experimental blocks they were asked to make upright vs. inverted judgments and in control blocks they completed colour judgements. Participants were screened for traits of DCD, dyslexia and ADHD. We replicated the SRC effects online, but only for the experimental task, in line with affordance interpretation. Additionally, we found that participants with high traits of DCD had significantly longer RTs in incongruent trials than those with low traits of DCD. These results were not mirrored in ADHD or dyslexia, suggesting that affordance effects may be sensitive to DCD.

Do we navigate through a 3D model or across a surface of images?

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Recent advances in Generative Query Networks (eg Eslami et al, 2018) offer new ways for neuroscientists to think about 3D representation of scenes that avoid explicit 3D reconstruction. In our experiment in immersive virtual reality, participants viewed a naturalistic scene from one location, were teleported to a new place in the scene and had to navigate back to the original location ('homing'). However, their field of view was restricted to a 90deg cone that meant, for example, that they could only look north in the first interval and east in the second. 3D reconstruction algorithms (SLAM) predict unbiased performance on this task. At the other extreme, any approach based on matching of views suggests the task should be impossible. The results are somewhere in between: participants show distinct, repeatable biases in their estimates of the target location. We assessed 3 one-parameter 'models' (descriptions of the data) that predict participants should stop short of the target location assuming they travelled on a straight line from (i) the start location to the target, (ii) a line from the centre of the room to the target or (iii) a point on a part of their actual trajectory, one where they could see objects that were visible in both the first and second interval. Model (iii) provides the best description of the data compared to Model (i) ($t(18)= 5.29$, $p<.001$) and Model (ii) ($t(18)= 2.23$, $p= .038$). Both reconstruction or latent representation models would need to be adapted to explain these biases. [This project was funded by EPSRC/Dstl EP/N019423/1.]

Perception of Actions on Their Fundamental Dimensions

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To enable us to behave and respond optimally in our social environment we evaluate the actions of other individuals based upon movements that reveal their goals and intentions. In this study, we explored the representational space of action perception using two complimentary, bottom-up, exploratory methods, namely exploratory factor analysis (EFA) and multidimensional scaling (MDS). These methods aim to uncover the underlying structure of action perception from ratings of action characteristics (EFA) or judgements of action similarity (MDS). For these experiments we recorded 240 different actions using motion capture and used this data to animate a volumetric avatar. In the EFA experiment, following similar methods to Sutherland et al., (2013), participants (n=235) viewed 240 actions and rated (on a 1-9 Likert scale) the extent to which each action demonstrated one of 23 different action characteristics (e.g., pulling-pushing, weak-powerful, etc.). The best fitting model was a four-dimensional oblique model. We named these factors: unfriendly-friendly, feeble-formidable, adduction-abduction, and unplanned-planned. In the MDS experiment the pairwise similarity judgements (on a 1-9 Likert scale) for a subset of 120 actions were

completed by participants (n=50) following a single subject incomplete design (Spence and Domoney, 1974). There were differences between the results of the MDS and EFA experiments that might reflect the different nature of the tasks. Our converging results show that actions are evaluated along a small number of fundamental dimensions, from more abstract social intentions, which might overlap with evaluation of other stimulus types, through to more specific action-only dimensions.

Visual adaptation to scattering induced by Bangerter filters in myopes

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Visual adaptation might take place after a period of vision under modified conditions. In this context, myopes are known to present a larger capability of adaptation to blur caused by defocus as compared to emmetropes. There are nevertheless other important sources of blur, such as optical diffusion or scattering, whose effects on adaption have not been explored in detail so far. In this work potential adaptation in myopes induced by vision through diffuser filters was studied. In the experiment 20 myopes with normal vision after refraction compensation underwent high contrast visual acuity (VA) tests under different conditions (with or without diffuser filters). After 40 minutes of binocular vision through Bangerter Filters (BFs) of density 0.6 a statistically significant enhancement from 0,54 to 0,62 VA in decimal scale (0,3 to 0,2 logMAR) was found. Ocular refraction was not correlated with the improvement. A control group underwent the same experimental procedure wearing no BFs. Within this group VA hardly changed. A new adaptation effect to scattering in myopes has been described. These results have relevance in studies with patients suffering from early cataracts, amblyopia treatments and for a better understanding of vision in myopes. [Financial disclosure: none.]

Can Music Influence our Visual Perception? A Psychological and Neuro-cognitive Study in search of Intermediality

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Just as lightning without thunder appears incomplete, our aesthetic experiences and their memories, whether knowingly or unknowingly, are mostly combinations of different senses – visual and auditory being the most dominant among them. This study attempts to explore this extremely natural yet lesser researched paradigm of audio-visual intermediality from the psychological and neuro-cognitive perspectives of the audiences. In a silent laboratory environment, eight famous abstract paintings of varying complexities, colors and compositions were viewed sequentially by 45 visually and musically untrained participants, who were asked to mark the corresponding emotions in a 5 point Likert scale after viewing each painting. Following significant time gap, similar responses were collected from the same audience group for the same paintings, but along with a set of (eight) piano music clips of varying tempo and complexity playing in the background. Analysis of participants' emotional ratings revealed that for a compatible combination between the visual and audio stimuli (in terms of common characteristic features like ordered-chaotic or continuous-fragmented), the arousal level of the evoked emotion corresponding to a specific painting increased from the silent viewing condition, but for an incompatible combination, the reverse trend was observed. Nonlinear Detrended Fluctuation Analysis (DFA) of the brain (EEG) responses recorded from 5 participants under the same two experimental conditions (silent vs. musical viewing of the eight paintings) also revealed that alpha and theta EEG bands featured higher symmetry scaling in presence of musical intervention. These unique findings have immense application potentials in media and therapeutic settings. [Archi Banerjee would like to acknowledge Department of Science and Technology, Government of India for providing her the DST CSRI Post doctoral fellowship (SR/CSRI/PDF-34/2018) to pursue this research work. The authors declare that they do not have any conflict of interest.]

What matters most - lines or colors? An experimental study on perception of emotions in non-figurative paintings

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Literature suggests that lines and colors, being two most fundamental visual elements, can have distinctive emotional attributes. For scientific validation of the same, an experimental study was conducted where 60 art practitioners each created six non-figurative compositions conveying six different emotions (anger, disgust, sadness, joy, romantic, calmness) and after individual content-analysis of 360 images, dominant color and line features were identified for each of the chosen emotions. In order to verify the individual and collective contributions of these identified features in elicitation of any specific emotion, another experiment was conducted where three non-figurative images were created to represent three negative emotions (anger, disgust and sadness) with their corresponding dominant line and color features. Then each image was manipulated by replacing only their colors (keeping other elements constant) with the dominant colors of three positive emotions (joy, romantic and calmness respectively). Through an online survey participants (N=920) were asked to identify the depicted emotions in these six images in a nine-alternative forced choice task and the dominating reason (i.e., lines/ colors/ both) behind choosing the emotions. Findings suggested that in the case of non-figurative images, though mostly the participants considered the combination of lines and colors as the emotion determining factor, in reality, colors played a more important role compared to lines in perception of emotions from these images, causing a switchover between negative and positive emotions singlehandedly even when the line patterns were unchanged. Results have relevance in the context of visual perception as well as design and marketing. [The authors declare that they do not have any conflict of interest.]

Crowding kills beauty

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We explore the influence of crowding on beauty in images. We asked 120 Prolific users to rate their enjoyment of 360 images (120 abstract arts, 120 figurative arts, and 120 photos) from Forsythe et al. (2011). This enjoyment rating is our operational definition of "beauty". After a fixation cross, each image was presented for 100 ms, and the observer rated how much they enjoyed the image on a 5-point Likert scale. Each observer saw any image once, which was displayed in one of six sizes (1, 2, 4, 8, 13, 18 deg) at one of two eccentricities (foveal or peripheral). The peripheral eccentricity, randomly right or left of fixation, was 21 deg for small images ($\leq$ 8 deg) and 16 deg for large images. For each image, each of the 12 conditions received ratings from 10 observers. Since crowding limits recognition, especially in the periphery, we anticipated that crowding might impair beauty. We estimated crowding distance as 1/3 eccentricity (Bouma, 1970; Kuzawski et al., 2021). For each image, a judge manually estimated the "key spacing", i.e., the minimum distance separating key components, where a "key component" is a group of features that is essential for semantic recognition of the image. For an image at some size and eccentricity, we computed its "crowding ratio" as the ratio of crowding distance (at the eccentricity) divided by key spacing (at the size). Across observers, sizes, and eccentricities, beauty is negatively correlated with crowding, $r(4318) = -0.48$, $p < 0.001$. Crowding kills beauty.

Attention sustainability and shifting in the digital environment

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The digital environment surrounds us everywhere and influences our cognitive system. Very few studies aimed to find mechanisms of how the digital environment influences visual attention. In two experiments, we attempted to investigate how the complexity of the digital environment affects visual attention and user's performance. Attentional sustainability and shifting were measured in "simple" and "complex" conditions. Participants were presented with an online planner. In the "simple" condition, no element changed its state or colour under the user's action. In complex condition, each element was interactive (changed its state and colour under the user's action). Modified Burdon test was used to estimate sustainability and shifting of attention. In both tasks, participants were asked to remember three words and search for slots with those words on the planner for 1 minute. In the shifting task, in addition, participants switched their target word by auditory signal, which occurred every 15 seconds. Obtained results showed that attention is less sustainable in "simple" condition, what was reflected in lower accuracy of the Burdon test performance. There were no differences in estimated attentional shifting. We suggest that attention is directed by the interface's cues (changes in state and colour) in the "complex" condition, whereas such guidance is absent in the "simple" condition. At that point, visual cues may organize attention and improve efficiency in the case of the "complex" environment. [The article was prepared within the framework of the Basic Research Program at the National Research University Higher School of Economics (HSE).]

Investigating the role of visual mental imagery in goal-driven involuntary attentional capture

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Attentional templates are considered to play a key role in guiding attention to specific information in the environment, in line with our goals. Recent work highlighted that both the theoretical concept of attentional templates, and their neural underpinnings, resemble another cognitive process: mental imagery. Coherently, initial evidence observed a relationship between the sensory strength of voluntary imagery and attentional templates (Keogh & Pearson, 2021), leading to proposals of a role of mental imagery in attentional templates. Here we further investigated this possibility using an alternative approach, adapting a well-established method of measuring involuntary attentional capture by goal-matching templates: the contingent capture paradigm (Folk et al., 1992). On each trial, participants were instructed to search for a different coloured object, which appeared in one of four locations. Colour cues presented prior to the target display allowed us to assess contingent capture by visual features of the attentional template. We expected that people who report more vivid mental imagery would be more likely to be captured by visual features of the attentional template, compared to people reporting faint or no imagery at all. Across two online experiments, our findings show that while our task elicited strong contingent capture effects by template matching colour, these did not appear to depend on individual differences in mental imagery. Indeed, robust effects were observed even among low imagers or aphantasics, suggesting a dissociation between self-report imagery and attentional templates. Further research is needed to elucidate the role of mental imagery in attentional templates and attentional capture.

Prior dynamic experience modulates spatial attentional rhythm

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The brain efficiently coordinates its limited resources over external information through attention. Recent studies demonstrate that attention works in a dynamic way, whereby multiple locations, objects, and features are rhythmically sampled over time. However, it remains largely unknown whether attentional rhythm is inherently hard-wired or can adapt to prior experience and changes flexibly. Here we used time-resolved behavioral measurements on 25 human subjects to examine whether externally induced rhythm in prior experience would influence spatial attentional rhythm. Specifically, subjects were first exposed to a rhythmic prime display (rhythmic prime), i.e., a near-threshold stimulus was presented alternatively between two spatial locations for 2500 ms at 3 Hz or 5 Hz. Next, after a varied time interval (200 to 1000 ms in steps of 33 ms), a near-threshold probe appeared at one of the two locations and subjects needed to detect the target and the accuracies were measured. First, behavioral data shows 2.5 Hz attentional rhythm when there is no prior stimulus, largely consistent with previous findings. Most importantly, the attentional rhythm is modulated by the temporal characteristics of prime stimulation, i.e., increasing to 4.5 Hz for 5 Hz prime and remaining at 2.5 Hz for 3 Hz prime, when the probe was presented in the left visual field. Taken together, our results suggest that visual attentional rhythm is not a fixed clock and could be modulated by and adapt to prior dynamic experience.

The impact of stressful situation on visual attention in virtual reality

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Studying the impact of the occurrence of stressful situations on visual attention is an important task for improving the efficiency of professional activity.This study was aimed at investigation of the impact of stressful situation created during the work in virtual reality on visual attention. 21 health participants took part in the experiment. The special virtual environment consisting of white (distractors) and red (target) flying linear balls was presented in a highly immersive virtual reality CAVE-system. Participants task was to press the button to respond to the appearance of the target stimulus. Each subject participated in two series of experiments lasting 10 minutes each. In the second stressful condition, an unpleasant sound lasting 5 minutes was unexpectedly delivered were asked to count out loud in order to have a cognitive load. During experiment the reaction time and indicators of cardiac activity were recorded. As a result, half of the subjects made more than 50% of mistakes in the stress series when reacting to the target object. It was obtained that these participants demonstrated significant differences in heart rate variability and heart rate between the control and experimental series. Thus, it was obtained that in a stressful situation in virtual reality a decrease in visual attention was linked with a changes in the functional state. [This work was supported by grant RFBR №19-013-00799.]

Unequal allocation of spatial attention in Multiple Object Tracking

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In typical multiple object tracking (MOT) tasks, the likelihood of each target being probed is equal. However, this is atypical of real-life contexts where specific targets or regions are of different importance. In two experiments we aimed to investigate whether participants can split their attention unequally across two regions of the visual field, in a modified MOT task where two distinct tracking areas were probed with high or low priority probability. In Experiment 1 we examined the accuracy with which participants report the movement direction of a target probed in either a low or high priority probability region. Accuracy improved with increasing priority probability and participants had more and longer eye fixations in the high probability region. In Experiment 2 we investigated if eye movements are necessary for unequal attention allocation. We compared performance in free-viewing and fixed-viewing conditions. The results from Experiment 1 were replicated, with better tracking performance in high compared to low probability regions, suggesting that attention was allocated unequally. This finding was obtained under fixed viewing, where moving items were tracked solely with peripheral vision, but the effect of priority was greater in the free-viewing condition. Unequal attention allocation is possible without eye movements. Eye movements, when permitted, do improve accuracy, presumably by allowing participants to fixate more in the high probability region and get a better, foveal view of the objects. These findings provide evidence in favour of flexible theories of attention allocation under dynamic conditions, suggesting a continuous pool of flexibly deployable resource.

No Evidence for the Self-prioritisation of Information Related to One's Own Limbs Versus the Limbs of Other People

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Evidence indicates that self-relevant information is automatically prioritised in perceptual processing. Specifically, we respond quicker and more accurately to information related to our 'self' than information related to other people. The magnitude of this self-advantage is greater when the information is more self-relevant. To date, research has primarily investigated information related to the 'global self'. However, our bodies are a fundamental subcomponent of our 'self'. Thus, we investigated whether people prioritise information related to their own limbs versus limbs of others, whether the dominant limb is prioritised more than the non-dominant limb, and whether the magnitude of heightened prioritisation is associated with the strength of self-reported limb dominance. Participants (N=38) learnt associations between shapes (circle, triangle, square) and their dominant, non-dominant, and a stranger's limb (hand or foot). In a perceptual matching task, participants judged whether different shape-limb pairs were correct as learnt, or a mismatch. Reaction times (RTs) and perceptual sensitivity (d') were measured. No differences in RTs and d' were found between judgements involving the dominant, non-dominant, and stranger's limb, regardless of whether the limb was a hand or foot (ps = 0.060-0.333). Bayesian analyses revealed moderate evidence for no differences in d' (BF10 = 0.295) but were inconclusive for RTs (BF10 = 0.841). Any differences in RTs and d' for judgements involving the dominant versus non-dominant limbs were not significantly associated with the strength of limb dominance. These findings suggest that self-prioritisation bias is not present for information related to our own limbs.

The Effect of Transient Attention on Motion Processing: Implications for the Magnocellular Pathway

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Spatial cues presented prior to the presentation of a static stimulus typically improve perception and performance. However, transient exogenous cues to direct spatial attention to the location of a forthcoming stimulus can sometimes lead to a reduced performance. Indeed, there is evidence that the perceptual advantage at the cued target location is reversed when the task and criterion content rely on temporal processing. In the present study, we investigated the effect of transient exogenous cues on the perception of brief drifting Gabor patches. Gabors' parameters were chosen to mainly engage the magnocellular pathway (i.e., low spatial frequency of the sinusoidal carrier linearly ranging from 0.15 to 0.55 c/deg, and 22% contrast). Observers performed a direction discrimination task. Peripheral cues preceding the Gabor patches either

indicated the target location (i.e., valid cues) or were uninformative (i.e., neutral cues). The behavioral results support the hypothesis that transient attention prolongs the internal response to the attended stimulus thus reducing the temporal segregation of visual events. In fact, we found more accurate responses with neutral cues than with valid cues, and faster responses in the valid cue condition than in the neutral cue condition. We fitted a response time model for perceptual decisions to check for a speed-accuracy trade-off. Although we cannot rule out this possibility, a better description of the data was a model in which valid cues lead to faster encoding, but neutral cues lead to higher overall processing speeds.

Cued Visual Selection

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Salient cues attract attention and may thus speed up pattern analysis at the cued location. In the standard cuing task the target is presented after, or sometimes simultaneously with the cue. By varying the delay between cues and targets, the task has been been used to analyze the dynamics of attention shifts. In the cued visual selection task I am reporting here, the target is presented, among other items, before the cue but is not yet selected until the cue occurs. With different onset delays this task, too, shows dynamic variations in the speed and accuracy of target identification. Contrary to the standard task, however, variations do not merely reflect the dynamics of attention but directly reflect response variations in target encoding. This may then be used to look at the modulation of neural signals in the visual system, i.e. the strength of how target properties are represented in the brain. After an introduction to the different tasks and the background for analysis, I will report findings that have been collected with the cued visual selection paradigm during the last years. Data confirm the transient response character of orientation sensitive neurons in the visual system, the different response strengths to oriented lines in uniform vs popout configurations, and reveal the timing differences of ocular input from dominant and non-dominant eyes in binocular rivalry.

More than the N2pc – what EEG components can tell us about the integration of attention-control sources

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The current study examined the effect of integrated top-down and bottom-up attention-control sources on known EEG components related to target selection (N2pc), distractor suppression (Pd) and a newly identified response-locked counterpart (RLpcN). In two experiments using a visual search task, endogenous cues (valid vs. neutral) were employed for top-down, and salience of a singleton color (of either the target or a distractor) for bottom-up attention control. Participants reported the orientation of a tilted target (Experiment 1), or the position of a small gap within the target (Experiment 2). Our results showed strong cueing effects on RT and accuracy in both experiments, demonstrating a general facilitation of responses to validly cued targets. Whereas salient targets were not generally processed faster than non-salient targets here, the presence of a salient distractor consistently worsened performance. The N2pc and Pd were only observed in trials where the target was preceded by a neutral cue in Experiment 1, and for validly cued targets and salient neutrally cued targets in Experiment 2. This pattern of results supports the idea that bottom-up attention capture occurs only when top-down allocation of attention is absent or inefficient. A decrease in Pd amplitude was found following a valid cue, indicating that the influence of top-down control on the suppression mechanism. The RLpcN was mostly evident for targets in Experiment 2, indicating its role in difficult tasks that require information maintenance. Surprisingly, response-locked positivity (RLpcP) was found in Experiment 1 for salient distractors, suggesting a connection with the suppression mechanism. [Funding: FLAG-ERA JTC 2017, MAC-brain project (FWO contract number S009918N).]

A case of moderate autism with a phenomenally superior but spatially restricted conjunction search: a hint for a dissociation between deficient endogenous and superior exogenous attention

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Several studies have reported superior visual search in high-functioning children and adults with autism in terms of response times during difficult search tasks such as conjunction (color and form) search. On the other hand, we observed that adults with moderate autism tend to report difficulty in visual search during daily life, which they overcome by keeping fixed order of useable objects. In order to resolve this apparent contradiction we studied psychophysically a single case of moderate autism (EC, age 35) who reported severe difficulty in visual search in daily life. We

tested EC on both feature and conjunction search for different number of distracters as well as manipulated target-distracter similarity. The results revealed normal parallel feature search as well as the previously found superior search for conjunction (color and form) in terms of shallower response time vs. distracter number curve. However, for a large number of distracters performance degraded significantly and approached chance level. We also tested EC on the attention cueing (Posner) paradigm and found normal exogenous cuing benefit but a total lack of endogenous cuing effect. This raises the possibility that what we are seeing in moderate autism is a dissociation between endogenous attention (impaired in both search tasks and orienting) and intact exogenous attention. Their superior visual search could be explained in terms of a superior parallel search that developed as a compensation for the impairment in serial processing.

Subjective sensory sensitivity in people with migraine, the role of anxiety, and possible neural correlates of the experience

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Migraine is characterised by intense headaches that are often accompanied by subjective sensory sensitivity (e.g., to sound, light and movement). We were interested in whether people with migraine also experience subjective sensory sensitivity between attacks and how this might relate to neural responses underlying the processing of sensory stimuli. We used online questionnaires to investigate how self-reported sensory sensitivities relate to migraine in a large community sample (n = 944). Mediation analyses were used to determine the contribution of anxiety symptoms to these relationships. Participants with migraine were found to report significant increases in subjective sensory sensitivity, and anxiety symptoms partially mediated the relationship between sensory sensitivities and migraine. Visual, movement and auditory subscales were found to provide unique explanatory variance in analyses predicting incidence of migraine. These findings suggest subjective sensory sensitivities are present between attacks and across senses in people with migraine. Anxiety symptoms contribute to this relationship, but sensitivities also exist independently. In a subsequent investigation, we are using MEG to explore whether subjective sensory sensitivity is related to differences in visual gamma response and psychophysical performance measures of detection/discrimination.

The effect of eye movement-based training in congenital prosopagnosia

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Prosopagnosia (face blindness) is a neuropsychological disease characterized by a selective deficit in face recognition. The prevalence of congenital prosopagnosia is 2-2,5%. Considering the severity of the disease and that patient coping efficiency differs for each individual, finding an efficient training method has the potential to significantly improve quality of life. Based on previous research, it can be stated that the scan path during face learning plays a crucial part in successful face recognition. The main goal for our research was to determine whether a more efficient face exploration pattern would provide better results in congenital prosopagnosia and to determine the exact factors that play a crucial role in the eye movement pattern. In order to achieve this, we have designed an "efficient", experimentally controlled scan path pattern based on previous research. The behavioural and eye movement data was recorded during three facial memory tests;1) efficient - experimentally controlled, 2) non-efficient - experimentally controlled, 3) free (spontaneous) face learning tasks. The recorded behavioural data of the subjects with congenital prosopagnosia (10 people) and neurotypical control patients (10 people) confirmed that the congenital prosopagnostic patients had impaired face recognition in the (3) free viewing learning task. While the controlled eye movement patterns (1,2) had a negative effect on the control group, the efficient scan path significantly increased prosopagnostic patient's face recognition performance. It can be presumed that the directed eye-movement patterns increase the accuracy of the fixations, change the facial encoding processes, and thus improve the facial recognition in subjects with congenital prosopagnosia.

LED ILLUMINANTS: EFFECT OF CORRELATED COLOR TEMPERATURE ON PUPIL SIZE IN OFF-AXIS VISION

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The increased use of LED technology is becoming more prevalent in our society due to its high energy efficiency. LEDs present different correlated color temperature (CCT); however, there is no evidence on how it influences pupil size. Previous studies have found variations in pupil size with retinal illumination for a single illuminant in the foveal area, where cones' density is high. Therefore, this pilot study has been conducted to analyze the influence on pupil size of the CCT, luminance and age at a retinal eccentricity of 10°. A pupilometer installed in a two-channel Maxwellian view optical system was used and four subjects, two young and two older, participated in this experiment. Pupil measurements were performed for six background luminances ranging from 0.01 to 50 cd/m2 provided by LEDs with different CCT: 2700, 4000 and 6500 K. As for the results obtained, we have observed that the pupil diameter decreases with increasing luminance and is larger for young than for old subjects for the same background luminance. Regarding CCT, in both young and old subjects, and for all background luminances, CCT does not influence pupil diameter.We can conclude that in off-axis vision the pupil size decreases with the luminance value in a similar way as it does in fovea. Old subjects have smaller pupil diameters than younger subjects for all luminances and for all illuminants, regardless of the CCT. Moreover, the decrease in pupil size at photopic luminance, where photoreceptors are saturated, is predictably caused by excitation of melanopsin cells. [The authors acknowledge the Spanish Ministerio de Economía y Competitividad (MINECO) (FIS2016-78037-P).]

Is visual discomfort is modulated by distance in cone-opponent colour space?

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Visual discomfort is modulated by chromatic perceptual similarity as determined by separation in CIE space. (e.g. Haigh et al., 2013; Haigh et al., 2015; Haigh et al., 2018). However, it is unclear if this is true for distance in cone-opponent colour spaces such as MB-DKL space (Macleod & Boynton, 1979; Derrington, Krauskopf & Lennie, 1984). This is important because early cortical areas respond strongly to contrast in the cardinal directions of cone-opponent colour space, but less strongly to colours on the orthogonal axes (Mullen et al., 2007), whereas sensitivity in later areas such as V4 might be associated with perceptual similarity (e.g. McKeefry and Zeki, 1997). Therefore, investigating these relationships might help us determine where visual discomfort occurs. EEG and discomfort judgements were measured for isoluminant cone-opponent stimuli. There was a non-significant trend towards more discomfort from increasing cone-opponent chromatic contrast, in agreement with the findings using perceptual CIE colour space (Haigh et al., 2019; Lindquist et al., 2021), however there was no effect of chromatic contrast on ERPs. Discomfort judgements were higher for the orthogonal axis compared to the cardinal axis, but the ERPs showed the opposite result. Time-frequency analysis showed lower alpha power for orthogonal compared to cardinal axes. These results indicate that the correlate of visual discomfort from chromatic stimuli does not seem to relate to cone-opponent colour space, which could suggest that it stems from later visual areas.

The effect of object shape and context cues on color constancy

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Color constancy refers to the ability to perceive the color of an object in a stable manner under different illumination conditions. Color constancy has been found to be better for the real environment than images (Mizokami et al., 2004; Morimoto et al., 2017). However, we do not currently understand well why constancy is better for real scenes. In the real environment, objects have a three-dimensional shape, which may provide useful cues to constancy. White objects in a scene can also be a strong cue for estimating illumination color. In this study, we investigated the effect of object shape and context cues on color constancy. We 3D-printed and painted target object stimuli with four shapes and eight colors. Illumination conditions were 6500K, 2800K, and Green which was orthogonal to the daylight locus. There were five context conditions with either no contextual objects or one of four shapes painted white. For each target in each illumination and context condition, observers rated chromaticness and the ratio of red-green-blue-yellow. We found that color constancy tended to be higher for three-dimensional stimuli compared to flat stimuli and with a white contextual object. The shape of the target stimulus did not influence color constancy in the no context condition. However, for scenes with a contextual object, constancy was better when those objects had smooth 3D shape compared to flat stimuli. This suggests that information from the shape and surface shading of contextual three-dimensional objects may be used to estimate the illumination, thus supporting color constancy. [JSPS KAKENHI JP16H01663, JP18H04183, Academy of Finland grant #319404.]

Adaptation of neural responses to naturalistic visual categories in low- and high-level visual cortex

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Neural responses adapt: they decrease to sustained or repeated stimulation. Adaptation is found throughout the nervous system, from sensory receptors to high-level cortical areas. Here, we investigated adaptation in both early (V1-V3) and late visual areas in the human brain using a repetition suppression paradigm. Specifically, we asked 1) is adaptation to repeated stimuli qualitatively different in early vs. late visual cortex and 2) how does temporal adaptation depend on category-selectivity? We presented naturalistic images from six categories (faces, limbs, buildings, scenes, objects and scrambled) to patients undergoing electrocorticography (n=4). Trials showed two identical consecutive stimuli with an interstimulus interval (ISI) ranging from 17 to 533 ms. Time-varying broadband responses were computed for each stimulus from band-pass filtered voltage time courses (50-200 Hz). We then summarized responses in a total of 102 electrodes from visual cortex which showed robust responses to the stimuli. First, our results show that, relative to V1-V3, higher areas exhibited stronger response suppression at all ISIs. Second, within higher areas, response suppression was stronger for preferred than non-preferred image categories, again for all ISIs. Third, the speed of recovery was similar irrespective of category-selectivity and visual area. Given these findings, we can infer that recovering from adaptation takes longer for preferred stimuli in high-level visual areas. We are currently developing computational models that predict these response dynamics by incorporating both adaptation and category selectivity. Together, our results suggest that adaptation differentially operates across the visual hierarchy to optimize visual processing of naturalistic visual categories. [This work was funded by BRAIN Initiative Grant R01-MH111417.]

Age Effects on Decision-Making and Learning Processes in Classification Tasks

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The present study aimed to investigate the effect of aging on the processes of the decision-making and category learning of visual stimuli. We varied the number of features that define the categories and used three different characteristics to assess subject performance: the proportion of correct classifications, the response time, and the eye movements' parameters. The stimuli differed by the type and direction of movement and the moving elements' color and shape. In all experiments, they were randomly divided into two categories. In Experiment 1, unknown to the participants, the classification was defined by the elements' color; in Experiment 2 – by the combination of direction and motion type; in Experiment 3 - by the combination of color, direction, and motion type. Two age groups participated in the study: 16 young (Md = 22 years) and 17 old (Md = 67 years). The results show that the learning performance deteriorates with the increase of feature number defining the classification. In all conditions, the young observers achieve a higher proportion of correct responses and shorter response time than the old. For both age groups, the number of saccades before giving a manual response depends on the task difficulty. The older group have a longer latency of the first saccade and made more saccades in all conditions. When considered together, the different performance characteristics imply reduced inhibitory control of the older group when evaluating the alternative responses, increased cognitive load on the memory processes, and decreased ability to ignore irrelevant information.

Two sides of the coin: The boost of object memory by schema violations is attenuated in older adults

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It has been proposed that prior knowledge is a key factor in understanding older adults' memory performance. However, it remains controversial whether it serves as compensational mechanism or might also interfere. We have shown that violations of prior knowledge benefit memory for objects embedded in real-world scenes. Here, we investigated age effects on this memory advantage, studying 23 younger (18–38 years) and 23 older adults (52–81 years). In a learning phase, participants were presented 60 real-world scenes taken from the SCEGRAM database containing target objects that were either semantically congruent or incongruent with the scene context (e. g. ketchup in the fridge versus in the shower). After a delay period, participants were asked to indicate for each of the 60 target and additional 60 distractor objects whether it had been presented during the learning phase. Using a

signal detection approach, we analysed participants' recognition performance for targets that were congruent or incongruent with prior knowledge, respectively. We corroborated that schema violations boost memory performance, but this benefit was significantly less pronounced in older adults (44% vs. 59% in younger adults). Whereas both age groups performed similarly on congruent targets, a substantial age-related performance gap emerged for incongruent targets. Our findings indicate that the potential of schema violations to boost object memory is compromised in older adults. Given age-related difficulties inhibiting prior knowledge, we suggest that though encoding of incongruent objects is strengthened by enhanced attentional selection, consolidation and decoding for recognition are hampered due to down-weighting of schema violations. [This research was supported by the German Research Foundation (DFG) - Collaborative Research Centre SFB/TRR 135, projects B5 & C7.]

Investigating older drivers' increased risk at intersections: A driving simulation in virtual reality

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While older adults are generally safer drivers than younger adults, they have an increased risk of being at fault for collisions and accidents at intersections. Such accidents can lead to personal injury and long-term consequences, such as losing one's driving licence. As being able to drive is an important factor in retaining independence for older adults, we strive to understand the factors that are involved in their impaired driving performance at intersections. In the current research project, we have developed a new driving scenario in virtual reality using Unity 3D. In our paradigm, participants navigate a series of intersections to drive to a specific landmark. We created custom 3D-models of UK roads and intersections in Blender and included realistic car and pedestrian models to make the scenario fully immersive. We used the Unity Experimental Framework to generate randomized routes for each participant and we systematically varied the amount of traffic at intersections and the presence of pedestrians. Within the driving scenario, a variety of behavioural data, such as velocity, acceleration and braking patterns and lane position can be recorded. In addition, the driving scenario can be easily adapted and customized, which makes it a promising new research tool for addressing further research questions or for developing driving assessments and trainings. We plan to test older and younger drivers using this driving scenario while also recording eye movements and electroencephalography to investigate the cognitive processes underlying driving performance at intersections. [Funded by the Rees Jeffreys Road Fund and the RAC Foundation.]

Effect of correlated color temperature and S/P-ratio of LED light sources on reaction time in off-axis vision and mesopic lighting levels

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The replacement of traditional lamps by LED technology offers the opportunity to research visual performance under its many possible spectral power distributions. The correlated color temperature (CCT) and scotopic/photopic (S/P)-ratio are considered parameters characterizing the spectrum of a light source. The lack of firm conclusions motivates the analysis in this work of the influence of the LED spectrum, which is defined by the CCT and S/P-ratio, on a representative night-driving task, the visual reaction time. A two-channel and four primaries photostimulator was used to measure reaction time in off-axis vision, at mesopic illumination conditions and for a range of stimulus contrasts. Reaction time was measured in a total of 16 young participants. The experimental conditions included a range of CCT, between 1870 and 6350 K, and different S/P-ratios for the same CCT. Reaction times are lower for conditions in which the spectrum has greater short-wavelength content, a fact corroborated by the greater stimulation of rods and S-cones obtained in the calculation of their excitation level. Moreover, the definition of the spectrum using the CCT and S/P-ratio does not equally define the spectrum effect. For the same temperature, a higher S/P-ratio provides lower reaction time values, but for the same S/P-ratio reaction time is independent of the temperature. A greater excitation of rods and S-cones under high short-wavelength LED spectrum provides faster reaction times. The S/P-ratio is the parameter that best justifies the effect of spectrum on reaction time, as it considers the spectral sensitivity of the visual system in its calculation. [Spanish Ministerio de Economía y Competitividad (MINECO) (FIS2016-78037-P) and the Fondo Social Europeo, Iniciativa de Empleo Juvenil and Junta de Castilla y León.]

The development of alpha activity in infants/children: a possible tool for sensorimotor integration

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Visual experience is crucial for the development of neural processing and the interaction with the environment. For example, the maturation of the alpha brain activity is a vision-dependent mechanism. This rhythm seems to have also a role in the network synchronization during sensorimotor processing. It is known that a dynamic bilateral recalibration between vision and motor action enhances the maturation of the visuomotor system. However, the role of this activity in spontaneous motor behaviour during infancy has never been studied. First, from EEG retrospective data, we consider the spectral power of resting-state EEG between 0 and 11 years of age to reconstruct the developmental trajectory of alpha activity. Then, we focus on the first three years of life to investigate the modulation of the non-nutritive sucking (NNS) motor behaviour and its relationship with cortical rhythms. The results show that background activity has two peaks in younger sighted subjects (4.5 Hz and 8.5 Hz), which progressively merge during development: the first one shifts with age while the second one corresponds to the classical alpha band observed in typical adults. This second peak seems to be more involved in sensorimotor coordination. Coherently, our results show a positive correlation between the power of 8 -10 Hz band and NNS frequency. These results suggest a possible synchronization of sensorimotor activities in the early stage of life, where visual and motor systems interact, leading to brain maturation. [The research is the results of MYSpace project, which has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement No 948349).]

Relationship between optokinetic nystagmus and the degree of autism disorder traits in typical adults

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Previous studies have reported that children with autism spectrum disorder (ASD) have atypical optokinetic nystagmus (OKN) responses. The autism spectrum hypothesis states that developmental characteristics continuously appear in individuals with ASD as well as in typical individuals. However, the relationship between OKN properties and the degree of ASD in typical adults remains unclear. This study therefore determines the Autism Spectrum Quotient (AQ) scores in typical adults to evaluate the degree of ASD traits in them and also investigates their OKN properties, such as the slow-phase velocity gain, peak velocity and the duration of the fast phase, frequency, and the mean eye position. A random dot pattern, moving in one direction (left, right, up, or down), was displayed while measuring the study participants' eye movements. The study results revealed a negative correlation between the participants' AQ scores and the OKN slow-phase velocity gain; in addition, no correlation was found between the participants' AQ scores and the OKN properties in the fast phase. These study findings indicate that the OKN disorder reported in ASD is associated with the neural basis disorder of the involuntary movement in the OKN slow phase. [This work was supported by JSPS KAKENHI Grant Number JP19K20328 and Adaptable and Seamless Technology Transfer Program through Target-driven R&D (A-STEP) from Japan Science and Technology Agency (JST) Grant Number JPMJTM20BY.]

Perceiving the patient's face: an eye-tracking study of dermatologist interpretation

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Interpreting medical diagnostic images is a complex process, which includes visual search, pattern matching, generating and testing hypotheses, reasoning, problem solving and decision making. Important part of clinical reasoning is based on visual information. Physicians use a variety of visual information in their practice: from direct observation of patients, to classical diagnostic methods such as dermatoscopy, x-rays, etc. Eye tracking reflects the focus of physicians' attention and provides an understanding of clinical thinking processes. In this study, we present different perceptual strategies by physicians with different experience. The novice physicians performs a large number of eye movements, paying attention to the entire surface of the face. With increasing experience, number of fixations is decreased, fixation duration increases, fixations are combined into clusters corresponding to the reference points of the analysis of the patient's face. Fixations, which are grouped at reference points, provide the physician with the data necessary to test the hypothesis of the presence of a pathology. Each commit cluster is considered a decision making node. Prolonged fixations that are grouped on image details signal active hypothesis testing and decision-making related to the interpretation of anatomical abnormalities. The number of fixations at each reference point decreases with increasing experience. The perceptual scheme, as well as the ability to perceive the patient's face holistically, allow experienced specialists to reduce the total length of the scanpath, compared to novices. The findings are consistent with the comparison of eye movements between novice physicians and experts in other areas of medical diagnostics.

Involuntary oculomotor markers of autism and its severity in children

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Movement disturbances are often associated with Autism Spectrum Disorder (ASD), including the movement of the eyes. However, oculomotor abnormalities in ASD have been typically studied in terms of the social aspects of visual exploration and engagement, either by analyzing gaze direction to points of social interest or by comparing gaze behavior to that of typically developing individuals when presented with specific stimuli. Here we analyzed a large eye-tracking data set obtained at the national autism research center of Israel from children watching three different short video clips with social content (n=165, 120 with ASD, ages 1-10 years). Inspired by a recent measure of "randomness" of movement found for pointing, we investigated the involuntary aspects of eye movements during video inspection, specifically the "randomness" of saccade timing. We found that the oculomotor measure of "randomness" (1) was significantly higher in ASD compared to the TD children; (2) was positively correlated with the ADOS severity score; and (3) was higher in ASD for all three video clips but to different degrees. The results persisted even when children with reduced tracking quality (primarily ASD) were discarded, and the effects were highly significant and robust. The finding of increased "randomness" of eye movements in ASD children watching video clips could be related to "neural variability" or noise, reduced executive control, or reduced engagement with the movies. These findings could contribute to the future development of oculomotor biomarkers as part of an integrative diagnostic tool for ASD.

Characterising the richer representations of face categories in the brain of super-recognizers

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Being able to recognize and remember the faces of our colleagues, friends, and family members is a fundamental aspect of our daily lives. But not all individuals are equally competent at recognizing the faces they interact with. Individuals within the neurotypical population vary a great deal in their ability to recognize faces. Little is known, however, about the underlying brain mechanisms explaining such behavioural differences. Here, we ask whether using electroencephalography (EEG) and representational similarity analysis (RSA), we can reveal a link between the real-world proficiency of "super-recognizers" (individuals within the top 2% of face recognition ability) and their brain representations. We used RSA with a large dataset of high-density EEG (>100k trials) acquired from super-recognizers (n=16) and typical recognizers (n=17) as they were presented with images of faces, objects, animals, and scenes. Using linear discriminant classifiers, we computed time-resolved representational dissimilarity matrices (RDMs) in each participant. First, we observed better decoding accuracies in the brains of super-recognizers for face-identity (504-606ms,700-750ms), face-gender (504-606ms), and face-emotion (500-559ms). Next, we constructed a brain intra-group similarity score (RDM correlations between individuals of the same group) for each individual and EEG time-point. Contrasting the brain intra-group similarity scores between groups revealed larger homogeneity between the brains of super-recognizers around ~130-150ms, suggesting that the brains of super-recognizers converge toward the optimal representation around the N170 window. In sum, we have shown that high-density EEG can precisely characterize the link between the superior recognition ability of super-recognizers and their richer, more homogeneous brain representations. [This work was supported by a NSERC and Mitacs scholarship to S. F-S, by a Swiss National Science Foundation PRIMA (Promoting Women in Academia) grant (PR00P1_179872) to M.R., by an ESRC IAAA grant to S. F-S, J. W and I. C, a NSERC Discovery grant to F. G, and an ERC-StG to IC.]

Congruent and incongruent social context changes the perception of complex emotions on a face

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Previously it has been shown that the perception of facial expressions of basic emotions can be influenced by context. We studied the influence of social context on the perception of complex social emotional expressions. Two

studies were conducted. In Study 1, short video recordings of posed complex emotions "loving", "nostalgic" and "empathic" were presented without any context. In Study 2, the same emotions were presented in social context that was either congruent or incongruent in emotional valence. To provide social context, we used silent scenes played by two actors whose faces were blurred. In both studies, the participants watched each facial expression twice: during first run, they provided short verbal description of the emotions seen on each face; during second run, they assessed emotions using the Differential emotion scale. Participants also completed the Toronto alexithymia scale. We expected that the emotionally congruent scene would lead to more consistent evaluation of the facial expressions, while the incongruent scene would bias their perception towards the context. The results show that "loving" and "empathic" expressions are indeed perceived as more positive while presented after the congruent scene or without any context, and as more negative while presented after the incongruent scene or without context. The "nostalgic" expression has similar emotional profiles regardless of the context of presentation, with only several scales showing significant differences. These results can be explained by ambiguous positive/negative valence of nostalgia, or by a lesser impact of the social component in the perception and experience of this emotion. [Research supported by Russian Scientific Foundation, project #18-18-00350-P "Perception in the structure of nonverbal communication".]

Eye movements during self-perception of the face of mature women with different personality difficulties

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Our own face is an important aspect of our identity, and it is one of the most familiar faces for each of us. Eye tracking during own face recognition allows not only to obtain objective data on self-perception, but also to better understand the perceptual strategies that underlie reflexive self-awareness. In this study we recorded eye movements during the perception of their own face by mature women with different personality difficulties (accentuation model by K.Leonhard). Positive correlations were found for the total observation time while perceiving whole face, number of returns to attractive AOI's, and the index of attention to attractive AOI with pedantry. We can assume that it is important for women with pedantic traits to control their age-related changes, paying more attention to maintaining attractive features than getting rid of flaws. Positive correlations with the same oculomotor parameters are also characteristic of exalted type. By focusing on attractive traits, exalted women receive positive reinforcement, thereby maintaining positive self-esteem. We also found a relationship between the number of returns to their deficiencies and emotional accentuation. For women with emotional accentuation, the shortcomings of their own appearance can be a relevant and emotionally significant topic and, due to suspiciousness, force them to return attention to them again and again, rechecking the state to prevent deterioration. Our results can be useful for dermatologists and plastic surgeons to understand the psychological reasons for patients' needs and to form a common understanding of problems and increase the level of customer satisfaction.

Perceiving the own fovea by using a rotating disc

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Our fovea centralis, the area on our retina that allows for sharp and highly accurate vision, is small: only about 1.5 mm in diameter, with an even smaller area of around 0.5 mm where no blood vessels impede the light trajectory. This approximates around 4.5-1.5 visual degrees, respectively; coarsely the area of our thumb when we extend our arm. Much of what we perceive from the world is actively constructed: extra-foveal information that is blurry and less colorful is automatically and inexorably supplemented via cognitive processing. We discovered a way to disrupt this process of filling-in. When looking at a rotating disc (diameter 2 m), printed with a stochastic noise pattern (random arrangement of 2.5 mm black squares on white background), at different distances (d = 1, 2, 3, and 4 m), we perceived a rather circular and discrete area of black-white-patterns with sharp contours in the middle of our visual field, while the surroundings were blurred out and indeterminate. Using a perforated disc of varying distance, we were able to match the discrete area to about 3 visual degrees, relatively independent of the rotation speed (between 60-20 rpm). This was compatible with the area of the central fovea (1.2 mm diameter) measured for the tested participant by means of an optical coherence tomography (OCT). A rotating disc might thus be an entertaining and educating device for understanding foveal vision; a low-tech but high-insight gadget that was already employed by Goethe and Fechner for demonstrating the peculiarities of human perception.

Towards benchmarking models of brightness perception

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Both local luminance as well as visual context affect perceived reflectance (lightness) and perceived luminance (brightness). Various computational models try to capture mechanisms underlying these percepts, mostly for simplified stimuli where lightness and brightness cannot be distinguished. While each of the proposed models captures some lightness and brightness effects better than others, a comparative evaluation of their overall performance is difficult for the following reasons: (1) no commonly accepted set of stimuli serves as benchmark to test these models on; (2) openly available model implementations lack a consistent interface, and/or rely on closed-source software; (3) models without available implementations are difficult to re-implement due to ambiguous descriptions of stimulus- and model-related parameters. To address these problems we present an open-source framework for testing and comparing models of human brightness perception in Python. For this, we provide implementations of many commonly used stimuli and tools for producing parametric variations of these. We also provide implementations for various existing models of brightness perception including several multiscale spatial filtering models and an edge-based model. Finally, we provide example workflows for evaluating these models on sets of stimuli, both replicating published results as well as challenging models with novel stimuli and model parameterizations. This platform provides a better overview of the advantages and limitations of existing and future models of human brightness perception. Additionally, we hope to start a discussion about stimuli appropriate for benchmarking models and about standardization of interfaces for computational models. [Funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) under Germany's Excellence Strategy – EXC 2002/1 "Science of Intelligence" – project number 390523135 and MA 5127/5-1.]

Searching through lightness sequences using the MILO task

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The multi-item localization task (MILO; Thornton & Horowitz, 2004) was used to study search through a sequence of gray targets. As the MILO task focuses on spatio-temporal aspects of search it is ideal to test theoretical proposals of the Anchoring model (Gilchrist et al, 1999). The anchor, i.e. the highest luminance (HL) determines the lightness of every other surfaces within a framework. The effects of HL on other surfaces are measurable in classical psychophysical lightness tasks but a search paradigm can directly reveal whether its position is registered by the visual system. In two online experiments, participants (N=36, 37) performed a sequential search through 9 gray targets. Search order was either from black to white target, i.e. toward the HL, or away from the HL. In different blocks, targets either vanished from the screen or remained visible once selected with the mouse. This influenced the range of grays in the framework and in the set of targets differently especially when shown on a gray (E1) vs. white (E2) background. Participants were faster in the vanish than remain condition, although serial position did not interact with any other factor indicating equally efficient search. In the remain condition, search away from the anchor was always faster than search towards the anchor. As expected, background color interacted with the direction of search with faster search toward the anchor on a gray background. The current findings largely replicate previous laboratory work that used a calibrated monitor.

Decoding fMRI multivoxel patterns reveals diverging representations throughout an object recognition learning task

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Much is known about the representation of different kinds of visual objects -- small and large, animate and inanimate, faces and landscapes -- in human ventral temporal cortex (e.g., Grill-Spector, Weiner, 2014). Less well understood is how these representations change when initially unfamiliar visual objects gradually become familiar and are recognized. We addressed this question with three-dimensional, slowly rotating objects, which were computer-generated to be characteristic and distinguishable. Eight observers viewed each object several hundred times over one week (Kakaei et al. 2021), while cortical BOLD signals were recorded (fMRI, 3T Siemens Trio, TR=1s). Fifteen recurring objects appeared in variable order, but subsets of 5 mutually predictive objects formed three distinct "temporal communities". Additional, non-recurring objects were

interspersed as controls. To assess the neural representation of objects, we analyzed the linear discriminability of 15 object classes (Fisher's LDA) in the multivoxel response of 758 functional parcels (Dornas, Braun 2018). Each functional parcel comprised about 200 voxels (2x2x2mm, MNI152 space) or 1.5 cm^3 of gray matter. We found significant discriminability of objects in 124 occipital, temporal, parietal, and prefrontal parcels. As objects became familiar, the representations of recurrent and non-recurrent objects diverged, especially in 3 fusiform and 2 parieto-frontal parcels. "Temporal community" structure was represented in 3 fusiform, 5 occipital and 3 inferio-temporal parcels. We conclude that visual recognition learning engages a specific network of ventral temporal, parietal, and frontal areas. [funded by the federal state Saxony-Anhalt and the European Structural and Investment Funds (ESF, 2014-2020), project number ZS/2016/08/80645.]

Multistability of homonyms' meaning

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Multistable perception occurs when an observer is confronted with a sensory stimulus that is consistent with two or more comparably plausible perceptual interpretations. When perceiving such stimuli for an extended time, observer's perception endlessly oscillates between the alternatives. This behavior appears to reflect activity of fundamental common neural circuits, because even as they are independently implemented, research shows qualitatively as well as quantitatively similar processing for visual, auditory, tactile, haptic, and olfactory stimuli of various complexity. Here, we investigated the experience of multistability for the meaning of homonym words, a case where its sensor (auditory) representation remains constant. We compiled a set of fifteen German words with two clear meanings, five words with three clear meanings, and five words a single clear meaning, used as a control. The word was acoustically presented 30 times within a one-minute slot. Participants responded on its current meaning (choices were among all possible meanings plus "other" unlisted meaning or no meaning at all). For most of the homonyms, we observed a temporal dynamics qualitatively similar to that of other multistable displays with prolonged dominance of one of the meaning followed by a switch in reports. Our results support the idea that multistability is not a sensory phenomenon but reflect actions of canonical neural circuits and should be observable in any winner-take-all network.

Now You See Me: Identifying non-linear cross-correlation between audio-visual and EEG signals

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Human emotions are a complex interplay of systematic and physiological behaviour reflected in the mental state of the respondent obtained from Electroencephalography (EEG) signals. In this study, we look for the neural and perceptual attributes of emotion while watching a real time audio-visual clip. We chose 10 min clips of two movies which displayed different emotional attributes while behavioural and EEG data were collected. For the behavioural responses, 50 participants were asked to score the clips in an interval of approximately 60 seconds for nine conventional emotions, namely amusement, excitement, happiness, calmness, anger, romantic, fear, sadness and surprise on a 5-point Likert scale. The obtained results were subjected to one way ANOVA tests to assess their statistical significance. Next, the video clips were converted to individual 1-D time series signals using Convolutional Autoencoders. An EEG experiment was conducted with 5 participants using the two (2) 10 min clips as stimulus, where the subjects were asked to view continuously with a break of 5 mins in between the two clips. Multifractal Detrended Cross Correlation Analysis (MFDXA) technique has been applied to assess the degree of correlation between the EEG time series and the obtained time-series of video clips. This technique revealed novel and interesting findings regarding the varying degree of association between the brain lobes and the source video clips over an interval of time. The neural results have been corroborated with the perceptual ones obtained from the behavioural responses.

Proximity, expectations, and attention but not necessarily physics determine perception for simultaneously viewed multiple bistable displays

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When several multistable displays are viewed at the same time, typically, the same perceptual state tends to be dominant for all stimuli, and perceptual switches tend to occur at the same time (so-called perceptual coupling). We investigated whether this can be altered by an opportunity for a physical interaction between objects. We used a well established version of the walker-on-a-ball display plus a novel display consisting of two rotating gears. In the default configuration, perception for both displays was congruent with physically interacting objects. We gradually altered displays to produce either an abrupt change to the potential interaction (e.g., moving objects away from each other) or to keep it constant despite the visual changes (disambiguating one of the objects). We fit four models that assumed 1) independence of perception of the stimuli, 2) dependence on the stimulus's properties, 3) dependence on physical configuration alone, and 4) an interaction between stimulus properties and a physical configuration. For the gears display, the perception depended on the stimulus properties, as in perceptual coupling, rather than on the possibility of physical interaction. Regarding the walker-on-the-ball, the perception depended neither on stimulus nor on the possibility of physical interaction but on whether participants were asked to respond with respect to the relative motion of both objects or the absolute motion of the walker alone. This suggests that perception of the walker-on-a-ball was driven primarily by expectations. The results reveal multiple perceptual mechanisms acting at various levels of processing, whereas priors of physical interaction had little influence.

Speed blindness in the visually impaired

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Speed blindness is a physiological phenomenon whereby the normal field of vision is perceived as narrower as the vehicle speed increases. In the case of eye diseases with a narrowing of the field of view, this impairment can be greater, so that driving can be dangerous. In this study "normal" vision is modeled with the combination of three different visual models: Visual model of Yarbus, in which the central retina with the 1.0 visual acuity (Snellen) fixates only 6 different points in the visual field in 2 seconds , visual model of Or for normal sighted people shown with eye tracker curves and the physiological visual model of Or, in which visual perception in the visual field becomes less and less in direction to periphery. Speed blindness itself is shown using a kinetic model (gif) as an illusion for normal people, which can be projected onto the combined visual model. The visual field losses in some eye diseases are projected onto these (moving) models (gif). Progressive eye diseases are also mimicked. It can be seen that the speed blindness losses, which physiologically arise in normal persons, are greater in eye diseases with visual loss. As eye diseases progress, the field of vision can be even more narrow. So, speed blindness is physiological. However, due to the loss of vision in the visually impaired, who are still allowed to drive, it can reach pathological dimensions.

Major Depression and the Perception of Affective Instrumental and Expressive Gestures: An fMRI Investigation

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Major depressive disorder (MDD) is associated with biased perception of human movement. Gesture, a subtype of biological motion, is particularly important for communication. This study investigated the neural correlates of gesture perception in MDD. We hypothesised different neural activity between individuals with MDD and typical individuals when viewing instrumental and expressive gestures that were negatively or positively valenced. This difference was expected to manifest in brain areas associated with gesture perception, including superior temporal, frontal and emotion processing regions. We recruited 12 individuals with MDD and 12 typical control individuals who were matched on age, gender and handedness. They viewed displays of point-light gestures while functional magnetic resonance imaging (fMRI) was performed. The results of a random effects three-way mixed ANOVA indicated that individuals with MDD had greater activity in the right claustrum compared to control individuals, regardless of gesture type or valence. Additionally, we observed main effects of gesture type and valence. Perceiving instrumental compared to expressive gestures was associated with greater activity in the left cuneus and left superior temporal gyrus, while perceiving negative compared to positive gestures was associated with greater activity in the right precuneus and right lingual gyrus. We also observed a two-way interaction between gesture type and valence in various brain regions. To the best of our knowledge, this is the first study investigating neural correlates of affective instrumental and expressive gesture perception in individuals with MDD and typical individuals. We encourage replications with larger samples to extend our initial findings. [Funded by the Carnegie Trust for the Universities of Scotland.]

Developing a web-based optokinetic rehabilitation program for people with Persistent Postural Perceptual Dizziness

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Persistent Postural Perceptual Dizziness (PPPD) is characterised by dizziness and non-spinning vertigo that is triggered by visually complex environments (e.g. supermarkets) and self-movement. Leading theories claim that people with PPPD over-rely on vision, relative to vestibular and proprioception, for balance and postural control. Treatment typically involves "optokinetic desensitisation", where patients are exposed to triggering visual stimuli in order to "down-weight" visual information. However, current treatment options involve passively watching dynamic abstract patterns, which is unengaging for patients and attrition is high. We have built a web-based optokinetic desensitisation program (a game) for PPPD that: aims to increase engagement and enjoyment; is flexible and allows patients graded control over their visual stimulation as treatment progresses; includes virtually rendered real-life environments to boost confidence and reduce situational anxiety. Stage 1 piloting with 11 participants indicated that the visual stimulation within the game was able to induce dizziness, nausea and discomfort symptoms - in theory, a prerequisite for desensitization. As expected, symptoms were rated as more severe when visual flow increased, such as during viewpoint rotation or traversing environments with closer and denser features. Importantly, participants reported that they would play the game if it aided their PPPD rehabilitation, despite it triggering discomfort. Stage 2 piloting is allowing us to set the spatial frequency and flow characteristics for Stage 3, in which we will in parallel i) test the rehabilitation efficacy of the game with a randomised-control trial and ii) use it to understand more about the triggers and underlying causes of PPPD.

The role of bias in a letter acuity identification task: a noisy template model

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In clinical testing of visual acuity and contrast sensitivity, it is often assumed that data reflect sensory performance and observers do not exhibit strong biases for or against specific letters, but this assumption has not been extensively tested. We measured letter identification performance against letter size, spanning the resolution threshold, for 10 Sloan letters at central and paracentral visual field locations, for 10 naïve observers, using the method of single stimuli. Results showed that observers had individually different letter biases consistent across the whole range of sizes. Preferred letters were called more often and others less often than expected (group averages from 4% to 20% across letters, where the unbiased rate was 10%). A "noisy template" model was used to distinguish biases from differences in visibility. A model with varying bias across letter templates fits much better than one with sensitivity variation, but the best model combined both - having substantial biases and small variations in sensitivity across letters. The over- and under-calling decreased at larger letter sizes, but was well-predicted by templates having fixed additive response bias: with stronger inputs (larger letters) there is less opportunity for bias to influence which template gives the biggest response. The neural basis for such bias is not yet known, but a plausible candidate is the letter-recognition machinery of the temporal lobe. In the future, it will be important to investigate whether the observed response biases are likely to have a meaningful effect on clinical measures of visual performance.

Multi-feature ensemble is summarized as the correlation of bound features

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Representing multiple objects statistically, rather than individually, is an efficient way to process them in a complex scene. Using ensemble perception, people readily extract statistical summaries like mean and variance from the distribution of features in multiple objects. However, it is unclear whether conjunctional information of multiple features is extractable without focused attention that is necessary to bind features as an object. To investigate this, we conducted a pair-matching task on a multi-feature ensemble. A display set comprised 8 circles of different colors and sizes, and their combinations were either perfectly correlated ($r = 1$) or uncorrelated ($r = 0$). After the set presentation, a test probe representing a value of either color or size was presented along with 9 options representing the other feature values (e.g., a color test probe and 9 size options, and vice versa). Participants chose an option judged as the corresponding pair with the test probe based on the display set. We observed that participants'

response pattern differed depending on the correlation of the features in the display set: as the test value increased, the response value also increased when the color and the size of the display set were correlated, but there was no such pattern with the uncorrelated display set. In addition, participants estimated the corresponding pair even to a test value not presented in a display set, following the correlation of two features. Our results suggest that people represent the conjunctions of multiple features in objects using a multivariate summary, the correlation. [This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIT) (NRF-2019R1A2B5B01070038).]

A grammar-based description of perceptual organization for scene segmentation

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Humans excel at visually decomposing scenes into individual objects. This ability of structured scene interpretation is also of fundamental interest to the study of cognitive reasoning with common applications in psychometric testing of general intelligence (e.g. Raven's Progressive Matrices). The Abstraction and Reasoning Corpus (ARC), Chollet (2019), has recently gained popularity as a benchmark of skill-acquisition e?ciency in artificial agents. Each task in the corpus consists of 2-10 pairs of input/output images. Agents must infer the underlying manipulation rule that exactly transforms an input image into its output image. We propose a grammar-based description of segmentation procedures based on empirical image segmentations. This visual grammar is a programmatic description of perceptual organization in humans and it complements ARC agents with object priors. Our perceptual grammar produces easily interpretable segmentations even for complex scenes involving many objects in di?erent functional relationships. These ordered scene interpretations allow for a structural alignment of the scenes' input/output compositions and, thereby, guide the search for a task's unobserved manipulation rule. We collected image segmentations for all of the 400 tasks in the ARC training set through a self-developed web interface. Submissions were validated based on the participants' reconstruction of the missing task outputs. We show that with this object-based perceptual approach an agent learns suitable transformation programs using only about 10 object features and transformation primitives. We also propose a way of utilizing an agent's transformational knowledge base to incorporate more evolved core knowledge priors concerning geometry and intuitive physics.

An Ideal Observer Model for Continuous Tracking of Numerosity

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Continuous tracking is a recently developed technique where participants are required to track (by cursor or with their eyes) a randomly moving object. Task performance is measured by cross-correlating the cursor and stimulus movements. The technique yields large amounts of data with short periods of acquisition. To date, the technique has been mostly applied to "object-tracking", where participants follow random movements of a target on screen. In this study, we extended the tracking technique to study numerosity and size, showing that the technique can generalize beyond object-tracking. We then developed an ideal observer model that describes the results in terms of efficiency of conversion of stimulus changes into responses. The ideal observer simulated well the results of human participants and allowed us to partition the data into two separate noise components: an early sensory or perceptual noise, and a late noise, possibly a motor component. The proposed model is appropriate to study the divergence of human participants from ideal behavior in all tracking paradigms, in any perceptual domain. The results show that continuous tracking is a useful psychophysical paradigm to study more ecologically relevant stimulus situations, and may be particularly valuable for participants unable to undergo long testing sessions, such as clinical populations and children.

Is phasic alertness independent from top-down processing? Evidence from stimulus informativeness

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Warning stimuli before behavioural targets increase behavioural performance, which is referred to as phasic alerting. Similar benefits occur through preceding orienting cues that draw spatial attention to the targets. It is still unclear if alerting and orienting stems from independent or interacting mechanisms. Here, we investigate if the informativeness of orienting cues impacts the effectiveness of the same stimuli as alerting cues. Participants performed a speeded two-alternative forced choice letter classification task with alerting cues intermixed in blocks with informative and uninformative orienting cues. We used the same stimuli

for both types of cues but varied the orienting dimension orthogonally to the alerting. Results showed that the orienting effect increased for orienting cues with higher spatial informativeness. Alerting generally reduced reaction times, but this seemed independent of the informativeness of orienting cues. These findings are consistent with the hypothesis that phasic alertness is independent of orienting. [Funded by the German Research Foundation (DFG).]

A low-cost device and technique for generating big data in visual psychophysics to train brain models

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Deep neural networks, though brain-inspired, were formerly used in achieving data-driven engineering goals only. Presently, however, these are also considered as tools to model the human brain, especially its visual system (HVS). To build models of HVS in psychophysics, neural networks may be first trained on any visual psychophysics data, and subsequently tested on some different phenomena. For training deep networks and generalized models that could work on psychophysical data, not used for training, it will require vast amounts of training data. Psychophysics experiments on flicker fusion, that involve presenting a flicker stimulus to a human subject who classifies the signal as either flickering or fused, may be a source of such big data. One can computationally define the problem as the binary classification of a time-series signal. Here we present a low-cost device that can generate flicker patterns with desired temporal waveforms and intensity, and allows the response of any subject into such binary classes, viz. flickering or fused. An Arduino generates the flicker stimulus, and also detects button presses by the subject in the act of classification. Light Emitting Diodes (LEDs) having fast temporal rise and fall times generate the flicker signals with temporal precision. The power supply to LEDs is controlled by a transistor that can be turned on and off via the Arduino. The device generates complex flicker stimuli involving photic pulses of different colors and intensities in the same train. Voluminous experimental results from such complex signals can be used to test any neural model. [Acknowledgement: Cognitive Science Research Initiative, Department of Science and Technology, Government of India, CSRI/307/2016.]

Relationship between pupillary baseline and pupillary responses modulated by attention and cognitive load

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Pupillary response is a prevalent technique to know the mental state. However, it is hard to compare the absolute values of pupillary response since many factors, like environmental luminance and participants' arousal levels, can affect pupillary baseline. One way to reduce the influence is by subtracting the pupillary baseline from raw data. Although participants in high arousal levels, thereby large pupillary baseline, tend to have smaller pupillary responses elicited by cognitive factors, the relationship between large baseline and small response is not always observed. This study aimed to manipulate the pupillary baseline and then show its relationship to pupillary responses modulated by attention or cognitive load. In Exp. 1, we examined whether the two types of pupillary responses could co-occur using the Posner cueing task and multiplying task. In Exp. 2 and 3, we manipulated the pupillary baseline by cognitive load (easy or difficult task) or luminance (bright or dark disk) and then examined how the two types of pupillary responses were affected, respectively. We found that large or small pupillary baseline manipulated by cognitive load did not affect pupillary response modulated by attention, whereas large baseline was accompanied by the attenuated pupillary response modulated by cognitive load. In contrast, the large or small pupillary baseline elicited by luminance did not affect pupillary response modulated by cognitive load, whereas small baseline was accompanied by the attenuated pupillary response modulated by attention. We presumed that the different pathways for the pupillary responses modulated by attention and cognitive load might be independent.

Exercise alone influences binocular rivalry dynamics following short-term monocular deprivation

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Adult homeostatic visual neuroplasticity can be induced by short-term monocular deprivation (patching), as indicated by a shift in sensory eye dominance in favour of the deprived (patched) eye. The most common experimental paradigm used in the literature to measure this effect has been binocular rivalry, where the two eyes are shown competing images and conscious perception alternates between the two percepts. The potential to enhance visual neuroplasticity with environmental enrichment such as adding exercise to a monocular deprivation paradigm has also been explored; however, the results of such studies are mixed. Whether exercise alone affects visual neuroplasticity induced by short-term monocular deprivation is unreported. In this study, we measured binocular rivalry in 20

healthy young adults (aged 20-34 years) at baseline and after two hours of (1) patching (of the sighting dominant eye) only, (2) patching with exercise, and (3) exercise only. Consistent with previous work, patching strengthened the dominance of the deprived (dominant) eye. Mild-moderate intensity exercise alone led to a reduction in the dominant eye percept and increase in binocular rivalry switch rate. The proportion of mixed percept, and the time to first switch (onset rivalry), did not change from baseline across all interventions. Our findings indicate that exercise in the absence of patching influences rivalry dynamics, and that an exercise alone condition is important to include when studying interactions between exercise and visual plasticity. [This work was supported by an Australian Research Council Discovery Project grant to AMM and OLC (DP180102596).]

Effects of cute adult and baby faces on evoking approaching behavior as measured by involuntary body sway

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Cuteness is often treated as an infant attraction based on the baby schema. The approach motivation associated with cuteness perception has been examined as a psychological response contributing to nurturing behavior. However, no research has demonstrated unconscious approach behavior itself, and it is necessary to verify whether the forward-leaning posture occurs as a physical and involuntary approach response to a cute object. On the other hand, if the approach motive is a psychological response that contributes to nurturing behavior, then there is no necessity for the approach response to occur when perceiving cuteness in adult faces. In the present study, we examined the correlation between cuteness evaluation and body sway by observing adult female faces and baby faces to verify whether approach behavior occurs. We find that the relationship between cuteness evaluation and body sway was observed only in female participants, and no change in body sway was observed in male participants. The results differed among the female participants who showed a relationship between cuteness evaluation and body sway, depending on the object being perceived as cute. In the case of baby faces, the approach response occurred regardless of the degree of cuteness, but in the case of adult female faces, the avoidance response occurred as the cuteness increased. This suggests that the quality of cuteness evaluation differs between the faces of infants and adults. [This work was supported by JSPS KAKENHI Grant Number 17K13901; 21K13679.]

Poster Session 2

The Importance of Anchor Objects for Scene Affordance

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The world we live in is not one we merely perceive passively but one in which we actively interact with our surroundings, performing actions on and with objects. While research has already shown that anchor objects play an important role in visual search and scene understanding (Võ, 2021), the influence of anchors on the perceived functionality of a scene remains unexplored. In the current study, we investigated the influence that different action-related and unrelated anchors have on the perception of affordances, i.e. the action possibilities in a scene. Participants rated the fit between a verbally presented action and an indoor scene, in which either an action-related or an action-unrelated anchor was masked. Compared to the control condition, in which a random non-anchor object was masked, participants rated the scenes lacking the action-related anchor as less fitting to the presented action. A weaker, but robust effect was found even when the masked anchor was not directly related to the action but present in the same scene (e.g., a sink and the action "taking a shower"). Importantly, participants rated scenes lacking the related anchor as significantly less fitting than scenes without the unrelated anchor, demonstrating that the perceived functionality of a scene is strongly linked to the presence of specific anchors. However, anchor objects influence scene affordance, even if they are not directly related to the action at hand. We conclude that anchors appear to contribute to a holistic understanding of action possibilities within scenes. [Acknowledgments: This study was supported by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation), project number 222641018 SFB/TRR 135 TP C7 granted to MLHV.]

Comparing Visual and Auditory Modalities in an Online Intentional Binding Task

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With the increasing administration of psychology experiments online, it is important to determine how tasks translate from the lab. The intentional binding (IB) task measures agency by manipulating time delay durations between an action and response. Previous studies determined that the IB effect generates greater underestimations for shorter time delays, and for auditory (versus visual) modalities. However, this decreased effect for the visual modality might be because the choice of visual (colour) is not equated to an abrupt onset tone regarding attention capture capabilities. The objective of our experiment was to implement an IB task in an online setting, comparing two abrupt onset stimuli: a brief tone and a flashing shape. Should these two stimuli elicit comparable IB magnitudes, then future experiments could benefit from the more precise timing of online visual presentations as compared to auditory. Participants were instructed to watch a dot rotate around an on-screen clock and press one of two keys during the second lap. After a delay of 250, 450, or 650ms, either a brief auditory tone or flashing shape was presented and participants estimated when the stimulus occurred by clicking on the corresponding location on the clock. In contrast to prior work, we found comparable IB magnitudes across modalities and no effect of delay on IB, demonstrating the efficacy of our visual stimulus to elicit IB. Our study provides promising avenues for conducting the IB task online, which would allow for greater reach in studying agency across more diverse populations.

Perceptual biases in a superposition condition

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Previous studies revealed that similarity between the current and already observed items optimize perception by introducing attractive and repulsive biases. In the real world, stimuli sequences are not entirely predictable, which means there is always an uncertainty about the upcoming stimulus. Hence, our perception should be flexible tuned to various inputs. This study investigated if an observed item could introduce different biases to perception simultaneously to prepare it for different upcoming conditions (similar and dissimilar stimuli). To do that, a line (inducer) was shown on the center of the screen for 500 ms. On the next screen, in half of the trials, participants observed a line either on the left or right sides of the screen with a similar or dissimilar orientation in relation to the inducer orientation. In the rest of the trials, they observed two lines (one similar and one dissimilar in comparison to the inducer's orientation) on the left and right sides of the screen. Then, participants had to report the orientation of the line from the previously seen display using the response circle also located either at the left or the right to indicate, which line should be reported. The results showed that the inducer line could form two opposite biases simultaneously: a similar line is attracted towards while the dissimilar one is repulsed away from the inducer. In sum, serial dependence is not limited to a single test item, but can affect multiple items with the direction of the bias depending on the feature similarity.

Affordance for Sitting: Perception of Preferred and Maximum Sitting Heights in a Virtual Reality Environment

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Previous studies have shown that people use body-scaled information when perceiving action possibilities. For example, people use leg length information to perceive whether a platform is sit-on-able or not (Mark and Vogele, 1987; Stoffregen et al., 1999). In other words, even though the maximum sitting height changed as a function of participants' size, it was fairly stable across participants when expressed as a proportion of participants' leg length. Moreover, kinematic patterns in the optic flow are alone enough to perceive affordances for sitting (Stoffregen et al., 1999). The present study investigated whether people use their body-scaled information to determine whether a platform is sit-on-able in an immersive virtual reality (VR) environment. Using a mobile VR headset, sitting platforms with different heights were presented, and participants ($N = 11$) were asked to choose platforms to determine their preferred and maximum sitting heights. As expected, the preferred and maximum sitting heights increased as the height and leg length of the participant increased. However, the preferred and maximum sitting heights as a proportion of participant's leg length were found to be stable around 0.64 ($SD = 0.081$) and 0.75 ($SD = 0.062$), respectively. The results suggest that people use body-scaled information to choose their preferred and maximum sitting heights in virtual reality environments.

Face Adaptation Effects on Non-Configural Face Information

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Previously inspected faces can affect the perception of faces seen subsequently. The underlying mechanisms of these face adaptation effects (FAEs) have been considered to be based on sensory adaptation processes. However, by employing famous faces, recent studies were able to demonstrate that FAEs are very reliable and robust over long periods of time. This suggests a high level processing and an adaptation on a rather representational memory basis. Although research on FAEs seems to be well-advanced, our knowledge is still quite limited in terms of which qualities of a face can be adapted, as most studies have focused only on configural information (i.e., mostly 2nd-order relations). By altering different types of color information, we investigated whether non-configural face information also plays a significant role in the processing and storage of faces. Our results provide clear evidence for robust non-configural adaptation effects which seem to be very unique within the context of faces. [This research was kindly supported by the Deutsche Forschungsgemeinschaft (DFG).]

Aesthetic Components Underlying the Visual Perception of Spaces with Curved Boundaries in Virtual Reality Environments

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The built environment has an impact on human cognition, emotion, and behavior. Recently, a growing body of research in vision has investigated how people perceive the built environment and their aesthetic experiences there. In the present study, our main aim is to investigate how the variety of terms used to describe and understand aesthetic experience could be grouped into some key psychological dimensions. The second aim is to investigate what features of the built environment modulate these key dimensions. 128 participants evaluated sixteen different 360-degree spaces in virtual reality using 25 adjectives commonly used in the aesthetic judgments' literature. These spaces consisted of four specific properties in two levels of intensity; high and low (size: small-large; light: dim-bright; texture: longitudinal-lateral; color: cool-warm) in two curved boundary types (horizontal/ vertical). We performed principal component analyses (PCA) on the responses to reveal the underlying psychological dimensions and analyzed how various features of the spaces affected these dimensions. Our findings showed that the aesthetic experience of people in the built environments could be reduced to three main psychological dimensions, namely 'familiarity', 'arousal', and 'engrossing'. Different features of the built environment revealing their distinct characteristics modulate each psychological dimension. While the 'familiarity' dimension was modulated by boundary type, size, light, and color, the 'arousal' dimension was modulated only by size, light, and color. The 'engrossing' dimension was not modulated by any of these features. In sum, our study provides a comprehensive framework to understand the components of aesthetic experience for built environments.

Anticipating transitions in a movie. On dynamic order and interesting dynamics

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We perceive a scene as ordered if it seems to be organized according to a certain principle. The assignment of such a principle is idiosyncratic, dynamic, and based on previous interactions, expectations, and context. It has been shown that interesting structures often deviate from an obvious order. We explored the role of prior viewing experience and episodic context on the perception of order and investigated whether deviations from order induce interest. Using a digital slider, participants continuously evaluated the degree of order in a film. They then selected and described interesting, ordered, and disordered moments. The film comprised two phases: In the winding phase, a paper tape is slowly wound up into an ordered bundle; in the unwinding phase, the bundle is unwound again. Half of the participants (group wind-unwind) viewed first the winding, then the unwinding phase. The other half (group unwind-wind) viewed it in the opposite order, starting with the unwinding phase. Group wind-unwind rated the motive overall as more orderly and marked the very first windings more often as interesting than group unwind-wind who knew at the time what kind of order would develop. Ordered phases were often described as complete, flawless, understandable, or regular. Descriptions of interesting phases emphasized anticipation and transformation, sometimes referred to as turning points between order and disorder. This study illustrates the relevance of recognizing principles of organization for evaluating order and suggests that transitions between phases of order and disorder or disorder and order can trigger interest.

How sequential dependencies affect the intraindividual variability of beauty judgment

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Measuring intraindividual variability of beauty judgment is key to understanding the repeatability of beauty ratings within and between individuals. To calculate intraindividual variability using repeated measures, the repeated measures must be independent. Sequential dependencies, which occur when previous ratings influence following ones, threaten to violate such independence. We assessed whether such contrast and assimilation effects influence the variability of beauty judgment. We asked participants to rate (1-7) the beauty of 75 images in an arbitrary initial order. Then, participants rated all images two additional times. In the unscrambled condition, participants rated the 75 images in the initial order again. In the scrambled condition, participants rated the 75 images in a different randomized order. The order of the conditions was counterbalanced. We calculated the distribution of the differences between the initial beauty ratings and ratings in the unscrambled and the scrambled condition. We found that the standard deviations of the two distributions, 0.87 and 0.90 respectively, were not significantly different. To assess which sequence effects (contrast and/or assimilation) influence the variability in beauty ratings, we used a mixed-effect linear model to calculate the extent to which the preceding image's original and recent ratings predicted beauty ratings. We found that neither the previous image's original rating, indicative of a contrast effect, nor its recent rating, indicative of an assimilation effect, influence the current image's beauty rating. Overall, we conclude that sequential dependency does not affect intraindividual variability of beauty judgment.

Distractor probability cueing depends on the local distractor frequency, not the global distribution

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Ignoring irrelevant but salient stimuli and instead focusing on what is most important for the task at hand is an important ability. This has been studied in visual search experiments, showing that a salient but task-irrelevant distractor captures attention less frequently when it appears at a location where it has appeared frequently in the past. However, the precise mechanism of this distractor probability cueing effect remains unknown. It could reflect redistribution of resources, e.g.: allocating less attentional resources or more of a distractor suppression resource to frequent distractor locations. In this case, it would be expected to be a global effect: if more of a limited resource is allocated to one location, other locations must receive less of it. Alternatively, it could reflect a local form of learning, e.g.: more frequent exposure to distractors in one location makes distractors at that location less novel, so they capture less attention. In order to determine whether the distractor probability cueing effect is local or global, we performed three visual search experiments in which participants searched for an orientation target while ignoring a same-dimension distractor which occurred more often in one (frequent distractor) region of the search display. By varying the bias towards the frequent region while also comparing experimental conditions with the same distractor frequency in one region, but differing frequency in the other region, we found that attentional capture is reduced with increased local distractor frequency, but does not significantly depend on the global distractor frequency, consistent with local learning.

Rapid Distractor Rejection Drives Larger Attentional Benefits from Negative Templates during Difficult Visual Search

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Negative cues about the color of upcoming distractors can be used to form 'negative templates' which lead to attentional benefits during visual search, although these benefits are smaller than positive cues. Attentional benefits from negative cues are thought to be evidence of active distractor suppression. Previous research from Conci and colleagues (2019) showed larger negative cue reaction time benefits for participants engaged in a difficult search task where targets and distractors were similar shapes compared to an easy search task where target and distractor shape was more distinct. In our work, we examined what led to the additional benefits during difficult search by measuring eye tracking while participants engaged in the difficult and easy search tasks. We found that attentional deployments were more likely to be directed towards potential targets than distractors following the informative negative cues compared to neutral non-informative cues. Surprisingly, the attentional guidance effects of negative templates were similar for the easy and difficult search tasks. Instead, the larger reaction time benefits for the difficult search task were driven by dwell times. Rapid rejection of negatively cued distractors led to very short dwell times when attention was directed to a distractor. This

rapid rejection was especially important in the difficult search condition, where targets and distractors were of similar shape. Overall, these results suggest that negative templates lead to attentional guidance towards targets during search, and rapid rejection of distractors following negative cues aids search efficiency especially on difficult search trials.

Implicit Learning Modulates Attention in a Spatial Cueing Task

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The environment in which we live provides a continuous amount of information to the human brain, and some must be prioritized according to our goals and expectations, through a process known as 'attentional selection'. Selective attention is typically thought to be driven by either bottom-up (exogenous) or top-down (endogenous) processes. However, the dual dichotomy of attentional selection has been recently challenged. Evidence from visual search studies suggests that attentional guidance may be influenced by Statistical Learning (SL) of spatial regularities (Jiang, 2018). When a region of the screen is made more probable to contain the to-be-detected target, participants show faster reaction times compared to trials with targets appearing in improbable locations. The present study investigated SL in a Posner cueing task. Differently from previous studies, the present work involved a three-phase design, allowing us to exclude intervening factors (e.g., priming effects) and to isolate pure effects of SL (Jiang, 2018). Furthermore, cue predictive validity (i.e., the probability of a cue to predict target location) was manipulated only in one out of two spatial locations (i.e., left or right), with the aim to elicit an attentional bias toward that specific location. Results showed Cueing effects during the Learning phase (i.e., cue predictive validity at 75%), but not during the previous Baseline phase (i.e., first; cue predictive validity at 50%). Importantly, such effect persisted during the final Testing phase, when cue predictive validity came back to chance level (i.e., 50%), providing evidence that SL modulated spatial orienting of attention.

Do eye have your attention? Gaze cueing using emotional faces

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Humans are social creatures, and how we pay attention in social contexts is heavily influenced by the faces we are looking at. Previous literature has examined the ability of various genders, ethnicities, and emotional valence of facial stimuli to shift social attention, and the data have been mixed. In order to reconcile these discrepancies, we set out to measure how social attention varies using facial stimuli of varying genders (male/female), ethnicities (Asian/Black/Latinx), and emotional expressions (angry, happy, neutral). Participants first completed a discrimination task with faces displaying neutral, happy, and angry emotions, in which specific facial identities either consistently looked at (congruent) or away from (incongruent) the target. Subsequently, they rated which faces they felt appeared more often. We found intact social attention which did not vary by ethnicity or gender of the face but did vary by emotion. In contrast to previous findings, we found smaller magnitudes of social attention for angry faces as compared to happy and neutral faces. Finally, converging with prior work, we found that participants believed incongruent faces appeared more often in the experiment, despite equal presentations. These findings suggest that facial emotion, but not the gender or ethnicity of the face, modulates social attention such that angry faces are less powerful at shifting attention.

Investigation of self-initiated attention shift

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In everyday life, visual attention shift is self-initiated without the need of a cue, but most attentional experiments used a cue to trigger a shift of attention. To understand the neural mechanism of self-initiated attention shifts, we conducted an experiment where the participants shifted attention by their own volition while their brain electroencephalogram (EEG) signals are recorded. We estimated the onset and direction of the attention shifts by the spatiotemporal tuning of steady state visual evoked potentials (SSVEP). Based on the estimation results, alpha (8-12 Hz) and gamma (40-90 Hz) bands oscillation are analyzed as potential candidates related to self-initiation of attention shifts. Our analyses showed that increase of the alpha band amplitude from ipsilateral electrodes (alpha suppression) was shown after, not before, attention shifts, indicating that alpha band activity is not responsible for, but the result of attention shifts. The analyses also showed little change in gamma spindle around the time of attention shifts. Neither alpha amplitude nor gamma spindle are related to self-initiated attention shifts.

Robust and reliable implicit categorization of food information at the individual level with fast period visual stimulation

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Food information seems to capture our attention even when we are engaged elsewhere. Yet, how fundamental attributes of food—tastiness and healthfulness—might be processed implicitly remains largely unknown. Moreover, a reliable measure of food information processing remains elusive. We address these questions using EEG frequency tagging (fast period visual stimulation). Forty-two participants took part in an EEG session where randomly-selected, task-irrelevant nonfood images appeared sequentially for 16.7 ms each (i.e., 6 HZ). Importantly, every 5th image (i.e., 1.2 Hz) was an oddball food image from one of four categories (i.e., the crossing of healthfulness and tastiness). Participants were asked to focus on centrally presented letters, to monitor changes either in color (i.e., low perceptual load) or in color and letter conjunction (i. e., high perceptual load). The signal-to-noise ratio (SNR) was calculated at each frequency. For control stimuli, we used diffeomorphic transformation to scramble the original images. To evaluate test-retest reliability, the identical EEG session was repeated three times. We found that 1) the SNR of food oddballs was much higher than that of control stimuli; 2) the effect manifested at the individual level for all participants; 3) the effect was highly reliable; 4) the effect was not modulated by perceptual load or food tastiness, but might be higher for low (vs. high) healthfulness pictures. These results demonstrated robust and reliable implicit categorization of food information at the individual level, with the effect not modulated by perceptual load or tastiness (but might be by healthfulness). [Funding was supported by the NSFC (32071045)/No conflict of interest.]

Schizotypal traits and anomalous perceptual experiences are associated with increased temporal resolution of visual perception in a two-flash fusion task

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The visual system organizes the temporal flow of sensory input into meaningful patterns. An important balance between integration (combining features into a coherent object) and segregation (separating features from different objects/events) can be characterized in terms of the "temporal resolution" of perception: the ability, for example, to perceive a temporal gap between two identical flashes. Disruption of this balance may lead to impairment of perceptual organization. Indeed, schizophrenia, a condition characterized by unusual perceptual experiences, has been associated with abnormal temporal processing of sensory stimuli (e.g., dilated multisensory integration and greater masking effects). Here, a large cohort of healthy participants completed an online version of the two-flash fusion task in order to test the feasibility of web-based psychophysical procedures and to investigate individual differences in the temporal resolution of perception, in relationship with schizotypal traits. Participants first completed a staircase procedure to determine the contrast of the flash, then we measured the proportion of judgments of "two flashes" as a function of the interstimulus interval between flashes. Psychophysical curves were fit to the data ($R2 > 0.90$) to determine the two-flash threshold. We found that (i) visual temporal acuity declined with age, and (ii) schizotypal traits in the 'cognitive-perceptual' domain and self-reported anomalous perceptual experiences were associated with faster temporal resolution. Interestingly, this contrasts with recent findings of dilated temporal processing in schizophrenia and high schizotypy. This faster visual resolution may be the consequence of a disconnection/desynchronization between different sensory modalities.

Specifics in contour detection in Autism Spectrum Disorder

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We studied the ability of children with Autism Spectrum Disorder (ASD) to integrate visual contours embedded in noise. Twenty-four children and adolescents with ASD and 32 age-matched participants with typical development (TD) participated in the study. In a Yes/No procedure, the observers had to detect a contour consisting of Gabor patches embedded among similar Gabor elements while the orientation of contour elements changed by different amounts of noise. The results showed prolongation of the response time at all noise levels in the ASD group, a lower proportion of correct responses for the contour detection, and a higher proportion of misses than in the TD group. We applied the hierarchical drift-diffusion model to the accuracy and response time data to understand the processing components of the contour detection

task that differ between the two groups. We assumed that the noise added to the contour elements would affect the rate of information processing and the stimulus encoding time. The results show that the ASD group needed more evidence in making a decision, i.e., uses a more conservative strategy and has a lower rate of evidence accumulation than the TD group. The noise level increase reduces the rate of information processing for both groups. The non-decision time is longer for the observers from the TD group. These findings imply that the participants with ASD explore noisy visual information with less efficiency than the TD group. In these conditions, the encoding processes between the two groups differ. [The study was funded by grant DN15/6 from 2017 of the National Science Fund of Bulgaria.]

How attention underlies color category effects

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Color is one of the prime examples of categorical perception. Color discrimination across different color categories (e.g., blue vs green) is faster and more accurate than within the same category (e.g., only blue). However, the role of attention for such effects is still unclear. Feature-based accounts of attention have shown that when attending to a specific color, only that color will capture attention, but these studies have typically used discrete colors to test different attentional theories, rather than using fine hue differences to investigate the role of color categories. We investigated whether these attention effects depend on color categories, or whether they are driven by color similarity alone, that is, by distance in color space. In a spatial cueing task, participants searched for either a blue or green singleton target across different blocks. Prior to the target display, cues unpredictive of the target location were briefly shown, in which a singleton cue varied in different hues of blue to green using DKL color space. Our results showed validity effects (e.g., RTs were quicker on valid trials compared to invalid trials) only when cues were from the same category as the target (e.g., blue cues for the blue target; green cues for the green target), with no observed validity effects once cue color crossed into the next category. These results suggest categorical effects at the blue and green color category border are in line with attentional mechanisms. [DFG Sonderforschungsbereich SFB TRR 135 project C2.]

Why bananas look yellow: The dominant hue of object colours

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This study investigated how the hues of object colours are perceived, such as the yellow hue of a banana. By dominant hue, we refer to the hue direction that corresponds to the first principle component of the chromatic distribution of an object. To establish whether the dominant hue represents the perceived hue of the chromatic distribution, we tested whether observers are able to see the difference between original images of objects, and versions, in which we projected chromaticities on the dominant hue (one-hue images). For this, we used a 4-alternative forced choice discrimination task, and measured accuracy, response times, and response confidence. To assess the difficulty of one-hue discrimination, we compared the above trials with control trials, in which we slightly rotated chromatic distributions of objects. Three online experiments showed that discriminating one-hue from original images was more difficult than discriminating hue-rotated images. In experiment 1, we found that one-hue versions are barely discriminable from original photos of fruits and vegetables. Experiment 2 showed this when using Eidolons that have similar colour distributions as the fruits and vegetables but are not recognisable. The results of Experiment 2 suggest that the dominant hue is not bound to colour-diagnostic objects but to the colour distribution. According to Experiment 3, the differences between original and one-hue images are potentially discriminable but are missed due to inattentional blindness. Together, our results suggest that the dominant hue largely represents the hue of chromatic distributions of objects. [Financially supported by the Center of Perception and Cognition at the University of Southampton / No conflict of interest.]

A Neural Model of Contour Tracing Operation

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Contour tracing is a visual routine that enable serial grouping of distant contour segments into a unified object representation, and segregation of selected object from distractors. At the neural level, contour tracing is implemented by spreading of increased firing rates among orientation-tuned units in the primary visual cortex (Pooresmaeili & Roelfsema, 2014). Here, we developed a neural network model for contour tracing whose dynamics is comparable to neurophysiological measurements. Activity spreading is achieved by computing activity difference between two sets of units: 1) attentional units whose horizontal connections enable propagation of activity enhancement to collinear neighbors and 2) non-attentional units that receive only feed-forward input. The model employs multiple spatial scales in order to account for variable speed of contour tracing. In addition, the L-junction detection network enables tracing to change direction to non-colinear orientations when L-junction is reached. Computer simulations showed that the model

correctly predicts slower tracing times when target and distractor contour were placed closer to each other and when they intersected at smaller angle as it was observed experimentally. In addition, the model is capable of tracing contours whose segments vary in contrast. [This work is supported by the University of Rijeka under the Grant uniri-drustv-18-177.]

Derivation of visual timing-tuned neural responses from early visual stimulus representations

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Quantifying the timing (duration and frequency) of visual events is vital to the dynamics of human perception and behavior. Early visual neural responses monotonically increase with event duration and frequency. Other, timing-tuned neural responses give an abstract quantification of event timing and have recently been described in several areas implicated in accurate timing perception. It remains unclear whether and where the human brain derives these timing-tuned responses from early visual monotonic responses. Here we characterized both monotonic and tuned responses to the timing of visual events presented at fixation, using 7T fMRI and neural model-based analyses to investigate the transformation from monotonic to tuned responses. We found increasingly clear monotonic responses to visual event duration and frequency from primary visual cortex to lateral occipital cortex. From here, we found a gradual transition beginning in hMT+ from monotonic to tuned responses. The fits of both response models decreased with an increasing distance from the retinotopic location of the stimulus. However, the additional response component captured by tuning did not depend on retinotopic location. We therefore propose that abstract quantification of visual event timing is derived from temporally modulated responses in extrastriate visual cortex. Monotonic responses may be intermixed with tuned responses, with the proportion of tuned responses increasing through a hierarchy of visual timing maps that progressively abstract temporal representations from the spatial properties of their inputs. These properties resemble the derivation of numerosity, a spatial quantity, from early visual contrast representations. [This work was supported by the Netherlands Organization for Scientific Research (452.17.012 to Ben M. Harvey).]

Visual Tuning of Alpha Oscillations in Human Visual Cortex

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The alpha oscillation (8-13 Hz) is a pronounced neuronal signal measured from the human occipital lobe. Alpha oscillations are widely thought to reflect cognitive functions including attention and alertness, and are believed to be synchronized across a large expanse of cortex. However, there is some evidence that suppression of alpha oscillations in visual cortex can be spatially specific. Here, we used intracranial electrodes (ECoG) to measure and model alpha oscillations in multiple visual areas in 9 human subjects. The subjects viewed simple contrast patterns masked by an aperture that swept across the visual field. We used a model-based approach to separate out the change in the power of the alpha oscillation from broadband signals that overlap the alpha range. We find that for a given electrode, alpha oscillations are suppressed only when the visual contrast patterns appear in specific regions of the visual field. We used a 2D symmetric Gaussian population receptive field (pRF) model to explain the time series of the alpha signal and compare the solutions to pRF models fit to broadband responses measured from the same electrodes at higher frequencies (70-180 Hz). We find that the pRF centers are highly similar between the two measures, but that the alpha pRFs are several-fold times larger. The results demonstrate that alpha suppression in human visual cortex is spatially tuned and in agreement with the underlying retinotopic map. This finding supports the possibility that the alpha suppression reflects part of the computations in generating neural responses to visual stimulation. [NIH R01MH111417.]

Seeing features of unseen objects: feature migration in redundancy masking

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Redundancy masking (RM) refers to the reduction of the number of perceived items in repeating patterns. For example, when presented with arrays of 3 identical lines in the periphery, most observers reported only 2 lines. Here, we investigated if a unique feature on one of several otherwise identical objects is lost in RM, migrates to other objects or protects against RM. Stimuli consisted of 3-6 concentric circles surrounding fixation. One of the circles had a small gap in one of the four cardinal directions (left, right, up, or down). Participants performed three tasks, indicating (1) the number of circles, (2) on which circle the gap was perceived (1st, 2nd,…, nth circle, or no-gap), and (3) the direction of the gap. Overall, we found strong RM: the reported number of circles was lower than the actual number, even when gap direction discrimination was at ceiling performance. In non-RM trials (correctly reported number of circles), the gaps predominantly migrated towards more peripheral circles. In the key condition, where 3 circles were presented but 2 were reported (RM trials), the gap on the central circle was most often reported on the 2nd (i.e., outer) circle. Around gap direction discrimination thresholds, there were almost exclusively RM-trials. Taken together, these results showed that salient features did not prevent RM. Large gaps either migrated or caused RM of typically weakly masked positions (in particular, outer positions when three circles were presented). We suggest that feature migration in RM shows the perception of features of unseen objects. [This work was supported by the Swiss National Science Foundation (PP00P1_163723 to Bilge Sayim).]

Low accuracy and high confidence in redundancy masking

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Visual scenes typically contain redundant information. One mechanism by which the visual system compresses such redundancies is 'redundancy masking' – the reduction of the perceived number of items in repeating patterns. For example, when presented with three lines in the periphery, observers frequently report only two lines. Redundancy masking is strong in radial arrangements and weak in tangential arrangements. Here, we investigated whether strong redundancy masking is associated with high confidence in perceptual judgements. Observers viewed three to seven radially or tangentially arranged lines at 10° eccentricity. They first indicated the number of lines, and then rated their confidence in their responses. As expected, redundancy masking was strong in radial arrangements and weak in tangential arrangements. Importantly, with radial arrangements, observers were more confident in their responses when redundancy masking occurred (i.e., fewer number of lines reported) than when it did not occur (i. e., correct number of lines reported). Hence, observers reported higher confidence for erroneous than for correct judgments. In contrast, with tangential arrangements, observers were similarly confident in their responses whether redundancy masking occurred or not. The inversion of confidence in the radial condition (high confidence when accuracy was low and vice versa) suggests that redundancy-masked appearance trumps 'veridical' perception. The often-reported richness of visual consciousness may partly be due to overconfidence in erroneous judgments in visual scenes that are subject to redundancy masking. [This work was supported by the Swiss National Science Foundation (PP00P1_163723 to Bilge Sayim).]

The Effect of Motion Direction and Eccentricity on Vection and Cybersickness in Virtual Reality- an EEG study

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Virtual Reality experienced through head-mounted displays can lead to vection as well as cybersickness in the user. Vection is the illusion of self-motion in a stationary observer and is often related to cybersickness. However, vection can also improve the user's experience by eliciting a more realistic sensation of self-motion through the virtual environment. Identifying where in the visual field motion presented to an individual causes the least amount of cybersickness without losing vection can guide future development for Virtual Reality applications. This study investigated the effect of motion direction and eccentricity on vection and cybersickness in a head-mounted display, simultaneously measuring EEG. Optic flow patterns were presented in the full field of view (FOV), centre or periphery and moved either in depth or laterally. Overall vection was stronger for stimuli that moved in depth compared to laterally in the full FOV condition, with no difference in cybersickness found between the two motion direction conditions. Interestingly, motion direction had the opposite effect in the restricted FOV conditions, here laterally moving stimuli caused more vection compared to stimuli

moving in depth, with stimuli presented in the centre causing more vection compared to stimuli presented in the periphery. Neither motion direction nor eccentricity had an effect on cybersickness. Changes in alpha, beta and theta oscillations reflect the processes involved in the experience of vection (Harquel et al., 2020), therefore alpha, beta and theta oscillations were analysed to investigate these as possible neural correlates of vection and cybersickness.

Playing video games doesn't improve contrast sensitivity

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Literature indicates that long-term experience with action video games can lead to improvements in visual information processing in some tasks. However, few studies investigate the effects on contrast sensitivity. The present study aimed to investigate whether video game players (VGPs) and non-video game players (NVGPs) would perform differently in contrast sensitivity (spatial frequencies ranging from 0.2 to 19.8 cycles per degree). Sixty participants (30 VGPs and 30 NVGPs) aged between 18 and 36 years (mean age = 22.29 years; SD = 4.28 years) participated in the study. No differences were observed for any of the spatial frequencies between VGPs and NVGPs ($p>0.05$). Bayesian analyses were also performed considering maximum robustness to avoid bias. Our results indicated that spatial contrast sensitivity measures were minimally influenced, or not, only by the recreational practice of action video games. This study goes against what much of the literature believes to be something consolidated. In this sense, this investigation contributes to the growing debate and opens some more gaps. We believe that our results are relevant and may open doors for future studies using different approaches.

The effects of linear perspective cues and textures on perceptual rescaling of stimuli inside a corridor: A virtual reality (VR) study

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The effects of different pictorial depth cues on the perceptual rescaling of stimulus size in virtual environments are still poorly understood. We systematically removed linear perspective cues and textures of a corridor in a virtual environment to determine how the perceived size of 'far' (10 m) and 'near' (5 m) circles varied depending on the presence of different pictorial depth cues. The point of subjective equalities (PSEs) among four pictorial depth cue conditions (linear perspective cues+textures, linear perspective cues, textures, no cues) were compared with each other for the near and far circles across binocular (both eyes) and monocular (dominant eye only) viewing conditions. Perceptual rescaling was stronger for the far (M=52.45, SD=19.16) compared to the near ring (M=21.51, SD=12.28). There was also a main effect of Pictorial Depth Cues ($p < .001$) but not for Viewing Condition ($p = 0.336$). Size judgments were closer to what one might expect from perfect size constancy when there were linear perspective depth cues. An interaction was observed between Pictorial Depth Cues and Ring Positioning [$F(2, 25) = 8.433$, $p = .002$]. Post-hoc Tukey pairwise comparisons showed that the size of the far circle was consistently overestimated in each condition with linear perspective cues as compared to one without any pictorial depth cues (all $p < .001$), while the size of the near ring was never underestimated (all $p \geq .707$). We conclude that linear perspective cues contribute more than textures to the perceptual rescaling of far stimuli placed in virtual environments. [This work was supported by funds from La Trobe University's School of Psychology and Public Health and a La Trobe University PhD scholarship awarded to GYY.]

Development of allocentric representations using self-motion information

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Spatial orientation during locomotion is a fundamental function in daily life that requires building mental representations of the surrounding environment. Spatial representations are based on egocentric (self-based) and allocentric (world-based) frames of reference. While adults are known to combine the two orientation strategies, representing space according to the allocentric perspective is not fully developed in childhood. In the present study, we investigated allocentric representation skills in children from six to eleven years old using a spatial navigation task with no visual cues available. The children were blindfolded and guided along a path. The room they walked through was divided into four quadrants, each signaled by an animal-shaped landmark. The children could observe the landmarks from the starting position before each trial. At the end of the path, they were asked to localize all the landmarks. Children were required to represent the

relationship among the four landmarks regardless of their position in the room to accomplish the task. The results showed that children had higher accuracy when they were in the same quadrant as the landmark to be indicated across all ages. Interestingly, when the child's position was different from the position of the landmark to be indicated, accuracy was higher with increasing age. Overall, these findings provide new insights into human spatial development: the ability to represent the environment with an allocentric perspective, basing only on vestibular and proprioceptive information, continues to develop during childhood. [All authors declare no conflict of interest. This project has been supported by the European Union's Horizon 2020 research and innovation programme under grant agreement No 732391 and by the Unit for Visually Impaired People, Istituto Italiano di Tecnologia (Genoa, Italy).]

Fixation durations in free viewing search reveal target guidance and the functional visual field

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The functional visual field (FVF) has been used to explain how many fixations are necessary to find a target in a visual search and why observers sometimes miss a target even though their gaze fell near to the target position. FVF studies have focused on the number of fixations and/or saccade amplitude. In contrast, fixation durations have received relatively little attention. We conducted a free viewing search experiment where participants had to find a specific target shape (an O among Cs) and manipulated target discriminability. Results: When search was easy, the fixation before the final saccade to the target had shorter duration than other fixations. Importantly, this effect only occurs when the target falls within a specific distance from the fixation center. We hypothesize that this distance is related to the size of the FVF, and that covert processing of the target produces a signal that speeds saccade planning, yielding shorter fixation durations. This effect is diminished in the difficult search condition, suggesting that the target saccade was unguided. Instead, harder targets may produce a random, serial, item-by-item search with a small FVF. Interestingly, in the easier task, shorter fixations can also be observed at earlier fixations in the search trial when the fixation is relatively near the target. This may reflect some knowledge of target presence several fixations prior to fixation on the target. [This study was supported by Deutsche Forschungsgemeinschaft (ER 962/1-1).]

Search with Dynamic Scenes: Head and Body Cues Guide Eye Movements and Facilitate Target Detection

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Introduction: Gaze, head, and body postures are socially important cues to indicate future actions and intentions (Emery, 2000). Most studies have investigated how foveally presented faces orient attention. Here, we investigated how people's dynamic gaze behaviors contribute to the orienting of overt attention in an ecologically relevant search task. Method: Twenty subjects searched for a target person (yes/no task; present in 50 % of trials) in sixty videos of real-world scenes with an eye-tracking device. In each video, subjects maintained central fixation while 1-3 individuals looked towards a common location. After a random SOA delay (200ms or 500ms), 3-4 individuals appeared in the videos. In 50% of the target-present trials, the individuals in the videos oriented their gaze to the target's location (valid-look trials), while in the remaining 50%, they looked at a distractor person (invalid-look trials). Videos were manipulated so that looking individuals (but not targets and distractors) contained: entire silhouettes, floating heads, or headless bodies. Results: We found a larger cueing effect (valid vs. invalid gaze direction) for the joint presence of heads and bodies (Δd'valid-invalid = .57) compared to floating heads (Δd'valid-invalid = .36), and headless bodies (Δd'valid-invalid = .3), all $p<.001$. First fixations foveated on the target person more frequently when the cue was valid vs. invalid with entire silhouettes (Δpvalid-invalid=22%) or floating heads (Δpvalid-invalid=21.2%), both $p<.001$, but not for headless bodies (Δpvalid-invalid=9.4%), $p=.13$. Conclusion: The dynamics of heads and bodies contribute to target detection, with the head playing a crucial role in guiding eye movements.

Effects of aging and hearing loss on identity and emotion perception and stimulus interference in faces

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Successful recognition of facial identity relies primarily on information in the top-half of a face, whereas the identification of some facial emotions (e.g., happiness and disgust)

relies more on the bottom-half. Whereas younger adults can flexibly extract information from relevant face regions depending on the task, older adults are less consistent in their ability to extract information from the top of the face for identification. One reason for that difference may be that older adults attend more to visual information from the lip region to aid speech perception due to hearing difficulties. Here, we evaluated hearing abilities and both identity and emotion perception of faces in 94 younger and 200 older adults, when identity and/or emotion could be either consistent or differ across comparator faces - a variant of the Garner interference paradigm. Older adults showed better performance and sensitivity than younger adults for emotion perception, whereas the opposite trend was found for identity perception. Identity changes did not interfere with either group's emotion perception, but older adults' identity perception showed more interference from emotion changes than younger adults. Both are consistent with the idea that older adults extract more information from the lower half of the face, regardless of the task. In older adults, worse hearing was associated with lower face perception performance and sensitivity, but hearing was not related to the interference effect. Overall, hearing ability and age predict both facial identity and emotion perception, but only age predicts the interference between the two.

Interpreting facial features to determine an observer's attention to a video

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The perception and interpretation of complex facial behavior is challenging for observers. This is mostly due to bottlenecks in the visual system and other limitations of subjective interpretations. Here we report on two novel aspects of perceiving facial behavior: (1) an objective measurement of facial features from webcam recordings (2) to detect an observer's degree of attention to an infotainment video about a controversial company. We applied artificial intelligence and computer vision models to extract features from action unit activity, emotional expressions, head pose, and eye-movements from facial landmarks, as well as heart rate from pulse-induced skin changes. The features served as input to a cross-validated statistical model to predict media interest that the participants introspectively reported post-hoc. Results showed that levels of attention varied considerably across observers, likely due to the reputation of the company displayed in the video. More importantly, the facial behavior model determined each observer's level of attention well above chance performance. Feature relevance inspection revealed that especially raised eye brows, opened eyes, a relaxed jaw, intense but short signs of confusion, and elevated heart rate were related to increased states of visual attention. To conclude, the results suggest that attention, and likely also other cognitive states, are reflected in complex facial behavior and physiology. Automated computer vision and machine learning models can successfully probe and interpret these markers. Our attention models may find way to various applications, such as in education to track students' attention during lectures or in media industries to gauge audience reactions. [This research has been conducted in collaboration with the startup Neurolytics in the context of a valorisation grant of the National Dutch Science Institute. Author MN is head of research of this startup.]

Are facial impressions in the eyes of the beholder?: The relative contributions of face- and perceiver-variance in perception of trait impressions from faces

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Facial appearance is one of the salient sources of personal information and strongly affects various social interactions. Data-driven computational studies have asserted that trustworthiness, dominance, and attractiveness constitute the core impression dimensions, and perception of these impressions is guided by distinct facial features associated with these impressions (e.g., Nakamura et al., 2020; Oosterhof & Todorov, 2008; Sutherland et al., 2013). However, more recent studies have suggested that perception of facial impressions varies across perceivers as well (Hehman et al., 2017). This study aimed to quantify how much facial impressions are guided by facial features and perceiver's individual tendencies with well-controlled face images. Sixty Japanese observers evaluated the trustworthiness, dominance, and attractiveness of 400 computer-generated East-Asian faces on a 9-point Likert scale. To quantify face-based and perceiver-based variance in the facial impression judgments, we analyzed the rating scores with cross-classified random effects models using Bayesian estimation, where both random by-face intercepts and random by-perceiver intercepts were estimated simultaneously. The results revealed that the proportion of variance explained by facial features varied between the impressions (trustworthiness: 12%, dominance 26%, attractiveness: 22%), and the proportion of variance explained by perceivers' tendencies also varied (trustworthiness: 18%, dominance 10%, attractiveness: 4%). Our findings suggest that although there are distinct facial cues to the three impressions, perception of

facial impressions can vary significantly across individuals, which cannot be reduced to random noise. [This work was supported by Grant-in-Aid for JSPS Research Fellow to K.N. (17J04125), Early-Career Scientists (19K20387) from JSPS to K.N., and Grant-in-Aid for Scientific Research on Innovative Areas (17H06344) from JSPS to K. W. The authors declare no competing interests.]

Eye regions dominate judgements of surprise in static face stimuli

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The classification image technique has been used to derive templates for judgements of facial emotion in static stimuli and can reveal the facial features that dominate specific emotional judgements. For example Kontsevich and Tyler (2004) uses this method to show that up-turned lips indicate happiness. Here we explore templates for judgements of surprise. Noting that surprised faces typically have widened eyes, raised eye-brows and open mouths we hypothesised that these features would dominate. We used the 'base image' method in which a high contrast but ambiguous stimulus is embedded in random visual noise samples and those samples which promote or conversely demote judgements of the emotion are averaged to reveal templates for the detection of the target emotion. Our base image was a photograph of a female face with a neutral expression. In separate sessions we showed this face with or without eyebrows to test the importance of the raised eyebrow element of surprise. Our results suggest that the eye-region is used to judge surprise. Specifically, the contrast between the sclera and iris is increased. We found no evidence of effects in the mouth region that might indicate an open mouth. Our eye effect was stronger when the eyebrows were absent but people did not infer eyebrows when they were missing. We conclude that the eye-region is key to judgements of surprise. [ES was supported by the College of Health and Life Sciences, Aston University and Ordnance Survey. CSQ was supported by the Engineering and Physical Sciences Research Council; grant number EP/S016260/1.]

Lightness in the Ensemble Perception Paradigm

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Ensemble perception demonstrates an impressive ability to grasp visual properties not physically present in a scene, such as the average value of a perceived set. There is another comparable ability, the perception of constancy. In lightness domain, constancy refers to the ability to perceive an object's true shade despite changes in illumination. Lightness constancy is accounted for within Anchoring theory and the current experiments test the theoretical predictions of this model within the context of ensemble perception. In the first experiment we briefly presented participants (N=25) with ten gray circles, either in a single gray color or in shades spanning the range from black to white. Their task was to produce the average gray of the ensemble, using a matching patch. Ideal observer analysis indicated that participants used only 2.11 circles to produce that average gray. In the next two experiments (with new participants) we changed the range of presented gray shades, using only dark gray circles on different backgrounds, dark gray in E2 and white in E3. Anchoring theory would predict that the targets would look much lighter in E2 while the large white background should ensure veridical perception in E3. The results for these two experiments did not match such expectations in either of the conditions: sets of single gray shades vs. shades spanning the range from black to middle gray. Anchoring theory was not initially made for ensemble perception, and although it can handle emerging properties such as constancy, ensemble averaging appears to present a different challenge.

Imagery experience while reading text in native vs. foreign language

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We examined whether the vividness of visual imagery depends on language. Hayakawa and Keysar (2018) demonstrated that bilinguals experienced imagery less vividly in their second language (L2) than in their native language (L1), but the finding may be simply due to L2 language proficiency (Montero-Melis et al., 2020). Further, the H&K study only considered object imagery, i.e., mental visualization of the pictorial properties of objects (e.g., color and shape), and not spatial imagery, i.e., mental representation and processing of spatial relations, locations, and spatial transformations (see Kozhevnikov & Blazhenkova, 2013). In the present study, Turkish-English bilinguals read 9-sentence descriptions concerning object visualization (e.g., a colorful bouquet) or spatial visualization (e.g., building a 3D structure using blocks) and, after each sentence, rated the vividness of the evoked imagery. After reading all 9 sentences, participants rated different characteristics of object imagery (e.g., vividness of color and texture) and spatial imagery (e.g., clarity of movements and spatial positions).

An English language test and a battery of imagery measures were also administered. In all trials, the vividness of imagery was higher in L1 than in L2; however, the English test scores also predicted vividness in L2, suggesting that L2 proficiency affects the vividness of visual imagery in L2. The ratings of object imagery characteristics were higher in the object trials, whereas the ratings of spatial imagery characteristics were higher in the spatial trials, indicating the importance of evaluating object and spatial imagery separately.

Measuring detailed memory for visual scenes

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The amount of information our memory stores about photographs is a subject of current debate. If we study only a few photographs for a longer time, how many details can our memory store? In current studies, researchers ask only once about each memorized item. We developed a novel paradigm (denoted as intensive memory) to quantify the fidelity in a single memorized image. We compared performance in a typical scene memory study (denoted as extensive memory) and our novel paradigm (in counterbalanced order). In the intensive-memory condition, 33 participants saw 3 scenes, each for 3 minutes. In a subsequent 2AFC recognition test, only a small patch was visible within each image (2.7% to 11.1% of area) and the rest was desaturated and blurred to reduce the effect of relearning (21 pairs for each of 3 photographs). In extensive-memory condition, participants saw 104 scenes and were later tested with 52 pairs of scenes. The accuracy was high in extensive-memory condition (accuracy = .89, SD = .08). In intensive-memory condition, the ability to correctly distinguish individual changes was lower but still above the chance level (accuracy = .64 SD = .08). The response pattern cannot be explained by perceptual difficulty or by sensitivity to image manipulations, as explored in separate rating study. We observed medium correlation between extensive and intensive memory measures (r = .39). Our results show that higher capacity to memorize many photographs is associated with more detailed memory representations if only several photographs are memorized and sufficient time is provided. [The research has been supported by Czech Science Foundation (GA20-06894S).]

Functional modulation of targeted perceptual decision-making networks causally dissociates response accuracy and confidence

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The relationship between accuracy and confidence does not seem to be as linear as previously thought, and appears to be mediated by different neural mechanisms. Current findings suggest that a highly interconnected functional hierarchy may exist, where sensory discrimination and perceptual certainty are not based on the same cortical representation, and this would explain the discrepancy that is often found between the correctness of the report and the confidence about it. We have recently reported that, in a motion discrimination task, boosting feedback connectivity from V5-to-V1 is critical in improving motion sensitivity, and also causes an overall increase in confidence regardless of correctness. Most importantly, by affecting the IPS-to-V1 network, we showed that confidence can be selectively increased without affecting accuracy. Here, we aimed to concurrently induce plastic changes on the network responsible for sensory discrimination, V5-to-V1, and crucially inhibit the substrate of confidence in intraparietal sulcus (IPS) in the same individuals, in order to causally disentangle these components. As expected, facilitation of V5-to-V1 by means of cortico-cortical paired associative stimulation (ccPAS) leads to improved motion discrimination performance. On the other hand, the general higher perceptual confidence accompanying V5-to-V1 ccPAS ceases as soon as inhibitory continuous theta bursts stimulation (cTBS), but not SHAM cTBS is administered to IPS. Our findings provide causal support to the notion of a double-dissociation between V5-to-V1 network, responsible for perceptual sensitivity to motion, and IPS function causally shaping response confidence.

On speed overestimation effects in both mechanical and psychological causal events

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Recent research has investigated a new illusory speed effect in visual events derived from the ones developed by Michotte to explore causal perception, in which there is spatiotemporal contiguity between two moving objects A and B (Vicovaro et al, 2020). We reported and discuss here from a theoretical perspective the results of three experiments exploring the relationship between the speed of A and the speed of B in different causal events. In one Experiment we presented the participants with stimuli that elicited a launching impression, and tested how the judged speed of B varied with variations of the pre-collision speed of A. In a second Experiment, we adopted stimuli in which object A could move with uniform positive or negative acceleration, to test whether the apparent speed of B depended on the speed of A at the moment of collision, as Newtonian laws of collision predict, or whether it depended on the overall motion pattern of A. Finally, we compared these results with similar findings (Parovel & Guidi, 2020) showing an overestimation of the motion of B in a psychological action-reaction sequence, where a moving object B is seen intentionally escaping from another object A, and we discuss this common effect according to the property transmission hypothesis. Moreover, this speed overestimation effect could be added to the list of functional effects of causality – both mechanical and psychological - on the low-level properties of the scene.

Task-Irrelevant Biological Motion Recruits Motion-Sensitive Occipito-Temporal Cortex Under Attentional Load

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Perception of biological motion (BM) under attention is supported by a network of regions in the occipito-temporal cortex including superior temporal sulcus (STS), and premotor cortex (PMC). Yet, how BM is processed when attention is directed away lacks thorough examination. Behavioral experiments show that when presented as a task-irrelevant distractor at the periphery, BM impairs performance on a task at the fovea (Thornton & Vuong, 2004). In the present study we investigated whether the brain regions that process BM are recruited when attention is directed away from BM, and how attentional load at the center modulates this processing. Participants (N=17) underwent a functional MRI study in which they performed an attentionally demanding task at the fovea while BM in the form of point-light displays were presented at the periphery. We manipulated the attentional load at the center. Univariate analysis and MVPA show that fronto-parietal attentional regions were more active when attentional load was high than when it was low. More importantly, we found that motion-sensitive areas in the occipito-temporal cortex were activated in the presence of task-irrelevant BM stimulus even when attention was directed away from it. Furthermore, during low attentional load condition, BM related activation was stronger compared to that of in high attentional load condition. Thus, our results show that BM can be processed in the periphery even when it is not at the focus of attention, and it is modulated by attentional load.

Bottom-up perception of biological motion is influenced by perceptual load and eccentricity

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Biological motion (BM) is a crucial stimulus with social and survival value that can be processed incidentally. However, no study has examined the factors that would affect bottom-up processing of BM in depth. Therefore, we investigated the effect of perceptual load and eccentricity on BM perception in two experiments. In experiment 1 (n=17), biological and scrambled motion (which lacks global form and motion information) were used as task-irrelevant distractors while participants performed visual search tasks with low or high perceptual load. We found that both distractors interfered with task performance under load, but scrambled motion affected performance more than biological motion in both tasks. These results support the findings that search performance is better if the distractors are familiar and meaningful, as in BM, compared to if they are not, as in scrambled motion. In experiment 2 (n=16), we used only BM stimulus as a distractor and manipulated the eccentricity of the distractor. Our results show that, in line with the results of the first experiment, BM interfered with task performance in both perceptual load conditions. Moreover, we also found an effect of eccentricity: when the perceptual load is low, people are distracted more by BM at near eccentricities, whereas when the load is high, the position of the distractor does not have any effect on distractor interference. In sum, these results suggest that bottom-up perception of biological motion is influenced by perceptual load and eccentricity.

The relationship between central and peripheral motion perception and hazard perception abilities of younger and older drivers

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Timely detection of hazards is a key driving skill. This skill is commonly assessed using computerized tests that require observers to identify potential hazards in traffic-related video clips. Previous studies have shown a relationship between measures of motion perception in central vision and hazard perception reaction times. However, these studies have not considered motion perception in peripheral vision, nor the effect of age on this relationship. In this study, we assessed 65 drivers including a younger group: mean age 25.54 , range 19-34 and an older group: mean age 71.00 , range 60-80. Four motion perception tasks were tested: minimum displacement to identify direction of motion (Dmin), contrast detection threshold for a drifting Gabor, translational global motion coherence, and the ability to discriminate direction of biological motion in noise. Testing was in central and at 15° of horizontal eccentricity. Participants also completed a computer-based Hazard Perception Test (HPT) that has been related to driving performance and crash risk. In central vision, motion contrast thresholds and Dmin significantly correlated with HPT scores ($r=0.30$, $p=0.02$ and $r=0.28$, $p=0.02$ respectively). In peripheral vision, only Dmin correlated with HPT scores (0.34, $p=0.005$). After adjusting for age, peripheral Dmin was the only task that remained significantly associated with HPT scores ($r=0.34$, $p=0.02$). Our results provide indirect evidence that the ability to detect small motion changes in peripheral vision has the potential to identify unsafe road users, as the hazard perception test has demonstrated to be a valid index of driving safety and performance. [This work was supported by Australian Research Council Discovery Project 190103141 awarded to authors JMW and AMM.]

Perception of wind direction in cutaneous sensation: Comparison of function with vision and auditory perception

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The location of a stimulus is as important for human perception as the identity of a stimulus. In vision and auditory perception, the fact that two eyes or ears are separated from each other contributes to the localization of the stimulus source. However, as the eye is in the frontal plane, it cannot perceive objects in the back. In auditory perception, there is a large discrepancy in the localization of sounds from behind. It is also common to perceive sounds from behind as coming from in front. In cutaneous sensation, despite differences in density, receptors are scattered throughout the body. In everyday life, we are able to detect changes in wind direction. In vection evoked by air flow and vibration without vision, the direction of perceived self-motion is determined by wind direction. This might be highly related to the fact that the participants could perceive from where the wind is blowing. In this study, we investigated the extent to which we can perceive the direction of the wind (air flow) as determined by cutaneous sensation in human participants. The wind direction was varied 360° around the participant in eight directions at 45° increments. As a result, we were able to perceive them generally accurately, including backward and oblique directions, although there was some degree of deviation. There was a certain tendency for the misalignment to converge to the rear of the participants. [This work was supported by JSPS KAKENHI GrantNumber JP40837465.]

Predictive Processes in Audio-Visual Perception: A View From Social Robotics

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Previous work shows that top-down processes such as expectations, which are formed based on our previous experiences, affect perception. In the present study, we investigated whether our expectations about other people can be multimodal and whether we could extend our expectations to non-human agents. 30 healthy adults participated in a behavioral experiment in which they discriminated whether a 2-sec sound stimulus was a human voice or a robot voice. Prior to the sound stimulus, they were presented a 2-sec visual cue (static image of a person or a robot), which was 80% of the time congruent with the presented sound stimulus. We hypothesized that participants respond

faster when the visual cue is congruent with the sound stimulus (e.g. a human image followed by a human voice or a robot image followed by a robot voice) than when the visual cue is incongruent with the sound stimulus (e.g. a human image followed by a robot voice or a robot image followed by a human voice). Our data confirms this hypothesis suggesting that we expect agents to sound robotic if they have a robotic appearance, and human-like if they have a human-like appearance. These results also highlight that we could make predictions across different perceptual modalities.

Touching a Renoir: Understanding the associations between visual and tactile characteristics

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Although enjoying a painting is mainly a visual experience, some visual features such as textures, brushstrokes, glossiness, or color might invite the viewer to touch it. For preservation reasons, people are not allowed to touch paintings in museums, often limiting the aesthetic appreciation to vision only. We investigated how tactile inputs affect these dynamics by determining if greyscale levels, colors, and content associated with a specific texture changed based on the quality of a painting (based on rankings on the aesthetic quality scale). Seventeen participants haptically explored 32 paintings via a surface haptics tablet that provided modulated tactile feedback with four textures: grainy, wavy, choppy, and fine. Each painting was explored with 3 or 4 different tactile maps that were a combination of the four textures—the participants never saw but just haptically felt these maps and selected their preferred map. Our results showed that the association of a texture with a greyscale level, content, or color follow ecological characteristics. For high-ranked paintings, a strong association between Light Grey and Grainy was observed. Color-texture associations showed also an interesting trend: Black was mainly associated with Fine-a texture associated with background noise and hair. Cyan and Green was associated with Choppy, typically shown by objects like tree and clothes. Yellow and Orange-Yellow were both associated with Grainy. For low-ranked paintings, we observed different associations: Here, Grainy texture was associated with human skin, building objects, and sky.

Real-world size bias strikes back: mean size estimation biased from the prior knowledge of object sizes

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The real-world size of one object may affect the observer's evaluation of the size: participants overestimate the size of the familiar object if that object has a big size in the real world. However, would the same biases be observed for ensemble representation, where access to the features of each object is highly limited? We conducted a series of experiments where we manipulated the real-world size of the objects in the set. In our previous experiments (Tiurina, Markov, Paramonova, 2020), we used objects of different shapes and found inconsistent results; thus, here, we used objects only with round shapes to estimate the mean size less noisy. We compared averaging for sets of 8 images of objects with big real-world size (e.g., road signs, sewer hatches) and small real-world size (e.g., coins, donuts). We used 5 categories with small real-world size and 5 with big (24 images for each category). In Experiment 1, the set consisted of items from one category (e.g., 8 different coins). In Experiment 2, the set consisted of items belonging to various categories according to three conditions: small real-world size, big real-world size, and mixed, as the control condition. The results of both experiments showed bias in mean size estimation - observers tend to underestimate sets consisting of items with small real-world size compared to control conditions. Complex properties of real-world objects affect not only object perception but also ensemble summary statistics representation.

Do we perceive the world differently if we need to evaluate our percept? – an EEG study

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The information available to our senses is incomplete and ambiguous. Our perceptual system needs to disambiguate it and make perceptual decisions based on probabilities. Depending on the sensory evidence these decisions are more or less reliable. Recent studies indicate the existence of a meta-perceptual evaluation system, rating the reliability of perceptual decisions. In the present study we focused on such evaluations and investigated whether the necessity to explicitly report them changes processing of the observed stimulus. We presented ambiguous and unambiguous Necker lattices in random order. In Condition 1, participants only indicated the perceived 3D lattice orientations. In Condition 2, participants additionally reported the confidence of their perceptual decision. Results: The ERP traces from Conditions 1 and 2 started to differ already 104 ms after lattice onset with overall larger amplitudes

of an occipital component in Cond. 2 than Cond 1 (E1). Corresponding amplitude differences were found for a second frontopolar component at 172 ms (E2), a parietal P300-like signal at 300 ms (E3) and a temporally sustained larger amplitude thereafter lasting until 1000 ms (E4). No differences were found between stimulus ambiguity levels. Discussion: The a priori knowledge about a second evaluation task may amplify visual processing units (E1). Both the perceptual decision and top-down evaluation steps may start immediately after the lattice-gestalt construction, at about 172 ms (E2). In Condition 2 the perceptual evaluation result needs to be kept in working memory until the evaluation response, which may be reflected by the sustained larger amplitude in this condition.

Intensity Before Valence: Pupillometry as Temporal Measure Emotional Intensity During Reading and Imagery

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In the present study we investigated the differences and similarities between a spontaneous intentional imagery during and after reading by inspecting changes in pupil dilation. Two groups of participants were asked to read different 9-word scripts describing positive, negative, and neutral events; Scripts were presented word by word using rapid serial visual presentation (RSVP). The intentional imagery group was asked to intentionally imagine themselves in the situations described by the scripts. The spontaneous group was required to silently read the scripts. No explicit demand for imagination was presented to this group. In both groups, the reading interval was followed by a blank interval that was followed by a shape identification task. Our results indicated similarity between the intentional and spontaneous (control) groups during most of the reading phase. For both groups, pupil dilation reflected differences between emotional and neutral conditions and no difference between positive and negative conditions. However, differences between groups have sharpened over time. That is, only in the intentional imagery group different pupil dilation patterns were found for the positive and negative conditions in the blank interval. In addition, the effect of the emotional (and especially negative) scripts on pupil dilation lasted longer for the intended imaginary group, compared with the spontaneous group. This pattern of results suggests that the distinction between different levels of emotional intensity (i.e., emotional versus neutral) precedes the distinction between different emotional values (positive, negative). Moreover, it suggests that intentionality is a prerequisite to processing positive and negative emotions as different.

Noise generation by pixel replacement that preserves the global characteristics of the images

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In recent decades, the application of background visual noise is a method widely used to broaden our understanding of information processing of visual stimuli. The main idea underlying this methodology is based on the assumption that two sources of noise limit sensory processing: the external noise inherent in the environmental signals as well as the internal noise or internal variability at different levels of neural system. The most popular types of added noise such as Gaussian, Random, 'Salt-and-pepper' noise modify the characteristics of the original image and it is unclear whether the visual system responds to their change or to the noise presence. We developed a method and software for noise generation by pixel replacement that preserves the global characteristics of the images like the mean image intensity, and the variability of the image intensities. Our noise randomly exchanges the colors of selected number of pixels. First, the indexes of all image pixels are shuffled. After selecting the number of noise pixels, the program exchanges sequentially the colors of pixels starting from the beginning of the index list to the desired number. As a result, the new image has the same number of pixels of the colors as the original one. This procedure could be applied sequentially to any number of selected colors present in the image. In this way, the noise leaves the color histogram unchanged but destroys the image spatial structure. [The study was funded by grant DN15/6 from 2017 of the National Science Fund of Bulgaria.]

Action-induced visual working memory biases in attention

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Recent work suggests that visual working memory (vWM) representations are strengthened when coupled with action plans. If this is true, we should observe stronger attention guidance from vWM in a visual perception task when the memory representation is directly associated

with an action, compared to when the action is dissociated from the memory. Here, we tested this hypothesis by means of an attentional capture paradigm. At the beginning of each trial, participants memorized a geometric shape for a subsequent memory test. In the memory test, in case of a match, participants either had to perform a grip movement on the memorized object (action condition), or perform the same movement, but on an unrelated image of a button (control condition). These conditions were blocked. Before the memory test, participants performed a visual search, where the memorized shape was always present, either surrounding the target (valid trials) or a distractor (invalid trials). We found a significant interaction for saccade latencies between condition and validity in the visual search, indicating more pronounced vWM-guided attentional biases in the action condition. This enhanced attentional capture suggests that the perceptual representation of a memorized object is indeed strengthened when a planned action is associated with it.

Features of communication with an avatar in VR

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The research is aimed at studying the manifestations of the ability to perceive and identify emotional expression demonstrated by a virtual avatar in a virtual reality (VR) CAVE-system. The study involved 55 participants aged 18 to 25 years (average age-20.38+0.28), 23 of whom were men and 22 were women. During the study we diagnosed the level of development of emotional intelligence (EI); spatial abilities; type of attachment to the loved one. In the VR, a situation was simulated in which the subject had to detect the avatar and determine the emotional-facial expression displayed by it. It was shown that the level of respondent's EI development does not determine the success of identifying the avatar's emotion in VR. However, the success of identifying emotions depends on the level spatial abilities development. It was found that the distance between the avatar and the subject depends on the time spent searching for the avatar in the virtual environment (r=0.794, p=0.000), while the distance between the respondent and the virtual avatar determines the duration of their "interaction" (r=0.622, p=0.000). A high level of spatial ability development corresponds to a pronounced avoidance of close relationships (r=0.355, p=0.025). At the same time, it takes less time for a person with a high level of spatial abilities to communicate with the avatar (r=-0.326, p=0.040). People with a high level of EI (r=-0,293, p=0.030) suffer from similation sickness to a lesser extent, and people with high rates of avoidance of close relationships (r=0.389, p=0.003) - to a greater extent [This research was supported by Russian Science Foundation Project No19-78-10148.]

Audio-Visual Components and Cross-Generation Characteristics of Uncanny Valley

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In robot-human interactions, facial features and voice are the main determiners as to how human and robot designs are perceived and emotionally processed. By using a custom made audio-visual robotic animation design, we have studied how different levels of naturality of visual-auditory stimuli affect perception in human-robot interaction (HRI). We also assessed how the Uncanny Valley (UV) effect varied across two generations. Audio-visual, audio-only and visual-only stimuli modalities of human and robot designs were rated by 60 participants, where half of them were in the younger group and the other half were in the older group. The stimuli had four naturality levels: robot, semi-robot, human-like android and real human. Participants rated the stimuli between normal emotions to uncanny, eerie emotions. Mixed ANOVAs were performed on the uncanny ratings for audio-only, visual-only and multimodal conditions separately. A separate mixed ANOVA across modalities show that multimodal stimuli result in significantly higher uncanny scores than unimodal stimuli. There is a significant interaction between audio and visual aspects of the stimuli for the multimodal condition. Audio-only and visual-only stimuli are evaluated similarly. Stimulus modality has a main effect on UV scores across all types of stimuli and age group. There is a significant interaction between modality and generation. Multimodal audio-visual stimuli led to an amplified UV effect in comparison to the unimodal conditions. Our results emphasize the importance of the sound component in robot design and suggest that age groups evaluate visual and auditory components differently in HRI.

Face perception in the human brain as a small-world network

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The human face is considered one of the most complex objects in the universe. However, the neural mechanism of face perception is not clearly understood despite significant research effort. In the present study, we have tried to elucidate the mechanism of face perception using a graph theoretical approach. EEG data were collected from 11 healthy subjects in the age group of 20-30 years during separate face and object recognition paradigms, using 64 active electrodes. The functional connectivity matrices and their corresponding network metrics were evaluated in different EEG frequency bands using Phase Locked Value (PLV). The averaged PLV connectivity values and the graph-derived metrics were also analyzed statistically. The results illustrate enhanced functional connectivity for faces in the brain as compared to objects. Furthermore, a clear visual as well as statistical difference was manifested by two graph measures of functional networks in the theta band. The obtained graph metrics collectively exhibited a small-world network for face perception in the brain with balanced modular and distributed information processing. On the contrary, object perception in the brain loses this small-worldness and thus exhibits a less integrated brain network structure of information flow. Thus, our results suggest that faces are considered as 'special' stimuli and the process of face perception involves communication between different parts of the brain which are well connected to each other. These findings from healthy controls may aid our understanding of various neurological disorders such as prosopagnosia, autism, or other neural deficits.

Perceiving soft materials from Turkish onomatopoeic words

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Research on bimodal perception demonstrated the effect of sound frequency on perceived shapes, where people associate higher frequency sounds with angular shapes and lower frequency sounds with round shapes, known as the Bouba/Kiki effect. Onomatopoeic words mimic the sound of materials that they describe. In Japanese, the words have been linked to the perception of surface material qualities, among other sensory experiences. Similar to Japanese, Turkish also has a rich lexicon of onomatopoeic words that are frequently used (e.g., şap şap -splash, tıkır tıkır -rattling). Here we wanted to see whether similar associations exist for perceived softness of dynamic materials. In the first experiment participants rated 47 Turkish onomatopoeic words on a list of 31 softness related adjectives. Results of the principal component analysis (PCA) revealed 4 dimensions in words: Fluidity, Surface Softness, Granularity, and Roughness (control), leaving out deformability which is a commonly reported softness dimension. The words showed distinctive associations with material adjectives, such as: vıcık vıcık for gelatinous, slimy, sticky, doughy; tiril tiril for velvety and silky; pıtır pıtır for sandy, granular; fokur fokur for fluffy; gıcır gıcır for glossy; tak tak for compliant and woody. We conducted a similar experiment with 40 soft material videos, and PCA resulted five dimensions, with Deformability this time linking the adjectives to everyday materials. Our results show for the first time that Turkish onomatopoeic words have unique associations with material adjectives, and the sounds symbolism effect go beyond surface material qualities, to the perception of three-dimensional everyday materials. [UNESCO-L'Oréal For Women In Science Fellowship Awarded to DND (2020).]

How does Text Format influence the Reading Process? Evidence from Russian Texts

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This study aimed to answer two questions: what are the cognitive mechanisms that process different types of multimodal text, and what type of text presentation contributes to more successful information processing and understanding. Mayer's (2009) Cognitive Theory of Multimedia Learning suggests that effective engagement with the material presented in the form of polymodal text takes place, due to the need to switch attention between text and image, oral signal and text, and to establish connection between these elements, This leads to integration of the new information into the existing cognitive system, as well as the ability to use the acquired information in the future. Our study investigates how readers process, understand and remember information when reading and listening to texts in four different formats: infographics, audiotext, infographics combined with audiotext, plain written format. Biographies of four Russian writers were used as the material. All the texts were of the same length and the same level of readability (checked via http://readability.io/). In a four-group experimental design, 32 students learning Russian as a foreign language and 32 native speakers of Russian examined four different texts in four different formats. Afterwards, they answered the factual and analytical questions, identified the keywords and estimated the difficulty of each text. Results show that audiotext is the most difficult text format for both groups of the participants. Written text is the easiest and better perceived format for foreign students. No significant differences were found in processing the text presented in infographics and combined (audio + written) modalities. [Supported by research grant no. 21-18-00429 from RSF.]

Tuesday August 24th

Poster Session 3

Is Garner interference valid evidence for the Perception-Action Model?

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The Perception-Action Model (PAM) assumes that visual information is processed in qualitatively different ways in the ventral and dorsal cortical streams for the purposes of perception and action, respectively. Evidence for such differential processing of visual information was provided by Ganel and Goodale (2003, Nature), who observed Garner interference in perception and manual estimation tasks (both assumed to be guided by the ventral stream), but not in a visuo-motor action task (assumed to be guided by the dorsal stream). Garner interference experiments include a baseline condition, in which only the task-relevant stimulus dimension is varied, and a filtering condition, in which task-relevant and task-irrelevant dimensions are varied. Longer reaction times in the filtering condition compared to the baseline condition indicate Garner interference. We attempted to replicate Ganel and Goodale's results in a within-subjects design (N=24). In the perception task, participants judged the width of rectangular objects as "narrow" or "wide" with a button press. In the manual estimation task, they estimated the width of these objects with their finger-span. In the action task, they grasped the objects along the width. We replicated Ganel and Goodale's findings for all tasks except manual estimation: Garner interference was not observed in the reaction time to initiate the movement. We discuss this result within the framework of an alternative account suggested by Hesse and Schenk (2013, Behavioural Brain Research), without resorting to a functional division of labor as proposed by the PAM. [This project is supported by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) – Project 422180965 – Research group 2718: Modal and Amodal Cognition.]

The role of reference location for the post-saccade temporal distortion

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Subjective time can be deviated a lot from the physical time by various types of contexts. Eye movement, for instance, can induce temporal distortions in both directions - dilation and compression. One representative dilation is the chronostasis illusion. The first post-saccade interval is perceived longer than the subsequent ones (Yarrow et al., 2001). Interestingly, saccade can also induce temporal compression, when the to-be-estimated interval occurs during the saccade (Morrone et al., 2005). Both effects were caused by simple saccade, yet the bias in time perception is opposite and no unified explanation was given. Both typical paradigms applied the duration discrimination task, in which participants compare a test and a reference interval to determine which is longer. Other from the stable location of the test interval (first interval after saccade), one critical difference is the location of reference interval. Specifically, the reference interval was presented immediately or closely after the test interval in the chronostasis paradigm but presented after a long gap in the saccadic temporal compression paradigm. The current eye-movement study was, therefore, designed to investigate the role of reference location for the post-saccade temporal distortion. Two reference conditions were compared: after the test interval, the reference presented immediately without gap (No-gap condition) or after a 2- second gap (Gap condition). In addition, two fixation conditions with and without a gap served as the baselines. The results showed that chronostasis illusion was modulated by the reference location. The effect was stronger when the comparison was immediately followed by the reference. [This study was supported by German Science Foundation (DFG) research grants SH 166/7-1 to ZS and the China Scholarship Council (CSC) Scholarship to LC.]

The Uznadze illusion reveals a two-pronged dissociation between perception and action

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Do size contrast illusions affect grasping? Is the effect of such illusions different for visuomotor representations than for conscious perception? To tackle these questions, we adopted visual and haptic versions of the Uznadze temporal illusion, in which a 'test' object appears smaller (or larger) after exposure to a larger (or smaller) 'inducing' object. Participants observed ('vision') or touched blindly ('haptics') a large, a small, or a medium inducer ball, either presented in the same ('congruent') or a different ('incongruent') position relative to the test medium ball. After that, participants grasped the test with the right hand (motor task), and then intermanually matched its size with the left hand (perceptual task). We analyzed the kinematics of the maximum grip aperture (MGA, motor) and the intermanual matching aperture (IMA, perceptual). We

report novel findings: with visual inducing, both MGA and IMA showed size contrast (i.e., the Uznadze illusion) in congruent but not incongruent positions; with haptic inducing, the IMA showed size contrast but, surprisingly, the MGA showed either no illusory effect or size assimilation (the inverse Uznadze illusion) in congruent and incongruent positions, respectively. Thus, visual (unimodal) and haptic (crossmodal) inducers revealed a two-pronged dissociation between vision-for-perception and vision-for-action. In contrast to current models on motor cognition claiming differences in size coding between perception and action, we propose that multisensory integration mechanisms and the internal hand schema are crucial in visuomotor representations.

Visual Bio-Feedback and Skill-Acquisition of Intentional Finger Grip-Force-control: A Psychophysical Study

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Our study involved the performance of psycho-physical haptic tests, in which participants intentionally controlled finger grip-force, while "holding", "moving" and "threading" disks onto poles, in a virtual variation of the 'Hanoi-Towers' game. Each disk has a defined holding grip-force whereby under minimal finger-pressure the disk will drop, or above a maximal pressure, it will crash. To enable this, we have utilized an innovative technology, the "Mudra-Strap ®", developed by "Wearable Devices", which identifies finger movements and measures forces elicited between defined fingers. These measures are achieved by receiving the neural activating signals from the nerve supply of individual fingers via embedded sensors within the wrist strap. Disk holding is simulated by pressing together two fingers and a column bar gauge display provides visual feedback. Twenty healthy students participated in a two-phase session, seven-days apart. The sessions contained various trial-combinations; two or three poles, with two or three different-sized disks with variable holding forces, and three poles with three identical-sized disks, although still with variable holding forces and only differing by color. The participant's task was to lift, move and thread the disks onto the correct pole, as quickly and accurately as possible. Additionally, participants noted on the bar-gauge display their last performed finger pressure level. Results showed significant improvement between sessions in performance time, number of drops, disk-crashes, and stabilized holding of constant pressure during disk moving. Performing self-pressure-evaluation had high variability, but demonstrated an improvement trend. Visual feedback proved crucial for acquisition of controlled finger-pressure.

Preference for generic viewpoints between foregrounds and backgrounds

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Generic viewpoints are those where the spatial relationships between features are largely preserved despite small changes in the observer's position. Whilst viewpoint preference has been well investigated for individual objects, less is known about the preferred relationship between foreground and background objects. We investigated this relationship for two different image types: firstly, a cartoon of a tree in front of two triangular-shaped mountains, and secondly, a Monet painting containing a prominent horizontal alignment between a foreground clifftop and the background horizon of the sea. For the first image, the horizonal position of the tree was in one of five positions, two of which giving specific viewpoints (i.e. the tree aligned with either the valley between the mountains or a mountain peak). Thirty-five observers viewed all possible image pairs online (presented side-by-side, with a small vertical positional jitter between images in a pair), and selected which image in the pair was preferred. Images where the tree was not aligned were preferred significantly, with this preference not being predicted by the absolute position of the tree in the frame when the tree was presented on its own in a control series of images. We performed a similar experiment where we digitally manipulated the Monet image to introduce a vertical offset between the clifftop and the horizon: image preference again increased significantly with image offset. Our results provide experimental support for the proposition that images containing suspicious spatial coincidences are less appealing than those showing generic viewpoints (Ramachandran & Hirstein, 1999).

Theoretical and Empirical Considerations of The Mode of Art Experience (MAX) Concept

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The question whether people approach art with a unique state of mind has been variously debated by art-related philosophies. Typical studies in empirical aesthetics mostly lack ecological validity in many respects, therefore we might not

arrive at the entry level of typical art experience in galleries, and fail to contribute to the debate. Our concept of Mode of Art Experience (MAX), based on condensed conceptualisations in the philosophical and cognitive literature, proposes MAX as a mode of active visual exploration without the ultimate aim to fully understand the artwork's meaning, but to open oneself to the impression an artwork has on oneself. We tested these theoretical considerations in a study where participants (N=47) reported on their visits to art museums, in relation to key variables of the MAX concept. Beyond reports of experiences referring to beauty and interest, participants aimed to experience challenging things, which emotionally move them and inspire awe. They were also motivated to reflect on society, their lives, and the world, learn and interpret artwork. This illustrates how far MAX is indeed from typical lab contexts, where some target concepts like beauty and preference are rigidly tested, ignoring the richness and uniqueness of art experience.

Factors to create an appealing cinemagraph in terms of perceived causality

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A cinemagraph is a short looping video with both moving and stationary parts. There are many online advertisements using cinemagraphs; however, some of them are not surprising. Considering "perceived causality," we hypothesized that the difference in impression of cinemagraphs was caused by the type of repeated scene: when a scene lacking the inevitable result was repeated, the cinemagraph seemed strange. In this experiment, we confirmed which type of cinemagraph posted online was preferred. Nine cinemagraphs obtained from Pinterest were used as stimuli and 15 students signed in the site to evaluate the stimuli. Four cinemagraphs had the cause event in motion (the cause condition), four had the result event in motion (the result condition), and the residual cinemagraph neither had the cause scene nor the result scene (neutral condition) in motion. For example, in the cause condition, milk is continuously poured into a glass, but the liquid level remains unchanged; in the result condition, milk is continuously mixed into a glass of iced coffee, but the moment of its pouring is not shown; in the neutral condition, someone is continuously stirring iced tea. The participants were instructed to select three cinemagpaphs: the oddest, the most favorite, and the most unamusing. Fisher's exact test revealed a significant difference among the frequencies of the three conditions ($p = 0.003$). The cinemagraphs showing only the cause event significantly seemed strange and were liked, while the cinemagraphs showing the result event did not receive these impressions. These results were consistent with our hypothesis.

Factor analysis from the semantic differential on computer-generated art

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Artificial intelligence technologies have made significant progress in an area that has always been considered creative. The first notable success in this area was an artificial neural network developed by Google, which learned not only to transfer the artist's style to an arbitrary image but created a new artistic technique - inceptionism (Mordvintsev, 2015). Previous research has shown that individuals can distinguish man-made and computer-generated paintings and there is no significant difference in aesthetic rating(Chamberlain, 2015). The current study examined what representations individuals use for artificial art and whether there is a difference in semantic profiles for these types of art. The semantic differential was used to evaluate the representations about computer-generated art, it contains 13 bipolar adjective pairs marked along a 7-step Likert-type scale. Data (N=127) from semantic differentials are analyzed with factor analysis, the observations converged into 4 dimensions of perceived visual quality. A difference in semantic profiles between computer-generated and man-made paintings was found.

Embodied and Aesthetic Processes in the Evaluation of Tourist Destination Image

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Photographs as cognitive sources might have an impact on the development of a tourist destination image (TDI). When we look at pictures of places to visit, we imagine being in the represented place, "as if" we would be physically present exploring that place. This mechanism is grounded on the match between perception and action advocated by the embodied cognition account. Besides, it has been demonstrated that the aesthetic appearance of the place has a significant impact on the TDI. Since images can influence TDI, we aimed to test the role of embodied and aesthetic components in the choice of tourism destinations. In an online study, we presented 50 photographs of tourist places. Participants (N=121) provided ratings to evaluate three embodied components (bodily engagement, sense of exploration and the will to explore behind the scene) and symmetry. They also indicated how much they

like each photograph and how much they would visit the place. All ratings were provided on a 0-100mm visual analogue scale. In addition, image aesthetics (symmetry, self-similarity and variance) were extracted with a Convolutional Neural Network (CNN) deep learning algorithm. We found that bodily engagement and sense of exploration predicted both liking and tourist judgments, whereas the intention to explore further predicted only the tourist judgment. None of the CNN components accounted for liking and tourism judgments. Interestingly, left-right mirror symmetry predicted subjective symmetry, reflecting a left-right exploration strategy through the images. Taken together these results lend support to the involvement of embodied processing in TDI.

Applying Fechner's Aesthetic Association Principle to the World of Testimonials

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Advertisers often neglect cognito-perceptual factors, especially the power of associations, even though such factors make advertising what it wants to be: an incentive to buy. Knowing how to influence the viewer's perception of the product, namely by evoking associations, is the key to successful advertising. Fechner's Aesthetic Association Principle states that positive or negative assessments of an object (or product) are shaped by the observer's learning history. This principle forms the basis of what is recognized as the most promising but paradoxically neglected model of celebrity advertising — the Meaning Transfer Model (MTM) — and thus demonstrates the inseparability of perceptual psychology from advertising (research). A celebrity's ascribed attributes can be seen as associations evoked by the celebrity picture and formed by the observer's experience with the celebrity through media. Our study is one of the first to systematically address the transfer of celebrity personality attributes to products and the first to use empirically identified match-ups (good vs. poor fits) in doing so. Our results show that the type of fit determines whether positive or negative attributes are transferred to the product. The extent to which the association is manifested in the celebrity's meaning is directly related to the extent to which it is then manifested in the product personality. The results are captured in a new model, which we call Attributes Infusion Model (AIM). The AIM integrates the Match-up Hypothesis, the MTM, and the present findings into one coherent model.

The importance to follow the lines: normative values for the adult Italian population of the Groffman visual tracing test

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Background The Groffman Visual Tracing (GVT) test is an indirect psychometric measure of oculomotor performance, used for the clinical assessment. The test consists of two cards with five contorted lines of increasing overlapping, crowding, and difficulty. The task starts from each of the letters at the top of the page, follows the line from the letter to the corresponding number at the bottom of the page, and names the number. The GVT test was born for children evaluation but it can be applied also in adults with visual and cognitive deficits, but lacks reference values. Consequently, the aim of the study was to define normative data for this population. Methods A total of 526 adults aged between 20 and 79 years, without neurological or psychiatric deficits were enrolled. Standard GVT test composed of two card of five lines was applied. Results were analysed considering accuracy and execution times separately. Results We found a significant evolutionary trend in the accuracy ($p<0.0001$), which decreases over decades. Moreover, also the execution times increase with age ($p<0.0001$) and they depend on specific card, and line ($p<0.0001$). Reference norms were developed taking into account all these variables. Conclusions GVT test could be applied in healthy and pathological adult populations by taking into account that performance varies with age. This test can now be used in the adult population for the assessment of oculomotor behaviour with proper normative values that account for age, card and line.

Influences from Response Framing on Viewing and Decision Times during Evaluative Processing of Food Images

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Previous research suggested that response framing influences the relationship between viewing and preference formation. Two separable factors may modulate the preference formation: The absoluteness of selection (with or without an option to defer) and the competitiveness of selection (with high or low probability of inclusion). To clarify how these factors influence the evaluative processing, we designed a virtual-shopping paradigm with a series

of 80 food images presented consecutively, using a 2x2 design to vary the absoluteness and the competitiveness of the selection. For the absoluteness of selection, subjects were asked to make decisions for each food image in either a 2-options condition (i.e., "take" it or "leave it"), or a 3-options condition (i.e., "take it," "leave it," or "wait"). For the competitiveness of selection, subjects were instructed to select a maximum of either 5 items out of 80 (i.e., highly competitive) or 15 items out of 80 (i.e., less competitive). As in previous findings, both decision times and actual viewing times were consistently longer for "take it" than "leave it" options. Importantly, this difference was exacerbated under high competition, when subjects could select only 5 items, suggesting a role for opportunity-cost consideration in the decision process. Furthermore, as compared to 2-options conditions, subjects consistently spent more time overall in the less absolute 3-options conditions (with the option to defer), searching through more items, with particularly long viewing and decision times for the "wait" option. This finding suggested that response framing with a defer option nudged opportunity-cost consideration.

Speed and Polarization in the Moral Evaluation of Real-World Images

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In human perceptual decision-making, the well-known phenomenon of speed-accuracy tradeoff establishes a causal link between urgency and reduced accuracy. However, less is known about how urgency affects value-based processing of visual images. To study this question, we created a stimulus set ranging from "very moral" to "very immoral" images based on the Social Moral Image Database (SMID). We asked participants to rate real-world images on a continuous scale from -10 ("very immoral") to +10 ("very moral"). We used a cueing procedure to inform the participants on a trial-by-trial basis whether they could make a Self-Paced (SP) evaluation or whether they had to perform a Time-Limited (TL) evaluation within 2 seconds. Aross SP and TL conditions, there was a significant association between speed and evaluation such that fast responses were associated with more extreme (moral or immoral) evaluations. Compared to the SP condition, the responses in the TL condition were also much faster overall, indicating that our urgency manipulation was successful. However, comparing the SP versus TL conditions, we found no significant differences in the moral evaluation. The data clearly indicated that, while speed is associated with polarization, urgency does not cause the participants to make more extreme evaluations. Instead of a causal influence from urgency, the correlation between speed and polarization likely reflects the ease of processing. Images that are obviously moral or immoral are recognized faster and given more extreme evaluations than images for which the moral interpretation is more ambiguous.

Active Visual Inhibition is Preserved in the Presence of a Distracter: A Cross-cultural, Ageing and Dementia Study

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The current study investigated a novel visual distracter task as a potential diagnostic marker for the detection of cognitive impairment and the extent to which this compares in healthy ageing across two cultures. The Inhibition of a Recent Distracter Effect (IRD) refers to the inhibition of a saccadic eye movement towards a target that is presented at the location of a previous distracter. The current study compared the IRD across a large cross-cultural sample comprising of young (N=75), old European participants (N=119), old south Asian participants (N=83), participants with Dementia due to Alzheimer's disease (N=65) and Mild cognitive impairment (N=91). Significantly longer saccadic reaction times on the target to distracter trials, in comparison to the target to target trials were evident in all groups and age cohorts. Importantly, the IRD was also preserved in participants with Alzheimer's Disease and mild cognitive impairment demonstrating that the IRD is robust across cultures, age groups and clinical populations. Eye-tracking is increasingly used as a dual diagnostic and experimental probe for the investigation of cognitive control in Alzheimer's disease. As a promising methodology for the early diagnosis of dementia, it is important to understand the cognitive operations in relation to eye-tracking that are well preserved as well as those that are abnormal. Paradigms should also be validated across ethnicity/culture, clinical groups and age cohorts.

Statistical learning of distractor regularities facilitates visual search

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Visual search strategies are known to capitalise on the relationship between the target and the distractors – i.e., how the target differs from the distractors and where the target is likely to be amongst the distractors. Additionally, it has been proposed that statistical structure amongst distractors can also benefit search, enabling observers to parse

the scene more efficiently by reducing the number of distractors to contend with. Evidence for this hypothesis comes from studies using everyday object stimuli, showing that search efficiency improves when distractor objects are positioned in familiar arrangements (e.g., lamp above table; Kaiser et al. 2014). Here we asked whether the benefit of distractor structure extends to novel shapes, whose spatial relationships (groups) must be learned implicitly during visual search. By using novel shapes, potential low-level visual differences and semantic relationship differences between conditions can be ruled out. Participants searched for pre-cued target items in arrays of shapes that comprised either four fixed pairs of shapes (structured displays) or eight shapes randomly partitioned into four pairs on each trial (unstructured displays). The distractor positions varied across trials. Across three online experiments (N=700), we found that after a period of search training, participants were more efficient when searching for targets in structured displays, even though post-experiment they could not identify which pairs were fixed in a two-alternative forced-choice task. These results show that implicitly learned statistical regularities between distractor shapes increase search efficiency. [Horizon 2020 Framework Programme (725970).]

Categorical and perceptual similarity effects in visual search

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When people search for objects (a round apple), the surrounding nontargets may share perceptual (a round tennis ball), categorical (a banana), or both (an orange) properties with the target. Previous studies provided behavioral and neurophysiological evidence for the influence of perceptual similarity between objects in visual search. It is still unclear whether categorical similarity also influences visual search, and how this influence depends on perceptual similarity. In this study, we manipulated both categorical (animacy) and perceptual (shape) similarity between targets and distractors to investigate how and when the two similarities interactively affect search efficiency and neural correlates sensitive to spatial attention using electroencephalography (EEG). Behavioral results (N=40) showed that search efficiency decreased when one or both similarities increased, resulting in lower accuracy and slower reaction times (RTs). Importantly, the effect of categorical similarity interacted with perceptual similarity, being stronger for target-distractor pairs that were perceptually similar. EEG results (N=24) mirrored this behavioral pattern and provided information about its neural timecourse, with an interaction between perceptual and categorical similarity emerging around 270 ms after stimulus onset in both univariate (N2pc) and multivariate (target location decoding) analyses. At this time, target location was less strongly represented for categorically similar targets, but only when the target was perceptually similar to the distractor. Finally, RTs were negatively correlated with EEG measures indexing target location, linking the EEG results to the behavioral data. Together, these results demonstrate when and how perceptual and categorical similarity influence visual search. [This work was supported by a grant from the Ministry of Science and Technology, Taiwan (MOST 109-2917-I-002-023) and the European Research Council under the European Union's Horizon 2020 research and innovation program (Grant Agreement No. 725970). The authors thank Bo-Cheng Kuo for providing EEG equipment to collect data.]

Primary measures and secondary notations in visual acuity assessment

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Recent debates on visual acuity (VA) assessment revolve around the best procedures for VA measurement and notations, but suggested answers are inconclusive. An analysis of publications on this matter revealed that some arguments favouring specific choices were developed by unwittingly confusing certain basic concepts: the VA notation; unit of measurement; the predefined reference levels in VA assessment tools; suitable scale of measurement for presenting primary outcomes, etc. As a consequence of these fallacies, advantages or pitfalls of specific clinical tools were attributed to the VA notation used in the tools, although the choice of the notation is independent of the tool characteristics. Our analysis of various approaches to VA assessment justifies the conclusion that there exists the only primary VA measure – the minimum angle of resolution (MAR): it can be obtained by a direct measurement and expressed by the basic spatial metrics unit. Beyond MAR, one further VA measure – critical spatial frequency – can be gauged directly using gratings of varying frequency. It follows that all other VA measures – functions of MAR – are secondary, or derived. Various secondary notations were developed for special practical needs. In particular, the logMAR measure, currently used most frequently, has both advantages and limitations, and its applicability depends on VA assessment objectives. We argue that in view of substantial differences of the assessment purposes, requirements and criteria among professionals, the quest for a unique all-purpose VA measure is probably unresolvable, as is establishing of the "gold standard" method of VA assessment.

Effect of skin color change due to melanin and hemoglobin modulation on the conspicuousness of a pigmented spot

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The facial impressions such as health and attractiveness depend on the homogeneity of the skin and pigmented spots. It has been known that the conspicuousness of pigmented spots is affected by the number, area, concentration, position, and redness of the skin. However, the conspicuousness of pigmented spots on various skin colors has not been studied in detail. In this study, we investigated the conspicuousness of a pigmented spot when the skin color was modulated in the direction of increasing/decreasing hemoglobin and melanin. A stimulus was a synthetic image of a face and a pigmented spot. A pigmented spot was located on the left upper cheek. The reference stimulus was a face image with the average skin color of Japanese females and a pigmented spot of moderate concentration. The skin color of test stimuli was modulated in increase and/or decrease in five steps for the melanin, hemoglobin, and both directions. A pigmented spot of the test was modulated in the melanin increase/decrease direction in seven steps. The conspicuousness of a pigmented spot in each stimulus image was evaluated on a 10-point scale compared with the reference stimulus. As a result, a pigmented spot was more noticeable when melanin in pigmented spot increased and melanin and hemoglobin in facial skin decreased. It was suggested that the color and lightness differences between the skin and a pigmented spot contributed significantly to the conspicuousness of a pigmented spot. [JSPS KAKENHI JP16H01663, JP18H04183.]

Effects of color–emotion association on facial expression judgments

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Color and emotion are metaphorically associated in human mind. Such color–emotion associations even affect perceptual judgement. For example, stimuli representing a color associated with an emotion can facilitate judgement of the emotion expressed in faces. The present study examined whether colors associated with happiness (e.g., yellow) and sadness (e.g., blue and gray) facilitate judgements of the associated emotions in facial expression. We also examined whether any such effects interact with temporal proximity between color and emotional stimuli. Participants were presented with pictures of happy or sad faces on yellow, blue, or gray backgrounds and asked to judge as fast as possible whether the face was happy or sad. The face stimulus was presented simultaneously with (Experiment 1) or preceded for 1 s by the colored background (Experiment 2). The analysis of response time showed that yellow facilitated happiness judgments, while blue and gray did not facilitate sadness judgements. Moreover, the effect was found only when the face and color stimuli were presented simultaneously. These results may imply that the association of sadness with blue and gray is weaker than the yellow–happiness association and does not affect emotion judgement. Our results also suggest that temporal proximity is critical for the color–emotion association to affect the judgement of emotion.

Neurodynamical model for the visual recognition of dynamic bodies

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For many social species, the ability to recognize different actions is critical for survival. The detailed underlying circuitry of the neural processing of visual recognition of dynamic body movements is currently unknown. We have developed a physiologically inspired hierarchical neural model for the recognition of body movements for comparison with electrophysiological data. The model combines a standard DNN with a neurodynamical model (Giese & Poggio, 2003) that has successfully reproduced the neural dynamics at the single-cell level in higher areas of the visual and premotor cortex. The initial layers of the visual pathway for mid-level feature detection were modeled by VGG-19. Informative features were extracted and used as input signals for radial basis function networks that were trained with individual keyframes of the actions. Sequences of such keyframes were then encoded by recurrent neural networks (neural fields). The outputs of the individual neural fields were summated by higher level motion pattern neurons that are active during individual actions. We tested the model on movies of macaques performing different actions. Similar movies are presently being used in physiological experiments on body motion encoding in macaque body areas. The motion pattern neurons show responses that differentiate between the different encoded actions. The model successfully recognizes actions from real videos and makes precise predictions about the response dynamics of different neuron classes,

which are being compared to electrophysiological recordings. [Funded by ERC 2019-SyG-RELEVANCE-856495, HFSP RGP0036/2016, BMBF FKZ 01GQ1704 and SSTeP-KiZ BMG: ZMWI1-2520DAT700.]

An event-related potential study for preferential judgment of color

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A few psychological studies have been conducted in an attempt to uncover the causal explanation for color preference. In this study, we used an electroencephalogram to register the brain activity of participants while deciding their preference for colors. Participants rated their preference for 32 chromatic color samples from the Berkeley color project using a line-mark rating scale. Event-related potentials (ERPs) were recorded during the assessment. The results indicated that both high and low preferred colors produced larger amplitudes for the P300, while frontal N400 (FN400) was found for some of the most preferred colors. In a previous study involving affective oddball tasks, the arousal level rather than valence was found to have a stronger influence on P300 amplitude. In line with this observation, a person's liking or disliking for a color (instead of whether the color would be preferred or not) was the primary determinant in the present study. We believed that this could probably provide evidence of color preference being linked to the affective/emotional response to it. FN400 observed while assessing the most preferred colors, was often found to be associated with familiarity processing and concept priming. It was also suggested that higher evaluated colors were perceived to be more familiar, whereas vice versus repeated exposure has emerged in previous psychological studies. This study has shed light on the process of the preferential decision for colors at the neutral level and suggested that colors were not equally processed while assessing.

One less is enough: Evidence for redundancy masking in the fovea

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Contextual visual information profoundly influences detection and discrimination. Objects surrounded by neighboring objects are harder to identify than the same object in isolation especially when presented in the visual periphery, a mechanism called crowding. Crowding affects target identification and appearance. Recent work revealed a related phenomenon coined redundancy masking. When targets and flankers are identical, entire parts go undetected: In such displays observers often reported seeing less objects than the actual number of presented objects. This shows that entire objects were not detected– at least in the visual periphery. In the current study we examined these omission errors for the first time in the fovea. We presented observers with sets of 3-5 small dots at 1-2° around fixation. Dots were equally spaced but spacing between dots was varied to avoid any correlation between the number of dots and the length of the stimulus. Minimum inter-dot spacing was set to be above the resolution limit. The line that the aligned dots formed was either horizontally, vertically or in an oblique arrangement and were presented for 100ms. Observers indicated the number of dots they perceived. Our preliminary results indicate that observers underestimated the number of dots in foveal vision: In one third of the trials observers missed to report one of the dots. We suggest that redundancy masking can also occur around fixation for the briefly presented items we showed. This shows how redundancy masking reduces the number of perceived objects in the fovea and how information goes unnoticed during visual processing.

Sensory components of event-related potentials react differently to the perception of volumetric 3-dimensional and 2-dimensional images

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By developing several 3-dimensional (3D) visualization methods, a demand to investigate the interaction with the human visual system is inevitable. Although most studies focused on stereoscopic depth perception. However, our knowledge about non-stereoscopic displays is still low especially in sensory or exogenous components of the brain waves. In the study, we determined the cortical activity correlated with the volumetric image, both 3D and 2D perception by analyzing the sensory event-related potentials (ERPs). Our method was based on two conditions. The first condition was tested as a 3D experiment by presenting four constant angular size rings in which one of them was closer to the subjects. The second condition as a 2D experiment was performed by presenting the same rings however, all rings presented at the same distance. A volumetric multiplanar display was employed to produce our non-stereoscopic visual target. Obtained results by EEGLAB showed a significantly higher amplitude in the P1(50-100ms), N1(100-175ms), and P2(175-225ms) components in 2D volumetric images across most of the central electrodes. To conclude, the results showed that

not only the sensory components of ERPs have a fundamental role in the sensory analysis of visual targets but also, they can contribute to perceptional processes such as depth perception or attention. [This work was part of the research project supported by LightSpace Technologies ("Evaluation of volumetric display's 3D image effect on human visual system", project No. ZD2019/20807) and the European Regional Development Fund ("Development of a compact, high-brightness laser image projection system for application in volumetric 3D displays", project No. 1.1.1.1/18/A/179).]

Chromatic discrimination: The response window does matter for veridical measurement in mature observers

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The Trivector test (Cambridge Colour Test) was employed to assess chromatic discrimination in normal trichromats (N=30) aged 20–64 years, stratified as 'young' (20–29), 'middle-aged' (31–48), and 'mature' (57–64). Prompted by our observation that a longer Trivector response window (RW) improves older observers' estimates, we explored whether the RW duration would affect chromatic discrimination for the Protan, Deutan and Tritan axes. Three RWs were used: 3 sec, 5 sec and 8 sec. For the 'young' and 'middle-aged' subgroups, we found no differences in Trivector measures between all RWs. For the 'mature', all thresholds were higher than in the younger subgroups. Also, their thresholds were significantly higher at 3-sec than at 8-sec RW. Furthermore, Protan and Tritan thresholds decreased at 8-sec compared to 5-sec RW, while Deutan thresholds levelled at 5-sec RW. Notably, at 3-sec RW the Tritan measures were greatly beyond the upper tolerance limit for this age group (Paramei & Oakley, 2014), suggesting spurious chromatic discrimination. Along with the effector mechanisms impacted by ageing, the observed threshold elevation at shorter RWs could be indicative of slowing down, suboptimal processing of colour in the visual system. Leaning upon Whiting's (1969) model of information processing, we conceive of several loci in the visual system that are implicated: photoreceptors, LGN, and V1-V2 underpinning perception of complex stimuli defined by their contrast (Tang & Zhou, 2009). Based on our results, we suggest at least 8-sec RW in the Trivector when testing mature observers to ensure veridical measures of their chromatic discrimination.

LexiaD, the first dyslexia-specific Cyrillic font compared to the popular Times New Roman and Roboto fonts when read by adolescents

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The LexiaD font, designed for Russian-speaking people with dyslexia, has been shown in our previous studies to be more efficient than other Cyrillic fonts (PT Sans and PT Serif) when reading by primary school children with and without dyslexia (Alekseeva et al., 2020). In this study, LexiaD is compared to other well-known fonts – Times New Roman (TNR) and Roboto when read by adolescents. Design and method. Previous studies have shown that the font has a similar effect for different types of readers, so we recruited only adolescents without reading disorders (N = 72, age 14 – 17 years old). Adolescents read three connected texts (about Easter Island). Each text was presented on a separate sheet of paper and was printed in one of the fonts – LexiaD, TNR, or Roboto. During the reading process, eye movements were recorded on a mobile tracker PupilCore 200 Hz. After reading the text, the participants answered comprehension questions and evaluated the font according to two parameters: 1) which is easier to read and 2) visually more pleasant. Results. We performed linear mixed-effect modeling on mean fixation duration with font as a fixed effect. As for preference factors, the chi-square test was used. The average fixation duration is significantly less (195 ms vs. 203 ms) in LexiaD than in TNR ($t=-2.35$, $p = 0.02$) and does not significantly differ from Roboto ($t=-1.39$, $p=0.17$), although it is numerically smaller in LexiaD (199 ms). According to both preference factors, no difference was found ($p>0.05$). [Funded by Presidential grant #MK-1373.2020.6.]

Contextualised meaning maps do not predict how semantic object-context inconsistencies change human gaze behaviour

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Semantic information plays an important role in human eye-movement control. One well-known semantic

influence on gaze guidance relates to object-scene relationships: objects that are semantically inconsistent with the scene within which they appear attract more fixations than consistent objects placed in the same context. One interpretation of this effect is that fixations are driven towards inconsistent objects because they are semantically more informative. We tested this hypothesis using contextualised meaning maps, a method that uses crowd-sourced ratings to measure the spatial distribution of context-sensitive meaning in images. In Experiment 1, we compared human fixations with predictions by contextualised meaning maps for images in which the semantic consistency between objects and scenes was manipulated. As expected, semantically inconsistent objects attracted more fixations than the consistent ones. However, contextualised meaning maps did not assign more meaning to image regions that contained semantic inconsistencies. In Experiment 2, a large number of raters evaluated the meaningfulness of a set of carefully-selected image regions. Surprisingly, the same scene locations were rated as slightly less meaningful when they contained inconsistent vs. consistent objects. Taken together, our results demonstrate that, at least in the context of this specific rating task, semantically inconsistent objects are experienced as less meaningful than their consistent counterparts, and that contextualised meaning maps do not capture one prototypical influence of semantic information on eye-movement guidance.

Oculomotor Indicators Associated with Task Performance in Different Language Groups

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Researchers converge in identifying oculomotor correlates, associated with greater performance: experienced subjects exhibit shorter fixations and longer saccades (Ashby, Rayner & Clifon, 2005), as well as greater stimulus coverage resulting from increased saccadic speed (Blinnikova, Izmalkova, 2016). Changes in oculomotor activity in various language-related tasks such as reading, lexical decision or word recognition can be associated both with belonging to a particular language group and with linguistic competence. In order to investigate the oculomotor patterns of successful performance in solving a lexical task in a foreign language, we compared samples of different linguistic backgrounds (Russian, Japanese, and Chinese speakers, n=64). The task consisted in searching for words through letter matrices, similar to a word search game. Efficiency and oculomotor indicators were registered with "SMI Gaze & Eye-tracking System". In the group of Russian respondents, higher efficiency is associated to longer saccades ($F(2, 366) = 3{,}65$, $p < 0{,}05$) with larger amplitudes ($F(2, 366) = 3{,}19$, $p < 0.05$). Japanese subjects demonstrate a decrease in saccade duration saccades ($F(2, 349) = 4.24$, $p < 0.5$) as their effectiveness increases. Chinese subjects demonstrating higher search effectiveness show a lower fixation count ($F(2, 393) = 6.97$, $p < 0.01$) and frequency ($F(2, 393) = 7.02$, $p < 0.01$) along with a smaller number ($F(2, 393) = 7.72$, $p < 0.01$) and frequency ($F(2, 393) = 7.68$, $p < 0.01$) of saccades. Thus, changes in oculomotor patterns associated with higher search efficiency are specific for each language group, depending on the requirements of task. [The research is supported by RFBR project # 20-013-00674.]

Speed-Accuracy Instructions modulate Saccadic Velocity in an Eye-Tracking version of the Trail-Making-Test

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Examining the eye movements of a person during their performance of a task offers a way to gain deeper insights into ongoing cognitive processes of that person. A body of work suggests that the peak velocity of a saccade is related to the cognitive demands of a task. Recently, we recorded eye movements of participants while they performed a version of a computerized Trail-Making-Test (TMT), a popular test of executive functions applied in neuropsychological contexts. During the test participants clicked through a sequence of numbers (TMT-A) or alternated between a sequence of numbers and letters (TMT-B) emphasizing either the speed or the accuracy of their responses. Since part A and part B generally differ in their task difficulty, we examined if the saccadic peak velocities were reflective of that difference. Our analyses revealed peak velocities were greater during performance of TMT-B but only when participants were emphasizing the speed of their responses. TMT-A performance yielded no such differences. We suggest that this is due to the combination of test part B with the speed task-set. The speed task-set might amplify the effect of task difficulty on the level of arousal which becomes visible in higher saccade peak velocities. In contrast, the accuracy task set might limit the effect of task-difficulty on arousal, to ensure an appropriate level of carefulness in task performance. Taken together, these findings highlight saccade velocities as a tool to uncover cognitive and physiological states in sensorimotor tasks.

An active model of human edge sensitivity: Extracting edges via fixational eye movements

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Human vision relies on mechanisms that respond to luminance edges. As a result, visual percepts fade if we spatially or temporally interfere with edge-sensitive processes in the visual system. Standard vision models focus on spatial mechanisms for human edge detection assuming that the modeled processes occur within a single fixation and under static viewing. Inspired by cells in V1, these multiscale vision models are comprised of linearly operating filters at multiple scales and with different orientations. However, the assumption of static viewing is not doing justice to the fact that our eyes are constantly moving and that the visual system is fundamentally driven by spatiotemporal information. Here, we propose a spatiotemporal model of human edge detection which combines multiscale vision with an active sampling strategy via fixational eye movements. In simulations, we show that in our model edge signals naturally emerge as a byproduct of actively sampling the visual input via ocular drift. To test our model, we conducted two simulation experiments: In the first experiment, we propose that our model can indirectly account for the spatial-frequency-specific effect of narrowband noise in human lightness perception. Second, we show that our model can extract edge signals in natural images and compare its performance to several controls. We argue that in a system that performs multiscale spatial filtering, extracting edge signals via the proposed spatiotemporal mechanism could reduce the number of oriented filters needed in V1 that process the input with both different orientations and spatial frequencies. [Funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) under Germany's Excellence Strategy – EXC 2002/1 "Science of Intelligence" – project number 390523135.]

Saccadic Remapping of Contextual Influences in Color Vision

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Saccadic remapping is a mechanism thought to underlie visual stability despite eye movements and has been demonstrated for a number of visual object features. To investigate if remapping occurs not just for stimulus features but also for contextual information, we measured whether color judgments are influenced by contextual colors when context and stimulus are separated by saccades. Participants had to compare two 2° stimulus patches flashed for 60 ms at random times while performing saccades across contexts represented by differently colored 6-8° arrays of 1.5-2° color patches. We considered two conditions in which stimulus and context were separated spatially or temporally, respectively. In the first condition, the stimulus was flashed presaccadically at the intial fixation position while the context was presented around the target position. In the second condition, the context was removed at saccade onset and stimuli were flashed after the saccade at the same spatiotopic location. In both conditions, responses indicated that the perceived color of the stimulus was shifted away from the color of the context. Color shifts were qualitatively similar to those induced by simultaneously presented contexts and were on the order of 5% in magnitude for presaccadic stimuli and around 10% for postsaccadic stimuli. Our results suggest that not only local stimulus features but also contextual interactions are remapped around the time of saccades.

Pupil's temporal response function to color and luminance: the reverse correlation approach

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The pupil light response was traditionally considered as a subcortical reflex, but studies have found that it is also modulated by higher-level processing at the cortical level. One supporting evidence comes from studies showing that the pupil responds to isoluminant colors, and that the response latency is delayed by 40-50ms for red-green colors than for luminance. The additional delays suggest that cortical processing may be involved for the pupil response. However, it remains unknown how the pupil responds to different colors. In the present study, we aimed to measure the pupil's temporal response function to luminance and 4 cardinal colors (red, green, blue, yellow) in isoluminant plane of DKL color space. To quickly estimate the temporal response function, we developed a method based on reverse correlation. This method uses pupil responses to stimuli randomly varying in luminance or color contrast over time. By reverse correlating pupil responses to luminance or color contrast, the temporal response functions to each type of stimuli can be estimated. In all the temporal response functions, we observed a negative peak at a certain delay. The delay was shortest for luminance (95% confidence interval = [426, 443] ms), and was significantly longer for all colors. Red had a peak latency of [460, 480] ms, followed by yellow ([476, 501] ms), green ([512, 532] ms) and blue ([511, 560] ms). The increase in latency observed for color suggest that cortical processing is involved in triggering pupil responses.

Effect of eye movements on fading and recovery of Kanizsa triangle illusion

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The well-known phenomenon of Troxler fading indicates that visual stimuli fade away under sustained eye fixation. Usually this phenomenon is observed for physical stimuli, but it could be applied to some visual illusions as well. We investigated stimulus fading and recovery dynamics under suppression of eye movements for illusory figure – Kanizsa triangle. The stimulus was presented for 2 minutes and subjects were required to fixate a dot in the centre of the screen. Eye movements were recorded with eye tracking equipment and subjects were required to report changes in perception of illusory figure and physical stimuli. We found the effect of eye movements on the perception of illusory figure – eye movements decreased before figure fading and increased before figure recovery. Also, we found that illusory Kanizsa triangle have disappeared before physical stimuli started to fade away. The results support the hypothesis that we perceive the world due to active inference process. The disappearance of visual illusion before physical object fading suggests that eye movements suppression affects inference in two stages, first as most probable object perception and second as real object perception. [This work was supported by the Science Promotion Foundation of Vilnius University (No. MSF-LMT-3).]

An attentional limbo: Between saliency-driven and relevance-driven selection, saccades become momentarily non-selective

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Saliency and relevance are important factors in driving visual selection. These processes follow different time courses: the effects of saliency can be observed immediately after display onset but disappear rapidly. Conversely, the effects of relevance take some time to develop, but are sustained. Here, we report evidence for an intermediate period during which eye movements appear to be in limbo: they are neither driven by saliency nor by relevance. During the experiment, participants performed a simple selection task in which they were presented with either a salient target and a non-salient non-target (NSNT), or a non-salient target and a salient non-target. Participants were instructed to make a speeded eye movement to the target. The results showed that short-latency saccades were driven by saliency, whereas long-latency saccades were driven by relevance. Crucially, in between these time periods, we observed a small time window during which eye movements were neither driven by saliency nor by relevance. Here, participants were equally likely to select the NSNT as they were to select the salient target. We show this for saliency and relevance defined within the same dimension (orientation) and within different dimensions (orientation and color). We hypothesize that during this time window of non-selectivity initial signal processing of the salient and non-salient item have both been completed, thus eliminating the relative saliency effect, while differential relevance-driven modulation has not yet started. In this period, the eyes momentarily rely on information regarding signal presence, without being biased by saliency and relevance. [This project was funded by the Dutch Organization for Scientific Research (NWO; grant 453-16-002, to CNLO).]

The effect of eye blinks on steady-state visual evoked potentials (SSVEPs)

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Steady-state visual evoked potentials (SSVEPs) are widely used for vision research. Typical SSVEP studies used long durations of stimulations (up to a few minutes), and the observer is allowed to blink eyes. Eye blinks can cause rapid changes of visual inputs and also induce EOG artefacts. However, it is currently unclear how exactly eye blinks affect SSVEP signals. We recorded SSVEPs induced by flickering background (flickering rate = 7.5 Hz) for 60s in each trial. Observers (N=12) were required to fixate at a dot in the center of screen, and blink eyes at a rate of once every 4 seconds or 12 seconds in different trials. Eye movement data and EEGs were simultaneously recorded. We first analyzed SSVEPs over 60s EEG signals, and found that the amplitude was decreased for trials with more blinks than trials with less blinks ($t(11) = -3.54$, $p = 0.005$). Next, we found that the effect persists even after removing EOG artefacts by standard procedures ($t(11) = -3.34$, $p = 0.007$). Thus, artefact-removing procedures do not help to recover the reduced SSVEPs by blinks. Furthermore, we used short-term Fourier transformation to get time-resolved SSVEP amplitudes before and after blinks. We found that blinks induce a transient reduction on SSVEPs, starting from -100ms before blinks until 100ms afterwards. Therefore, blinks suppress SSVEP responses. The effect of eye blinks should be considered in SSVEP studies, especially in situations where blinking behaviors may be modified by the experimental task (e.g., Jin, Zou, Zhou & Ding, 2018, Nature Communications). [Natural Science Foundation of China, 31900758.]

The effect of mask on judging the overall mood of facial crowds

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Recently, we often judge the overall mood of a facial crowd wearing masks. The current study investigated how accurately people could estimate the average emotion of multiple faces with masks that cover lower halves of each face. After seeing two sets of a facial crowd sequentially, participants were asked to judge which set was angrier. One of the two sets was always a set with neutral emotion and the other set could be either a set with happy emotion or a set with angry emotion. Mean emotion intensities of the happy and angry sets were either high or low. To investigate a mask effect, the mask condition where all faces of the two sets were wearing masks was compared with the mixed and control conditions, each of which had only one set wearing masks and none wearing masks. A set had either 1, 4, or 8 faces and the same number of faces were presented within a trial. For all set sizes, covering the lower half of the faces with masks reduced the accuracy and increased the RT. With larger set sizes, participants judged the mean emotion faster with an equivalent accuracy. The effect of mask was particularly greater when the masked emotion was "happy" compared to "angry" such that participants often incorrectly judged a happy crowd with masks as angrier than a neutral crowd without masks. In sum, these results suggest that face masks reduce emotion intensities of a facial crowd and the benefit of multiple information. [This work was supported by the National Research Foundation of Korea (NRF) grants (NRF-2019R1A2B5B01070038 and NRF-2019S1A5A2A 03045884).]

A face is more than just a number for young domestic chicks. Individual processing of face-like displays supports 3vs.4 discrimination

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A limitation in distinguishing 3vs.4 objects - considered a key signature for small numerousnesses processing - was found in infants and other animals. We previously showed that the performance in domestic chicks can be improved by adding individually distinctive features to each object. Here, we explored the role of experience in this mechanism by rearing newborn chicks with seven objects before testing them with the proto-arithmetic comparison 1+1 +1 vs. 1+1+1+1. In Experiment 1, chicks (n=14) were reared and tested with seven individually different face-like displays. At test they discriminated, supporting the relevance of individual processing in numerical performance. In Experiment 2, a new group of chicks (n=15) failed when reared with seven identical copies of a face and tested with seven copies of a novel face. This suggests previous experience of individual recognition to be crucial. In Experiment 3, new birds (n=15) reared with seven copies of a same face and then tested with seven all different and novel faces, succeeded. Previous experience with a single face-like stimulus suffices in favoring subsequent individual discrimination of new face-like displays. In support of this hypothesis, a new group of chicks (n=15, Experiment 4) reared with featureless faces and tested with seven different faces, failed. Precocious experience of facial features, enhances individual processing and boosts proto-arithmetical calculation. [European Union's Horizon 2020 research and innovation program under the Marie Sklodowska-Curie (grant agreement No. 795242 SNANeB) to RR; and a PRIN 2017 ERC-SH4–A (2017PSRHPZ) to LR.]

Positive effects in detecting changes of dynamic facial expressions

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Dynamic facial expressions provide more ecologically-valid cues for understanding the affective states of others compared to static facial expressions that have been commonly used in previous studies. We used dynamic facial expressions to assess participants' sensitivity towards emotional changes, an important cue in social interactions. Participants watched videos of a face changing gradually from a neutral expression to a happy or sad expression (onset condition) or from a happy or sad expression to a neutral expression (offset condition). In each trial, the final intensity of the emotional facial expression was manipulated using the staircase method, and participants judged whether the video ended with a same or different emotional expression compared to the starting expression. The dependent variable was the smallest intensity of change of facial expression that participants could notice. We found two positive effects: participants were more sensitive to the onset than the offset of facial expressions, and more sensitive to changes of happy than sad expressions. As facial expressions were presented dynamically, the onset cue conveys an increase in arousal level, which may explain the observed higher sensitivity to the onset rather than the offset of emotional expressions. Participants' higher sensitivity to the changes of happy expressions could be caused by happy expressions providing a social cue for being approachable. The method we employed provides a useful tool to measure sensitivity to dynamic facial expressions, and the findings have critical implications for social interactions as the detection of emotional changes

motivates approaching or aversive behaviors. [This study was supported by the Ministry of Sciences and Technology in Taiwan (MOST 107-2410-H-002-129-MY3).]

Face-inversion effect of gaze perception in the frontoparallel plane

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The face-inversion effect is a well-known perceptual phenomenon to explore whether the face has been processed holistically (Yin, 1969) and has been reported to affect gaze perception (Jenkins & Langton, 2003; Schwaninger et al., 2005; Yokoyama et al., 2011, 2014). Although these previous studies have subjected the consciousness or attention to direct gaze, it has not been clarified how gaze direction is perceived. The present study examined the effect of face-inversion on the perceived gaze direction in the frontoparallel plane. The gaze direction deviated in 8 patterns (±5, ±10, ±15, and ±20 degrees) in each of the horizontal and vertical directions. The participant's task was to choose a perceived gaze direction from among the markers attached to a transparent plate. The deviation angle of the perceived gaze direction was calculated based on the location of the markers. A linear regression equation was fitted between the perceived and physical gaze directions. A two-way ANOVA analyzed the parameters with face direction (upright or inverted) x gaze direction (horizontal or vertical) as factors. As a result, the main effects of both factors were significant for the regression coefficients. It was found that the regression coefficient was larger for upright faces than for inverted ones and be larger for horizontal direction than for vertical ones. The results suggest that gaze perception is an anisotropy in the frontoparallel plane regardless of whether the face is upright or inverted and that the deviation of gaze direction is perceived for upright faces larger than for inverted ones. [This work was supported by JSPS KAKENHI Grant Number JP20K14227.]

Does animating virtual characters affect later face identity processing?

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Previous work from our group and others has demonstrated that learning a new face in the context of a dynamic head/body improves subsequent processing, relative to learning static snapshots (Knappmeyer, Thornton, & Bülthoff, 2003; Pilz, Thornton & Bülthoff, 2006). Here, we extend this work by asking whether computer-generated animations giving the impression of a live model (e.g., slight body sway, small changes in head posture, varied eye-contact) afford an advantage over a single static view of a virtual character. Participants were familiarized with two virtual characters using an incidental learning paradigm. The 3D characters were created based on photographs taken from the Glasgow face database (Burton, White, & McNeil, 2010) and had the same body, head outline and texture. During learning one character was presented in motion, the other as a static snapshot. The two identities alternated on screen while a series of questions were answered (e.g., Who looks happier? Sara or Lisa). At test, novel faces were generated by morphing each target identity 50/50 with 10 new identities. The task was to assign the correct "family" to the new character. Each new character was shown twice: once with congruent mapping relative to learning (i.e. motion-motion or static-static) and once with incongruent mapping (i.e., motion-static or static-motion). Preliminary results show above chance performance in all conditions and a clear trend for a congruency effect between learning and testing motion conditions, with better performance in congruent conditions.

Face detection from patterns of shading and shadows

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Here we investigate how characteristic patterns of shading and shadows that occur across the face act as a cue for face detection. We use 3D-graphical rendering to isolate facial shading under controlled lighting conditions. The rendered images are converted to two-tone images ('Mooney faces') to isolate broad patterns of contrast. We measured human performance in discriminating faces from non-face objects when rendered in identical lighting conditions. We find that the production of recognizable sensory patterns depends strongly on the lighting direction relative to the face. In particular, light arriving from above the brow tends to facilitate face detection, consistent with the statistics of real-world lighting environments, in which light commonly arrives more strongly from above. Indeed, in a further experiment, we find that asymmetries in lighting that occur in complex and naturalistic lighting environments produce contrast patterns across the face that facilitate face detection. Comparison with the performance of an image classifier trained to discriminate faces from non-faces suggests that these effects might in part be due to differences in image information across conditions as well as to human familiarity with overhead lighting. These results demonstrate that the sensory features that define a face

to the human visual system depend on the interaction between the characteristic 3D shape of human faces and lighting direction. [CP is supported by an Australian Research Council Discovery Early Career Researcher Award, DE190100459.]

Binocular response to light: a novel pupillometric and electrophysiological approach

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The anatomical pathways underlying the pupillary light reflex are reasonably well understood. However, less is known about the computational process by which different levels of light in the eyes determine pupil diameter. This computation must involve binocular interactions, including summation and interocular suppression. Pupillometric measures might therefore offer new information about basic neural circuits that may be affected in clinical disorders, such as amblyopia. We measured changes in pupil size and in the amplitude of the occipital EEG signal simultaneously in response to flickering lights of varying modulation depths. Because EEG and pupillometry have different temporal properties (the former responds better to frequencies >3 Hz, the latter to frequencies <1 Hz), the flickers were presented at frequencies of 1.6 and 2 Hz, producing measurable signals for both. Participants viewed the stimuli through a mirror stereoscope, enabling the use of three ocular configurations: monocular, binocular and dichoptic. We observed an increase in the amplitude of pupil diameter and EEG modulations in the binocular condition compared to the monocular condition, implying the presence of binocular summation. Summation was especially clear in the EEG results where, at high modulation depths, the amplitude doubled compared to the monocular condition. At the 2nd harmonic (4 Hz), summation was even stronger, with the amplitude being almost 2.5 times bigger at high modulation depths. Overall, these results imply the presence of linear interocular combination rules in pathways processing temporal luminance modulations, which are unlike the gain control mechanisms previously measured for the interocular combination of spatial contrast.

CDA as a measure of cognitive placebo effect in working memory

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The cognitive placebo effect strengthens participant's expectations of their cognitive ability, therefore, causes improvement in memory tests: people are capable of keeping more objects in their visual working memory. The behavioral experiment we conducted earlier showed trend level improvement in cognitive test results including attention (Bourdon test) and working memory (n-back test) tests. In this experiment, we tested the hypothesis that placebo intake can cause a temporary improvement of the visual working memory as compared to a control group if the participants in the experimental group are told they are taking a memory-improving pill. The experimental design is the following: participants are taking cognitive tests online (Raven's matrices, Digital Span test) before coming to the laboratory. In the laboratory they are completing a 10-minute change detection task followed by a 7-minute break with intake of the "memory improving pill" or tic-tac candy in the control group followed by a 10-minute change detection task. When the experiment is completed, participants are debriefed on the experiment goals, especially, with the focus of no possible side effects of the pill intake. We analyze the Contralateral Delay Activity (CDA). CDA is a negative slow wave sensitive to the number of objects maintained in the visual working memory. The increase of the set of objects kept in the visual working memory results into the increase in the CDA amplitude. We expect CDA amplitude to be higher in the experimental group than in the control group.

Efficient coding and random forgetting of facial feature information in visual working memory

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Although efficient storing of facial information is crucial in visual working memory (VWM), it is still unclear 1) which facial features are stored in VWM, 2) how these representations are forgotten, and 3) how efficient these representations are. We studied these questions using a novel type of classification image (CI) analysis that reveals what facial features observers use for face identity encoding. Stimuli were made using a morphing technique that allows to vary how much identity information each facial feature provides compared to a baseline average face. A large number of stimulus instances for each identity was then generated by randomizing each facial feature independently. Observers' (n=11) task was first to memorize a face stimulus close to one identity. After a retention interval (RI) of 500 or 4000 ms, a second face was shown. This was either a 'same' face (a slightly randomized instance of the memorized face), or an 'average face' (a face where most features were on average close to the average face, but where some features resembled the memorized face). We then used a regression model that predicts observer's 'same' responses

from the randomized feature values in 'average' trials to estimate the CIs. CIs revealed that eyes, mouth, and nose were heavily weighted in VWM storage. In general, weighting was very similar in both RI's suggesting memory loss is not feature-specific. Feature weighting in human observers was remarkably similar to an ideal observer, revealing surprisingly efficient coding for facial features. [This research was supported by Jenny and Antti Wihuri Foundation.]

Visual Long Term Memory for Objects Determined by Context Not Their Animacy

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The relationship between elements of visual episodes affects the memory for those episodes. Object and the background context it is encountered in are bound in memory to a different degree depending on their relationship. Our study examines how changes in background context influence memory for animate and inanimate objects appearing in real-world scenes. We presented participants with 216 unique inanimate or animate objects in 432 real world scenes. Each target object was presented twice during the study phase, either in the same background or in a new background. At test, targets appeared either in the same context that they were studied in, or in a new background scene. Object memory was tested using a two alternative forced choice recognition task immediately following the study phase, after a 24-hr delay, and after a 1-wk delay. Over time memory for target objects declined overall, linearly decreasing though the reason for the decline appears to be due to different mechanism at different time points. We observed a robust facilitation effect when the background context was reinstated at test as well as a determent to object memory when it did change between study and test with different dynamics emerging across the span of 1-wk. The animacy of the object did not have an overall effect on memory suggesting that animate objects might draw one's attention however they are not remembered better. Breaking the object-to-scene binding during encoding by presenting the target object in different background contexts at study maintains memory for target objects long-term.

The precision of representations in visuospatial working memory depends on their location in the visual field

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Visuospatial working memory (VSWM) has a limited capacity. However, the nature of this capacity limitation is debated. Slot models argue that there is an upper limit on the number of items that can be retained in VSWM (Zhang & Luck, 2008). In contrast, resource models propose a limit on the quality of representations that can be maintained in VSWM (Bays et al., 2009). Slot and resource models make different predictions about how the eccentricity of stimuli might affect representation in VSWM. According to the slot model, eccentricity should not affect the quality of representations. In contrast, the resource model predicts that the precision of representations will decline as eccentricity increases. We tested these predictions in a series of online and laboratory experiments using a spatial continuous report task. Participants were shown coloured dots at various eccentricities and asked to localise one of the dots after a short delay. We applied Bays et al.'s (2009) mixture modelling to responses to examine the sources of error in VSWM representations. VSWM representations were less precise when presented further from central fixation for both online and laboratory experiments. The pattern of response errors in the online experiment offers support for the slot model, whereas the pattern of results in the laboratory version indicates support for the resource model of VSWM. We propose that differences in eye movements might underlie the differences in results and thus differing support for the slot and resource models of VSWM.

Serial dependence under memory load

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Perceptual decisions are biased towards previous stimuli, a phenomenon known as serial dependence. However, the mechanisms of this bias are unknown. For example, it is debated whether serial dependence reflects a perceptual bias or interference of prior stimuli in working memory. We addressed this question by testing whether visual working memory load modulates serial dependence. We presented sequences of Gabors appearing at the same or different locations. At the beginning of each sequence, we presented a display with two lines. Participants reproduced the orientation of each of the three Gabors while holding the orientation of the lines in memory. In a control condition, participants reproduced only the orientation of each Gabor, ignoring the lines. Working memory load caused a repulsive bias in the adjustment responses when the previous Gabor was presented at a different location. In the control condition, Gabors at different locations caused no bias at all. When presented at the same location, however, the bias was attractive for small orientation differences (<45°) and repulsive for larger ones (>45°),

resembling typical serial dependence. Under load, this pattern was qualitatively more pronounced. Our results suggest that working memory load may interact with, rather than prevent, serial dependence by making perceptual decisions more vulnerable to biases. [This research was supported by funding from the Swiss National Science Foundation (grant no. 415 PZ00P1_179988 to DP) and the Swiss Government Excellence Scholarship awarded by Federal Commission for Scholarships for Foreign Students FCS (NT). The funders had no role in the study design, data collection and analysis.]

Tuning to a hip-hop beat: Pursuit eye movements reveal processing of biological motion

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Smooth pursuit eye movements can anticipate predictable movement patterns, thus achieving their goal of reducing retinal motion blur. Oculomotor predictions have been thought to rely on an internal model of the target kinematics. Since biological motion is one of the most important visual stimuli in regulating human interaction, we asked whether there is a specific contribution of an internal model of biological motion in driving pursuit eye movements. Unlike previous contributions, we exploited the cyclical nature of walking to measure eye movement's ability to track the velocity oscillations of the hip of point-light walkers. We quantified the quality of tracking by cross-correlating pursuit and hip velocity oscillations. We found a robust correlation between signals, even along the horizontal dimension, where changes in velocity during the stepping cycle are very subtle. The inversion of the walker and the presentation of the hip-dot without context incurred the same additional phase lag along the horizontal dimension, whereas a scrambled walker incurred no phase lag relative to the upright walker. Those findings support the view that local information beyond the hip-dot, but not necessarily configural information, contribute to predicting the hip kinematics that control pursuit. We also found a smaller phase lag in inverted walkers for pursuit along the vertical dimension compared to upright and scrambled walkers, indicating that inversion does not simply reduce prediction. We show that pursuit eye movements provide an implicit and robust measure of the processing of biological motion signals. [We would have liked to thank Nikolaus Troje for his various comments and suggestions on different versions of this project.]

Visual feature integration: how long can it last?

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Spatiotemporal features are integrated along motion trajectories. For example, when a central line is followed by pairs of flanking lines, two motion streams diverging from the center are perceived. The central line is rendered invisible by the subsequent flanking lines. Surprisingly, if the invisible central line, but none of the later lines, is offset, the entire stream appears offset. Further, if one of the flanking lines is offset in the opposite direction, the two offsets integrate and cancel each other out – given the offsets are presented within the same temporal window, lasting for up to 450ms. Here, we asked what determines this duration. Observers discriminated the perceived offset of the motion streams. In line with most models of decision making, one might expect that the window terminates as soon as sufficient evidence about the offset is accumulated. However, this is not what we found. When we presented either a large offset at the first line or smaller offsets at the following lines, all in the same direction, the duration of the integration windows was identical. However, when we increased the processing load by adding two additional offsets, which canceled each other out, the window duration increased slightly. Lastly, by varying the ISI between the lines, we found that absolute time determines the window duration but that the number of lines does not. We propose that perception is a series of discrete frames, which depends mainly on absolute time, potentially on the processing load, but not on stimulus evidence. [SNF n 320030_176153 / 1 "Basics of visual processing: from elements to figure".]

Comparison of non-visual vection with cutaneous stimulation to different body parts

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Vection is the sensation of illusory self-motion in the absence of physical movement. Because vection can be induced mainly by visual stimulation, it has been studied as a part of visual perception. Recently, we found that another modality combination, such as cutaneous and vestibular sensations, without visual stimulation could induce self-motion perception. In the present study, we examined the basis of non-visual vection induced by cutaneous

stimulation (wind generated by double feathers fans in front of the participant) and vestibular stimulation (vibration of a horse riding simulator) by comparing the strength of vection among body parts exposed to cutaneous stimulation. The rate of cutaneous stimulation was fixed at 0.3 m/sec, and the vestibular stimulation was set as a horse walking at a speed of 1.78 m/sec. Participants wore a plastic coat, hair cap, cervical collar, and mask to be stimulated with a specific part of the face and hands. Within the face, we compared the latency, duration, and strength of vection among the full, upper, and lower part exposure to the cutaneous stimulation. We found that the stimulation to face induced vection faster, longer, and stronger than the stimulation to hands did. Among the stimulation to the face, the strength of the vection was the strongest with the full exposure condition, and followed by the upper exposure condition as the second, and lower exposure condition as the third. Our results suggests that the ophthalmic nerve region would contribute to generating the non-visual vection in terms of cutaneous and vestibular stimulations. [This work was supported by JSPS KAKENHI Grant Number JP40837465.]

The organization of body-parts representations in Deep Convolutional Neural Networks

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In the last few years, deep convolutional neural networks (CNNs) have reached human level performance in object recognition, but the extent to which they capture neural representations is still debated. Here, we tested the role of CNN's training in explaining the domain-specific organization observed in the primate brain for different body parts. To this aim, we tested ResNet50 trained on two different datasets: ImageNet for object recognition, and VGGFace2 for face recognition. We presented both CNNs with a stimulus set including human and monkey body parts (headless bodies, hands, and faces). We performed Representational Similarity Analysis to test the convergence of object space between the networks and 6 models: three low-level computational models (GIST, Texture, Bag-of-Features), two conceptual models (species and body-parts), and one behavioural model (similarity judgments). We found that early and intermediate layers of both networks were best explained by the image's texture properties but representations in the last fully-connected layers diverged in the two networks. The representational space in the CNN trained on object recognition was best explained by the conceptual species model, suggesting that this CNN categorises objects primarily based on species, differently to the primate visual cortex where the different body parts are represented separately regardless of species. On the contrary, the CNN trained on face recognition revealed a cluster for faces separate from the remaining body parts. These findings highlight the critical role of training in DNNs' resulting object space and the need for tasks that closely resemble human everyday visual experience.

Shape-Related Size Biases in Visual Area Judgements

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Every day, we effortlessly interact with a wide range of objects of different size and shape, yet a range of shape-related size biases have long been reported. For example, in area judgements, observers consistently judge triangles as larger than area-matched squares and disks. Several authors have proposed that the biases are explained by the magnitude of a 'dominant dimension', but this is ill-defined, and the picture is complicated by different results from different studies using different subsets of shapes. Here we explore biases in area perception, across different shapes, allowing us to test the influence of various geometric features (e.g., number of sides / vertices, height, width, contour length, compactness, convex hull). Observers made 2AFC judgements ("which stimulus has larger area?") for pairs of objects that differed in shape and / or size and / or orientation. We found clear shape-related biases: triangles were systematically perceived to have larger area than the other shapes. Disks were perceived to have the smallest area. For convex shapes, perceived area increased as compactness (area / area of circumscribing disk) decreased. However, no single geometric feature provides a good correlate of the bias across all shapes, with a more complete description incorporating additional simple geometric features when explaining shape-related biases of area perception. [This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 765121.]

Subtle shape-cues differentiate animals from plants

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Seeing the difference between animals and plants is a vital skill. To make this distinction, especially when telling apart small insects from twigs or leaves, we often have to rely on subtle shape-cues. To identify and test these cues, we used a custom algorithm to create a large number of shapes varying along numerous generative parameters (e. g. number of parts, tapering of limbs). Then, we collected ratings from 18 participants about the extent to which shapes looked like plant, animal, or object. The results allowed us to identify the three parameters that best differentiated between plants and animals (symmetry of part pairs, curviness and sprouting limbs). For a follow-up experiment, we created 110 sequences of shapes smoothly morphing in 5 steps from animal-like to plant-like according to these three parameters. The resulting shapes were shown one-by-one in randomized order to 14 new participants which judged each shape on a scale from plant-like to animal-like. The results confirm that the three parameters are highly predictive of human animal-plant-judgments. Also we identified additional factors that biased ratings towards animals or plants (e.g. plant-like if the shape had an odd number of limbs). Our findings identify hitherto unknown shape cues that bias human judgements of shapes towards animal or plant, thereby demonstrating how superordinate object classes are affected by subtle differences in shape. [Research funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation)–project number 222641018–SFB/TRR 135 TP C1), and by the European Research Council (ERC) Consolidator Award "SHAPE"–project number ERC-2015-CoG-682859.]

Investigating hierarchical organization of objects in scenes through measurements of perceived similarity

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The arrangement of objects in the environment follows semantic and spatial rules (which we have termed "scene grammar") that we exploit to perceive and interact with objects in an efficient way. Recently, it has been proposed that scene grammar is hierarchically organized: scenes are divided into meaningful clusters of objects ("phrases"); within every phrase, one object ("anchor") holds strong predictions about the identity and position of other objects ("local objects"). To investigate if this hierarchy is reflected in the mental representations of objects, we collected pairwise similarity judgments for a set of everyday objects and used Representational Similarity Analysis to estimate behavioral effects of different predictors reflecting three levels of the hierarchy: scene, phrase and inter-object. Results show that similarity judgments are stronger for object pairs that appear in the same scene than for object pairs that appear in different scenes. In addition, object pairs that have the same status in the scenes (i.e., they are both anchors or both local objects) are perceived as more similar than pairs of different status, while object pairs that are more often anchored together (i.e., pairs where one object predicts the location of the other) are judged to be more similar than less often anchored pairs. Pairs belonging to the same phrase were numerically judged as more similar than pairs from different phrases, but this difference did not reach statistical significance. We conclude that most aspects of scene hierarchy are reflected in the mental representations of object but to varying degrees. [This study was supported by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation), project number 222641018 SFB/TRR 135 TP C7 granted to MV.]

Variability estimation of multi-feature stimuli

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Previous studies have shown that people can judge the variability of multiple visual items along various feature dimensions. This study investigated whether people can estimate the overall variability of multi-feature stimuli by considering multiple feature dimensions together. Participants were asked to estimate the overall variability of a stimulus array having various colors and orientations by considering both dimensions. In Experiment 1, variabilities of orientation and hue are determined randomly and independently in each trial, and there was no correlation between the two features. Bayesian multiple linear regression was conducted to estimate the contribution of each feature dimension on overall variability estimations. We found that people considered both dimensions to estimate the overall variability of stimuli, and that hue variability had a relatively larger impact than orientation variability. In Experiment 2, we examined whether people directly compute the variability from a joint distribution in a two-dimensional feature space, or they combine variabilities of different dimensions after computing them separately. For this purpose, we manipulated the shape of joint distributions by changing inter-feature correlations. Joint distributions of orientations and colors had a narrower shape due to high inter-feature correlations (correlated condition), or a wider shape due to the absence of inter-feature correlations (independent condition). We found that variability estimations were not different between the conditions, indicating that variability of multi-feature stimuli may not be directly estimated from a joint distribution. These results suggest that people combine variabilities of different dimensions after computing them separately to estimate the overall variability of multi-feature stimuli. [This work was supported by the National Research Foundation

of Korea (NRF) grant funded by the Korea government (MSIT) (NRF-2019R1A2B5B01070038).]

EEG correlates of simultaneous bottom-up and top-down processing during perceptual uncertainty

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Our visual system must continuously analyse stimuli of varying visibility to build stable and dependable percepts. So far, theories about perceptual processing, postulating recurrent feedforward and feedback activity challenge theories about strict feedforward spatio-temporally hierarchical perceptual processing. To test for these different approaches, we executed an EEG study, where participants had to identify the orientation of Landolt C stimuli which varied in size to represent three levels of recognisability (clearly above the threshold, slightly above the threshold, and below the threshold). We compared the temporal and spatial profiles of perceptual processing steps for the different stimuli, using the high temporal resolution of event-related potentials (ERPs). We report evidence for simultaneous bottom-up and top-down processing. Occipital ERPs at 170 ms post-stimulus gradually increase with stimulus size (P1). At the same latency, but at vertex electrodes, the amplitudes of an N1 component differ binarily between below-threshold and (both, clearly and slightly) above-threshold stimuli. Interestingly, two later ERPs at 200 and 400 ms post-stimulus (P200 and P400) showed increased amplitudes only in response to clearly above-threshold stimuli. The latter differences were labelled as 'Uncertainty Effects' in previous studies. These findings suggest that processing steps, previously thought to occur sequentially, at different hierarchical levels, like low-level visual processing and transfer to awareness, take place in parallel. A mere 30 ms later, meta-perceptual analyses of stimulus uncertainty characteristically modulate cortical processing. This rapid and partly concomitant processing suggests an inherently interwoven flow of information and requires redefining the concept of hierarchy. [Acknowledgements: We thank the Deutsche Forschungsgemeinschaft (HE 3504/9-1 resp. 435838478) for financial support.]

Assessing the influence of semantic knowledge on object correspondence

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The visual system uses spatio-temporal continuity and feature information to establish object correspondence, or update object representations. Here, we investigated whether semantic knowledge can also influence this process. To assess how correspondence is resolved, we used ambiguous apparent motion in the Ternus display, in which two elements can be perceived as either moving independently (element motion) or together (group motion). A previous study by Hsu et al. (2005) found that when using images of frogs as Ternus elements that were ready to jump, i.e., forward-oriented in the direction of the Ternus motion, participants reported more element motion compared to when the images were oriented backwards. We used a similar experimental design, but with Ternus displays that could move to the left or the right, so that the orientation of the frogs was not confounded with the general motion direction of the display. We found a significant effect of forward-oriented versus backward-oriented frogs and no effect of the general motion direction of the Ternus display. However, the effect of the frog orientation was in the opposite direction of the original study, as frogs oriented in the motion direction resulted in more group motion percepts. Nevertheless, these results confirm the interpretation of Hsu et al. (2005) that semantic knowledge can influence the perception of apparent motion. Our results also imply that this semantic effect might be dependent on the prior knowledge of the observers. We are currently investigating this interpretation by manipulating participants' associations with the semantic stimuli. [This research was supported by DFG project HE 7543/1-1.]

The impressions of another by looking at the pupils, fact or fiction?

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The eyes are important in social communication. The literature suggests that the pupils convey impressions about others. The pupils can influence emotion perception (Harrison, Wilson, & Critchley). We also perceive a greater sense of trust and attractiveness when viewing dilated pupils (Amemiya & Ohtomo, 2012; Kret, Fischer, & De Dreu, 2015). How robust is the link between pupil size and perceived impressions of a person, and do the pupils

convey more information about a person? We ran an online experiment where participants (N=246) rated characteristics of eyes in neutral expressions. Pupils appeared constricted or dilated. There were also two regular-sized pupils: normal and normal-vergence. We then measured participants' extraversion and emotionality (Ashton & Lee, 2009), big-five traits (Rammstedt & John, 2007), and their self-reported arousal and valence (Bradley & Lang, 1994). Results illustrated that the ratings for trustworthiness, attractiveness, realism, intelligence, familiarity, and perceived valence were higher for dilated and normal pupils than for small or normal-vergence pupils. This indicated that the results were driven by how strange the pupils looked, since ratings between normal and normal-vergence were statistically different. Moreover, participants' extraversion, emotionality, personality traits, and self-reported arousal and valence did not provide much advantage in guiding the ratings. Therefore, our results raise doubt regarding the relationship between pupil sizes and perceived impressions about others. We conclude that participants were generally bad at rating characteristics by looking only at the eyes.

Poster Session 4

The within-trial time course of two types of flanker interference effects: Selection errors from early perception or late working memory

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Studying how the mean (correct) response time (RT) varies as a function of stimulus-onset-asynchrony (SOA) does not provide information on the time course of an experimental effect. Here we apply response history analysis extended with conditional accuracy analysis to the RT and accuracy data measured in a manual two-choice magnitude comparison flanker task (the central digit is always 1, 2, 3, 4, 6, 7, 8, or 9 and must be compared with the standard magnitude 5), to study how number magnitude is activated even when it is task-irrelevant. Previous studies found three effects. First, participants are slow when the flankers are mapped to a response that is incongruent with the correct response to the target. Second, a number magnitude distance effect is typically found for the target, but not the flankers. Third, participants automatically make a dysfunctional second-order magnitude comparison in which they compare the target and flanker magnitudes. Our distributional analyses actually reveal all four effects, including the within-trial time course of two types of temporally-dispersed flanker interference effects that play out early and late after stimulus onset, respectively: early bottom-up perceptual selection of target versus -incorrectly- flanker magnitude (to be compared with the standard magnitude 5 stored in working memory), and later top-down working memory selection of „5" or -incorrectly- flanker magnitude (to be compared with the by-then perceptually selected target magnitude). These findings show that the appropriate distributional analyses can reveal the within-trial time course of experimental effects without a manipulation of SOA. [Supported by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) - Projektnummer PA 2947/1-1.]

Investigating the Role of Cognitive Control in Aesthetic Judgments

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Aesthetic judgments play a major role in how we evaluate people, objects, and experiences in our environment. However, the cognitive mechanisms that underpin aesthetic processing remain unclear. In the current study, we used a cognitive load paradigm to investigate the extent to which aesthetic compared to non-aesthetic judgments rely similarly on automatic versus controlled processing. In Experiment 1, participants (N = 92) completed aesthetic and motion judgments on paintings, whilst holding in memory a single letter (low load) or six letters (high load). In Experiment 2 (N = 95), we used a similar load task but manipulated the content of the target images by comparing paintings with naturalistic photographs. In Experiment 3 (N = 94), we changed the load content from letters to images of visual artworks, in order to probe how different aspects of working memory (phonological loop versus visuospatial sketchpad) impacts judgments. Across all three experiments, we found an effect of load on reaction time responses, but no interaction between load and the type of judgment (aesthetic versus non-aesthetic). Further, by using Bayesian multi-level analyses, we could provide empirical support for the null hypothesis that executive resources are deployed in a similar manner, irrespective of judgment type (aesthetic vs. non-aesthetic), image type (paintings vs. naturalistic photos) and load type (letters vs. paintings). Overall, the findings suggest that aesthetic and non-aesthetic judgments rely to a similar degree on automatic versus controlled processing and the operations of the central executive.

When conventionality breeds contempt: Using the Repeated Evaluation Technique (RET) to predict kitsch judgements

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Today, reproductions of Van Gogh's sunflower paintings adorn smartphone covers and paper napkins, while his potato eaters still go unnoticed. Can we estimate which artworks will eventually end up as kitsch? We used 19 relatively unknown paintings by distinguished artists of the 19th and 20th centuries to test the predictive validity of five much-debated kitsch criteria. The Repeated Evaluation Technique (RET), a test-retest design with an intermediate, deep elaboration phase, was employed to simulate long-term everyday experiences: Participants (N=79) rated each painting twice in terms of positive valence, conventionality, identifiability, familiarity, thought-provoking quality, and kitsch. For the intermediate elaboration phase participants were randomly assigned to two conditions: Following Fechner's classical distinction they either elaborated on associative or direct aspects of the paintings. In the associative condition (n=33), participants were asked to reflect on a painting's content (How would you title this painting?), its affective impact (What do you feel when you look at it?) and personal meaning (Does it remind you of personal experiences?). In the direct condition (n=46), participants examined formal aspects such as symmetry, contrast, brightness, or color saturation. Across both conditions, linear mixed modeling for retest-evaluations showed that kitsch was best characterized by conventionality, identifiability, and positive emotional valence, whereas a thought-provoking quality proved incompatible with kitsch. Altogether, our findings confirm a well-tried recipe for kitsch in the visual domain: Take a clear-cut and conventional rendering of a subject matter with a positive emotional charge that will not inspire any new associations even after repeated elaboration.

Information-optimal local features as attention grabbers in covert and overt tasks

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Visual analysis is optimized through the selective sampling of the most salient regions in the scene. Several factors may contribute to the definition of local salience. Here we used specific local features, predicted by a constrained maximum-entropy model to be optimal information-carriers, as candidate "salient features". Previous studies in fast vision showed that subjects choose optimal features as "more salient" if explicitly asked. Here, we investigate the implicit saliency effect of optimal features through subjects' performance in two attentional tasks. In the covert-attention task, contrast threshold for orientation discrimination of a peripheral gabor was measured; in the overt-attention task, saccades towards a peripheral placeholder were analyzed. In both tasks, the target was preceded by two brief peripheral cues, one more salient than the other according to the model. In valid trials, the target was presented on the same side of the optimal cue. Independently on cue validity (50% or 80%), results showed lower contrast thresholds, saccadic latencies, and proportion of direction errors in valid trials, and the opposite in invalid trials, compared to baseline values obtained with equally-salient cues. Also, optimal features triggered more anticipatory saccades. Similar effects were found with high-luminance control cues. Our results demonstrate that, in fast vision, covert and overt attention are automatically attracted by the saliency of the optimally informative features predicted by the reference model. These findings suggest that the maximization of visual information, coupled with biologically plausible computational constraints, contributes to determine what features are considered to be salient by our system.

Middle identification and spatial numerical bias in rhesus monkeys (Macaca mulatta)

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Animals master diverse numerical tasks, but studies involving the comprehension of the abstract numerical middle are sparse. Here we address whether rhesus monkeys (Macaca mulatta) can flexibly use the abstract numerical concept of middle to visually navigate expanded series. We trained two monkeys (Arrow and Tolman) to select the middle dot in a horizontal series of three dots on a touchscreen. We tested whether monkeys could transfer the learnt rule to longer series composed of 3, 5, 7 or 9 items. Both monkeys selectively chose the middle dots

above chance expectation. To test whether monkeys used an abstract numerical rule, we compared the accuracy on trials with different numerousness. Monkeys showed a clear magnitude effect (accuracy decreased as the magnitude increased), which is considered a signature of a numerical estimation by the number sense. Then we explored whether monkeys' attention was directed toward the left or the right depending on numerical magnitude. We calculated a laterality index to represent the percentage of right-sided choices on the overall number of wrong choices: number of right choices minus number of left choices. Though present in monkeys, the attentional bias was either left-to-right or right-to-left oriented, depending on the individual. These findings demonstrate that monkeys can extract an abstract rule to bisect a numerical stimulus. This ability should be considered part of the abilities supported by the non-symbolic numerical system. [European Union's Horizon 2020 research and innovation program under the Marie Sklodowska-Curie (grant agreement No. 795242 SNANeB); and PRIN 2017 ERC-SH4–A (2017PSRHPZ) to RR.]

Testing the Shrinking Spotlight Model in a Flanker Task study using random-dot kinematograms

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The Eriksen flanker effect supports the theory that visual selective attention operates like a zoom lens, trading off between resolution and space. Consistent with this, flanker items further from a target tend to interfere less, as they are suppressed earlier as the spotlight shrinks. In a recent study using random dot-kinematograms, we found the opposite effect, namely reduced flanker effects with narrow spacing. Interestingly, the flanker effect was also moderated by the level of noise, with lower noise leading to reduced flanker interference. To explore how the zoom lens theory could account for this, we fitted the Shrinking Spotlight Model (SSP) of White, Ratcliff & Starns (2011) to the data using a Differential Evolution Monte Carlo Markov Chain (DE-MCMC) algorithm. The results suggest a perceptual influence on flanker interference: despite containing the same amount of noise, closely spaced items were perceived as having greater perceptual strength, reflected in differences in SSPs p parameter. Surprisingly, for the shrink rate parameter rd, uniform posterior distributions indicated that its value was often arbitrary, suggesting that zooming had little effect on quality of fit. To test this interpretation, we fitted a simple diffusion model with separate drift rates for congruent and incongruent trials. Calculation of Bayes factors indicated a moderately superior fit for the simple diffusion model particularly for the low noise condition, suggesting the results favour an explanation without a zoom lens. On the poster we will further discuss these results and highlight the benefits of using a Bayesian approach to parameter estimation.

The contribution of meaning to the detection of task conflict

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The colour-word Stroop task produces both information conflict (detection of the ink colour vs word meaning) and task conflict (respond to the ink colour vs read the word). In this study, we measured both reaction time and pupil dilation, and the neutral stimuli in our study were non-readable letter strings as well as meaningless non-readable stimuli (i.e., coloured patches and abstract character strings). Our results showed slowest responses in the incongruent trials and fastest responses in the congruent trials. However, no differences were found between the investigated neutrals. In contrast, pupil dilation was largest in the incongruent trials and smallest in the neutral trials. Moreover, the more the neutral stimuli were meaningless, the less the pupil dilation that was observed. Our results suggest that non-word meaningless stimuli reduced task conflict (compared with all the investigated conditions). Neutral equivalence should be taken into consideration in Stroop and Stroop-like tasks. [This research was supported by Grant 146/16 from the Israeli Science Foundation.]

Changes of Mind in the Moral Evaluation of Real-World Images

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The process of value-based decision-making is flexible and dynamic. Due to the complex and subjective nature, the decision processes can be influenced by a range of variables, such as response framing, personal predispositions, cultural-historical or social environment, but also purely perceptual factors such as repetition and occlusion. Here, we present a new experimental "mind-change" paradigm to investigate the changeability of moral evaluation when judging real-world images. We created a stimulus set ranging from "very moral" to "very immoral" images based on the Social Moral Image Database (SMID). We asked participants to rate real-world images on a continuous scale from -10 ("very immoral") to +10 ("very moral"). In the present "mind-change" paradigm we require subjects to evaluate the same images twice, in separate blocks for first and second evaluation. In order to validate the paradigm, as a first step, we tested the straightforward hypothesis that changes of mind are more likely to occur with the addition of perceptual information. For this purpose, we presented the images either partially occluded or without

occlusion. We found that responses were faster overall during the second evaluation, and that repetition did not influence the evaluation, independent of whether the images were presented twice with occlusion or twice without occlusion. Notable changes occurred however, when images were presented partially occluded first and without occlusion later. This mind-change paradigm, then, appears suitable for a systematic investigation of the personal and situational factors that influence the changeability of moral evaluation.

The effect of spatial frequency and colour on disruptive camouflage

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Disruptive colouration, impedes both detection and recognition of targets, by using patches with colours that are similar to the background, but contrast between themselves. Disruptive colouration has been defined by a collection of colour/luminance- and geometric-based principles, with research focussing more upon the former. Here we explore how the colour and spatial frequency of these patches impacts the effectiveness of disruptive camouflage. We manipulated the visual components (colour, spatial frequency, luminance, and edge-enhancement) of a target and presented it to participants on multiple backgrounds, which varied in their scale and content (i.e., a leafy background and a grass background). Twelve participants had to find the hidden target, which was one of 480 target/background combinations, across five repetitions as part of a computer-detection experiment and report which quadrant of the screen it was located within. Response times indicated that when patch colours were dissimilar to the background this reduced camouflage effectiveness. The data also indicate a relationship between the spatial frequency of the target and background, indicating that the spatial frequency of the target patterning should match the background i.e., lower spatial frequency patches for a leafy environment and higher spatial frequency patches for a grass background. These results suggest that camouflage effectiveness is modulated by matching general visual properties with the background, and support the need to further examine the geometric-based principles of disruptive colouration. [This research was supported by an Abertay University R-LINCS studentship.]

The role of intentionality in the reflexive attentional shift phenomenon

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Attention allows individuals to allocate cognitive resources on a specific location. A Reflexive Attentional Shift is generated by cues in the environment, such as a person. This phenomenon can be measured experimentally employing the Dot Perspective Paradigm (DPP) consisting of a virtual room with targets into the side walls. The Other is represented by an avatar placed in the centre of the room. Participants have to judge as quick as possible how many targets they see. Typically, this task shows an interference pattern: slower RTs and more errors when the avatar is facing away from the targets. Pesimena & Soranzo (submitted) found that avatars with contrasting directional features don't generate interference in RTs. A residual interference however is registered in the error rate. To investigate why an Other with contrasting directional features generates a residual interference in the error rates, we consider the role of intention attribution to the Other; that is, the Other intentionality to indicate a direction. We used as avatar a human figure looking opposite to where the arm/finger are pointing, making its intentionality ambiguous. Results show that when the intention is ambiguous, also the residual interference disappears. We conclude that the attribution of intention to the Other plays a role in the reflexive attentional shift.

Spatial bias in a spatial-ordinal task: Children show a left bias in identifying target positions

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Humans organize numbers from left to right on a mental number line. Recently newborns and animals showed a representation of number oriented from left-to-right, supporting an intrinsic association between numbers and space. Nevertheless, its adaptive value is still largely unknown. Here we tested for any advantage in the identification of left versus right target positions in 167 3- to 6-year-old children. Children watched as a toy was hidden under one of 10 horizontally arranged identical cups and then asked to help a stuffed animal retrieve the toy. On each trial, the toy was hidden in the 2nd, 3rd, or 4th cup, from the left or right. Then, they were asked to pick up the stuffed animal from under their chair- an activity that prevents the child from staring at the cup- and then to indicate where the toy was. We found a strong effect of age with older children perform better than younger children, and an effect of magnitude, with performance higher for the second than the fourth targets. Remarkably, younger children also showed a left bias: they remembered the left targets better than the right targets. Overall, our results support the hypothesis that a left-to-right oriented scanning enhances

performance in a spatial/ordinal task. [Founding: European Union's Horizon 2020 research and innovation program under the Marie Sklodowska-Curie (grant agreement No. 795242 SNANeB) and PRIN 2017 ERC-SH4–A (2017PSRHPZ) to RR.]

Testing human's ability to search for materials in a visual scene using canonical material modes

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A recent study by Wolfe and Myers (2010) reported that materials don't efficiently guide visual search using the Flickr Material Database (FMD). However, FMD was developed to capture a range of real-world materials, in which the surface appearance per material class may vary largely. Here we present results from a standard visual search experiment using the images of canonical material modes (namely "matte", "velvety", and "specular") as stimuli. The images of canonical material modes provide key image features that trigger corresponding material perception. To ensure that participants only use these material-related perceptual features instead of sole perceptual features, the lighting direction was randomly varied throughout the experiment. Additionally, the 3D-shape of the materials was either a sphere or a blob. In three experiments, we compare each two of the three materials i.e., participants searched for one target material among another distractor materials vice versa, and there were four set sizes, 4, 9, 16, and 25. We found efficient searches for velvety and specular materials. The search slopes of velvety target were 3ms/item in target-present trials and 6ms/item in target-absent trials, respectively. The search slopes of specular target were below 3ms/item for both conditions. The error rates were below 10% except searching matte in target-absent trials. Hence, velvety and specular clearly constitutes a basic feature in the sense of Treisman's FIT. Our study presents a first evidence that material perception may extract basic features i.e., contradicting Wolfe and Myers' (2010) study. To strengthen our claim further studies will test more materials. [The authors are funded by a ESRC-UK (Ref: ES/T002409/1).]

Action video-games improves reading and global perception in children with dyslexia: An electroencephalographic study

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Developmental dyslexia (DD) is associated with an altered functionality of right-lateralized magnocellular-dorsal (MD) pathway, which would impact the processing of low spatial/high temporal frequencies stimuli such as global configurations and motion. Action video-games (AVG) training have been shown to improve reading skills in children with DD. However, it is not clear if AVG training can effectively translate into better MD functionality at the neurophysiological level. In a sample of children with DD we used electroencephalography (EEG) to study at the neural level the effects of AVG training, as compared to a non-AVG training. EEG signal was recorded before (T1) and after (T2) the training sessions, both at rest and during a coherent dot motion (CDM) task. At T1 and T2 we also measured reading skills and the efficiency of global perception in a Navon Task. We found that after AVG training children with DD exhibited: (i) at rest, a reduced amplitude of upper alpha oscillations (10-12 Hz) in parieto-occipital electrodes and an increase functional connectivity between frontal and posterior electrodes in the same frequencies; (ii) a reduction in the latency of the right-lateralized ERP N2 component, and an increase in the mean amplitude of the parietal P2 elicited by CDM stimuli. Alpha amplitude decrements were associated with an increase in phonological decoding speed and with a more efficient global perception in the Navon task. Similarly, N2 latency changes were associated with improved global perception. These psychophysiological findings support an effect of AVG on MD pathway in DD.

A simple perceptual model of surface colours: Assessments with hyperspectral images

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Unlike the colour of light (e.g., of a lamp or a computer screen), specifying surface colours (e.g., colours of objects and materials) is an important challenge, because the cone excitations at the origin of colour perception results from the interaction between the reflectance spectra of the surfaces and the lights illuminating them. Previous studies suggested a linear transformation that approximates surface colours independent of the illumination using just a few numbers rather than full spectral information. It is unclear whether the small numerical differences between approximated and full spectral renderings are negligible given the resolution of human colour perception. In this study, we tested whether observers are able to see the difference

between approximated and full spectral renderings. For this, we rendered hyperspectral images of a large range of different objects and scenes under broadband naturalistic and narrowband artificial illuminants with colours along and away from the daylight locus. Participants had to discriminate the approximated from the full spectral renderings in a 4-Alternative-Forced-Choice discrimination task. For several narrow-band illuminants, participants could see the difference between approximate and full spectral rendering, indicating a failure of our approximation under those narrow-band, artificial illuminations. However, responses were at chance level for objects and scenes under all broadband illuminants. This result shows that that our approximation is indistinguishable from full spectral renderings under broadband illuminations. Hence, this simple approximation can be used to characterize surface colours, allowing for efficient communication, hyperspectral compression, and fast computation of surface colours under naturalistic lighting conditions. [Mayflower scholarship of the University of Southampton.]

Training for object recognition with increasing spatial frequency: A comparison of deep learning with human vision

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The ontogenetic development of human vision, and the real-time neural processing of visual input, both exhibit a striking similarity – a sensitivity towards spatial frequencies that progress in a coarse-to-fine manner. During early human development, sensitivity for higher spatial frequencies increases with age. In adulthood, when humans receive new visual input, low spatial frequencies are typically processed first before subsequently guiding the processing of higher spatial frequencies. We investigated to what extent this coarse-to-fine progression might impact visual representations in artificial vision and compared this to adult human representations. We simulated the coarse-to-fine progression of image processing in deep convolutional neural networks (CNNs) by gradually increasing spatial frequency information during training. We compared CNN performance, after standard and coarse-to-fine training, with a wide range of datasets from behavioural and neuroimaging experiments. In contrast to humans, CNNs that are trained using the standard protocol are very insensitive to low spatial frequency information, showing very poor performance in being able to classify such object images. By training CNNs using our coarse-to-fine method, we improved the classification accuracy of CNNs from 0% to 32% on low-pass filtered images taken from the ImageNet dataset. When comparing differently trained networks on images containing full spatial frequency information, we saw no representational differences. Overall, this integration of computational, neural, and behavioural findings shows the relevance of the exposure to and processing of input with a variation in spatial frequency content for some aspects of high-level object representations.

Cortical magnification in human V1 correlates with contrast sensitivity measurements around the visual field

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Human visual perception varies with polar angle; performance is better along the horizontal than vertical meridian, and the lower than upper vertical meridian. We recently showed that perceptual polar angle asymmetries, averaged across observers, match polar angle asymmetries in the surface area of primary visual cortex (V1). Here, we quantified the relation between polar angle asymmetries in V1 surface area and contrast sensitivity across individual observers. In 22 observers, we psychophysically measured contrast sensitivity at the four cardinal meridians and retinotopically measured their V1 map using fMRI. We first replicated group-level results: (1) substantially more V1 surface area was dedicated to the horizontal than vertical meridian, and to the lower than upper vertical meridian, and (2) contrast sensitivity was greater on the horizontal than vertical meridian, and on the lower than upper vertical meridian. Next, we quantified individual differences. Across observers, the summed V1 surface area dedicated to the meridians (±15°) was correlated with contrast sensitivity measurements averaged across the meridians ($r = 0.4$). Thus, relatively more dedicated V1 surface area was linked to greater contrast sensitivity. Critically, the horizontal-vertical asymmetry in V1 surface area was strongly correlated with the horizontal-vertical asymmetry in contrast sensitivity ($r = 0.7$). Thus, a stronger horizontal-vertical asymmetry in the distribution of V1 surface area corresponded to a stronger horizontal-vertical asymmetry in contrast sensitivity. These data suggest that contrast sensitivity and perceptual polar angle asymmetries are related to V1 cortical magnification, thereby linking individual differences in V1 cortical anatomy to differences in visual perception. [This research was funded by the US National Eye Institute R01-EY027401 to MC and JW.]

Recurrent Convolutional Neural Networks trained by psychophysics data can predict EEG response to flicker

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The psychophysics of flicker fusion phenomena have long been investigated by a number of experiments. The parameters that influence whether a flickering source of light is perceived as flickering or fused for a human subject are its intensity, spectral composition, frequency of the light pulses and the fraction of time the pulse is present in the total cycle duration (pulse to cycle fraction). Electrophysiology of flicker stimulus, on the other hand, is an area that has also long been investigated independently. The flicker stimulus evokes oscillations in human EEG that are of the same frequency as that of the stimulus for frequencies up to 90 Hz. Furthermore, the oscillations, so evoked, show resonances for frequencies 10, 20, 40 and 80 Hz. Despite these well-known findings in psychophysics as well as electrophysiology of flickering stimuli, the relation between psychophysics of flicker fusion and EEG response to flicker or any such model is little known till date. Deep Neural Networks, starting from Feedforward Convolutional Neural Networks (fCNN) to more recent predictive coding based predNets or Recurrent CNNs (rCNN) are being successfully used, recently, for modelling the human visual system. In the present work, flicker stimuli were fed as a one dimensional time-series array of intensities to an rCNN. The stimuli were classified into flickering or fused, based on psychophysics data, in the same way a human subject did. Interestingly, the output from the convolution layer of this trained rCNN is observed to be similar to the resonating human EEG response to flicker.

A Model of Trans-saccadic Integration of Foveal Features in Visual Tasks

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In attentive robot vision applications it has been shown that a series of foveal images acquired over an observation period can be modelled and recognized as objects or scenes. Computationally, this can be achieved by constructing a probabilistic or evidence-based model of a sequence of foveal features, called an 'attentional sequence'. In case of highly salient objects, selective attention mechanisms result in location and sufficient coverage of object features. In the absence of salient objects, fixations can trigger hypotheses about an object or scene as the system encounters corresponding foveal features. A similar problem exists in understanding how the brain integrates visual information from different target areas over multiple saccades in order to support a decision about a given visual task. Recent studies have shown that such integration involves both contextual features and spatial relationships, as well as bottom-up and top-down attention mechanisms. Based on our earlier work and recent literature, this study describes a model of trans-saccadic integration of detailed foveal features in animals possessing a retinal fovea. First, contextual and spatial information that can physically be associated with a fovea during fixation is established based on evidence from studies of visual and spatial representations. This leads to an abstract representation of the foveal image, which is then related to similar representations from previous fixations associated with the same task. The resulting accumulation of foveal information along with spatial relationships then lead to activations representing task-related decisions. Finally, possible computational implementations and neural correlates of the model are discussed.

A computational model of the curvature blindness illusion

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The curvature blindness illusion involves the perception of shape of sinusoidal lines consisting of alternating light gray and dark gray segments. When the positions of the luminance switches between the segments are located at extremal points (peaks and troughs) of the sinusoids, their shape is misperceived as triangular; however, when the luminance switches are at inflection points, their shape is perceived veridically. The illusory effect is salient when the background of the stimulus lines is middle gray (in which case the segments alternate both in luminance magnitude and polarity), but is strongly diminished for white and black backgrounds (in which cases the segments alternate in luminance magnitude only). Thus both geometric (extremes vs. inflections) and photometric (polarity vs. magnitude) constrains are critical for the appearance of the illusion. This phenomenon has been accounted for as due to mid-level segmentation processes or competitions between hypothetical higher-level neuron types. Here I argue for a low-level account based on computer simulations of spatial distributions of reactions to these stimuli across layers of cells known to exist in the early visual pathways, such as neurons having concentric, odd-symmetrical, and even-symmetrical receptive fields. These convolution-based simulations suggest that the patterns of reactions of these neural populations to illusion-inducing triangular-appearing sinusoidal lines are similar to reactions evoked by veridically perceived actually triangular lines. However, this similarity is clearly present only when the sinusoids are displayed on middle gray backgrounds, but is diminished when they are displayed on white or black backgrounds.

Mental Geometry of 3D size perception in scenes and pictures

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Correctly estimating sizes and poses of objects in scenes is necessary for humans to operate successfully in the world. We demonstrate that human performance in 3D size perception in real scenes and pictures of scenes can be explained by an optimal geometrical strategy, but subject to biases. 3D objects seen from different viewpoints project to different retinal sizes, and additional distortions occur when pictures of 3D objects are seen from the other than the camera view-point. We examined how observers estimate 3D sizes of objects lying on the ground in 16 different poses in real scenes and obliquely viewed pictures. For real scenes, we found systematic underestimation of length close to the line-of-sight. The optimal geometrical back-transform accounted for the complete estimation function with one additional multiplicative factor given by the observers' misestimated object slant, or equivalently the viewing elevation. We confirmed this misestimation with two slant-matching measurements and a dynamic demonstration. In obliquely viewed pictures, the length of objects at fronto-parallel poses were seriously underestimated, but there were almost no changes at poses close to the line-of-sight. Shapes of empirical correction functions resembled the optimal ones, but with lower amplitude. Measurements disclosed that observers made systematic underestimations of the picture's 3D slant. A model based on the optimal geometric back-transform, but incorporating the empirically measured misestimation of the picture slant, quantitatively explained observers' 3D size estimates. These results add to accumulating evidence that humans use geometric knowledge to interpret views and pictures of 3D scenes.

Surface Attitude Judgements in monocular and stereo textures: a method evaluation

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People can judge the attitude of surfaces in the both ecological valid 3D environments and in 2D representations with no binocular disparity. Many methods have been proposed for measuring perceived surface attitude but the reliability and bias vulnerability of such methods is seldom compared. One concern is that test methods which use the same visual modality as the surfaces under test may introduce bias. We compared 2D, 3D gauge figures which use perspective only and perspective plus disparity cues respectively, and a perspective and disparity free dial method wherein observers set the orientation of two lines to represent perceived tilt and slant. Observers judged tilt and slant for artificial sloped surfaces patterned with randomly orientated squares providing strong perspective cues. Surfaces were presented dichoptically with perspective only (2D) and perspective plus disparity (3D), and monocularly with perspective only. All response methods showed reliable and unbiased responses in tilt judgements. For slant, bias varied between conditions. The dial method produced estimates that correlated best with ground truth and produced the least bias overall, although it tended to underestimate small slants and overestimate large slants. The gauge figure methods were similar and tended to overestimate all slants but were worse for small slants. These results suggest that our textures provide completing cues to slant that resulted in bias when tested within the same visual modality. Thus the dial method introduced least bias. This method is difficult, and introduces individual differences but practice might reduce this making it preferable to gauge figure methods. [This project was funded by the Engineering and Physical Sciences Research Council; grant number EP/S016260/1.]

Stochastic resonance in a coherent motion task and the effects of external/internal noise in the elderly

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In human beings, a stochastic resonance (SR) like phenomenon can be described as the counterintuitive effect of adding a proper amount of noise to a stimulus at a sub-threshold level, which results in increasing the stimulus detectability. It still remains unclear how this mechanism changes with age, given the age-related increase in neural noise, especially in vision. We recruited participants of different ages (young vs old), and they were asked to perform a coherent motion detection task with a random-dot kinematogram. In our experiment, we kept the ratio between coherent and incoherent dots constant while manipulating the total number of dots (the quantity of random moving dots is assumed to be the way to modulate the external noise). We found that performance in the young adults' group as a function of dots numerosity shows a peak at intermediate levels of noise and a drop for low and high noise levels and can be described as an inverted U-shape function, a signature of an SR-like phenomenon. In the old adults' group (>65 years old), the performance was found to be not statistically different from the one of younger adults at intermediate levels of noise, while to drop earlier at high levels of external noise and to be higher at low levels of noise. These results indicate

a greater deleterious effect of noise in older people compared to young people and suggest that the SR-like phenomenon could arise at a lower level of external noise in older people.

Smooth Pursuit Eye Movements Alter the Contrast Sensitivity for Drifting Achromatic Gratings

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The detectability of a low-contrast luminance-modulated sinusoidal target abutting a high-contrast drifting inducer is impaired when the two gratings are out-of-phase. This suppression is stronger at the leading than at the trailing edge of the inducer motion. Besides retinal motion, how smooth pursuit eye movements, which are intrinsically linked to motion perception, interact with this motion-induced contextual effect is yet unclear. Here, we investigated the phase-dependent modulation of contrast sensitivity in both fixation and pursuit conditions using a luminance-defined low-contrast target (width and height: 1x1deg, drifting at 5deg/sec) centered 1.5deg above or below the fixation, the envelope of which was either static or moving horizontally (4.29 or 10.56deg/sec) across the screen. Two high-contrast inducers (width and height: 6.67x1deg) drifting at the same speed were presented at the right or left side of the target. Observers indicated whether the target, which was either in-phase or out-of-phase with inducer, had been presented above or below the fixation. The results showed that while eyes and the grating envelope were fixed, the phase-dependent modulation occured at both leading and trailing edges but in different magnitudes. However, during pursuit, the magnitude of the phase-modulation at the leading edge increased with the pursuit velocity when the gratings drifted in the same direction as the pursuit, a pattern which was reversed when they drifted in the opposite direction. These results indicate that the phase-modulation at the leading and trailing edge are modulated via different mechanisms and that the effect of pursuit on the phase-modulation is direction-selective. [This work was supported by the Scientific and Technological Research Council of Turkey (TUBITAK), Grant no: 218K282.]

Differential Eye Movements During the Autobiographical Recall of Places, Events, and Thoughts/Emotions

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Recent research has suggested an important role of eye movements for spatial scene construction during autobiographical recall. In the current study we asked 18 students from the University of Trieste to retrieve recent or distant autobiographical events in response to 6 cue words. Participants sat in front of a blank screen and eye movements were recorded while they described the place and event associated with each memory. Memories were classified using the Autobiographical Interview procedure in recall periods corresponding to the event, place, and thought/emotion descriptions. Comparison of fixations and saccades across these recall periods showed statistically significant differences in the following parameters. The duration of fixations during place descriptions was longer than that of event descriptions and thought/emotion descriptions. The number of fixations per second and saccadic amplitudes were lower during place descriptions in respect to the event descriptions and thought/emotion descriptions. Finally, the number of consecutive saccades in the same direction was higher during place descriptions in respect to the event descriptions and thought/emotion descriptions. This pattern of results is compatible with an exploratory behaviour produced during the recall of places characterized by sequences of short saccades in the same direction and longer fixation periods. Instead, remembering details about thoughts, emotions and events is characterized by larger and random saccades, and short fixations. These results support the hypothesis that autobiographical memory triggers specific eye movements associated with the reconstruction of visuo-spatial layout of scenes.

Eye movements reveal the role of attention in change blindness for shadows

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In a change blindness paradigm, participants are presented with two images (alternating or side-by-side) and are asked to detect a change created with digital image manipulation. A recent study has suggested that changes in cast shadows are more difficult to detect than changes in objects (Ehinger, Allen, & Wolfe, 2016). Research has also suggested that when judging faces, observers show reduced attention to cast shadows (Hermens & Zdravković, 2015). A plausible reason for change blindness for shadows is therefore that observers fail to attend the relevant areas in an image. We here test this hypothesis by measuring eye movements while observers freely view the images from Ehinger et al. (2016). To compare eye movements with change blindness in the same set-up we also asked participants to perform a change detection task where we presented images side-by-side and balanced the number of object and shadow changes. During free viewing, observers paid little attention to the relevant shadows and objects, but significantly more

often fixated the relevant shadows than objects. During the change blindness task, changes in shadows were more easily detected than changes in objects. Attention during free viewing of individual images, however, did not predict change detection performance. The results suggest that during free viewing observers do not automatically discard cast shadows, and that change blindness may not be directly related to visual attention during free viewing.

Visual information search is affected by navigational features of digital environments: the eye tracking study

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Cognitive load theory offers a computational approach to assessing the relative conditions efficiency of digital environments (DE) through efforts and performance (Paas, F., 1993). Usually efforts are measured via self-report; this subjective parameter has significant drawbacks and is not specific for visual information search (VIS). We propose an innovate method for assessing the efforts of VIS in DE through the eye movements analysis, consistent with indicators of cognitive load. In the experiment, participants (N = 20) searched for the information in the texts using different types of navigation (scrolling or paging), and ways of volume visualization (scroll-bar or thumbs). Eye movements were recorded by the eye-tracker SMI RED 120. We developed an eye tracking-based tool for diagnosing DE for searching efforts, assessed through scan-path complexity (SPC). SPC was defined as a redundant gaze-path (the real-to-perfect gaze-path ratio measured in lines of the text), and was built through the second-by-second reconstruction of the search from the screen recording. Scrolling with scroll-bar condition was indicated as the less effective for VIS according to the highest SPC values. The analysis of conventional cognitive load parameters (fixation count, fixation duration, performance) showed same results. So the efficiency of visual search decreased in DE with less optimized cognitive load conditions, which was identified through the significantly ($p<0.001$) higher values of the eye-movement parameter SPC. Thus, we proposed an objective approach to assessing efforts of VIS in DE based on the eye movement parameter SPC, which reflects the specificity of VIS. [This work was supported by grant RFBR №18-29-22049.]

Serial dependence in orientation judgments at the time of saccades

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We actively seek information from the environment through saccadic eye movements, necessitating continual integration of pre- and post-saccadic signals, displaced on the retina by each saccade. We tested whether trans-saccadic integration may be related to serial dependence, by measuring how viewing a pre-saccadic stimulus affects the perceived orientation of a subsequent test stimulus presented around the time of a saccade. Trials started with participants viewing a fixation dot, 8° left of screen center. The pre-saccadic prior stimulus (a high-contrast grating patch) was briefly presented for 17 ms. 0.8 – 1.2 s later, participants saccaded to a saccadic target that appeared 8° right of screen center. At a random delay from the saccadic target, the test stimulus, a brief 17-ms Gabor patch of six possible orientations (±35°, ±45°, ±55°), was displayed in the center of the screen. Participants reproduced the orientation of the test by moving the mouse. The reproduced orientation was attracted towards the prior stimulus, so the error was positive when the prior was +15° and negative when −15° from the test. The attraction effect was strongest when the test stimulus was around saccade onset. The reproduced orientation also regressed to the mean orientation (±45°) and was also positively biased towards the previous test stimulus orientation. These results suggest that past information affects trans-saccadic perception, most strongly when the test stimulus is presented perisaccadically. This study unites the fields of serial dependence and trans-saccadic perception, leading to potential new insights of how information is transferred and accumulated across saccades. [Funded by the European Research Council (ERC) grant No 832813-GenPercept.]

Effects of mask color and patterns on emotional recognition

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Face masks are reported to inhibit the capability to perceive a lot of social information. By covering about 60% of the face that is pertinent to emotional expression (Carbon, 2020), facemasks may interfere with the recognition of its wearer's emotional state (Marini et al., 2021). Based on previous research that reported the effect of angularity vs. curvature on emotional perception (Blazhenkova and Dogerlioglu-Demir 2020), we aimed to further explore the effects of face masks on emotional recognition. Our study examined emotional recognition in faces uncovered and covered by masks with different colors (white and black) and patterns (curved vs. angular). Participants had to recognize emotional states exposed by male and female models and choose a response from a list of emotions (angry, disgusted, fearful, surprised, happy, neutral, and sad). Both accuracy and speed of emotional recognition were recorded. In addition, we administered several self-report measures assessing attitudes towards

masks as well as individual differences in emotional processing. Overall, accuracy dropped and reaction time increased for masked faces compared to unmasked faces. In addition, we observed some differences in emotional recognition depending on the mask pattern and color.

The role of dynamic non-emotional facial expressions in face recognition

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Models of face recognition suggest that faces are recognized through two interacting functional and anatomical systems: a ventral system, primarily devoted to the elaboration of perceptual features of faces, and a dorsal system, mainly dedicated to the elaboration of changeable aspects of faces such as facial expressions. In accordance with these models, the literature suggests a facilitatory effect of non-emotional static facial expressions on face recognition in people with difficulties in face processing. In addition, the motion seems to advantage face identification with respect to the presentation of multiple static images. The present study investigated whether dynamic non-emotional facial expressions facilitate face recognition and if this effect interacts with face recognition abilities. 25 healthy young volunteers were assessed for their ability in face recognition with Cambridge Memory Face Test (CMFT). Then, participants saw 30 faces in three blocks, one for each condition: dynamic facial expression, dynamic rigid movement of the head, and neutral. After each block, participants had to recognize the target faces among distractors. Participants with low scores at CMFT, compared with good recognizers, showed a better performance in recognizing faces encoded through dynamic non-emotional facial expressions than faces encoded through rigid movement or neutral. To disentangle the role of expressions from that of motion, in a second experiment a new sample of 25 participants underwent the same assessment and the same experimental paradigm, with the difference that faces were not represented dynamically, but as a succession of static images. No differences were observed with the removal of motion.

Face Familiarity Revealed by Involuntary Eye Movements and Fixation Related Potentials in Free Viewing

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Event related potentials (ERPs) and the oculomotor inhibition (OMI) in response to transient visual stimuli are known to be sensitive to different stimulus properties, including saliency, repetition, and attention. In natural vision, transient stimulation of the visual cortex is generated primarily by saccades. Recent studies suggest that the core EEG components in free viewing induced by saccades (fixation-related potentials, FRPs) are similar to the ERP components with flashed stimuli. We have recently found that the OMI in response to flashed stimuli is similar to that induced by saccades, and is sensitive to face familiarity. Here, we asked whether fixation-related potentials (FRPs) and microsaccade inhibition (OMI) in free viewing are sensitive to face familiarity. Observers (N=15) freely watched a slideshow of seven unfamiliar and one familiar world leaders face images presented randomly for 4-sec periods, with multiple images per person. We measured the occipital fixation-related N1 relative to the P1 magnitude, as well as the associated fixation-triggered microsaccade inhibition (OMI). We found that the averaged N1 FRP was significantly smaller and the OMI shorter for the familiar face compared to any of the 7 unfamiliar faces, with the N1 effect found individually in 10 of 15 participants. These results are opposite to the prolonged OMI and enhanced ERPs found for flashed face stimuli, indicating a different process. Overall, the results demonstrate the sensitivity of the occipital N1 FRP and the OMI in free viewing to face familiarity and could be used as a novel physiological measure for studying hidden memories.

Voluntary control eliminates the fovea bias in ensemble emotion perception

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Ensemble emotion perception refers to the visual system's ability to extract summary emotional information from groups of faces. However, not all locations in the group are weighted equally. In particular, foveal input was recently shown to be more strongly weighted, revealing a strong 'fovea bias'. To investigate if the fovea bias is ubiquitous in ensemble emotion perception, we manipulated the spatial and temporal variance of the stimuli. In two experiments, participants either judged the average emotion of a face set (Experiment 1) or were asked to ignore the foveal input and judge the average emotion of the surrounding faces ('flankers', Experiment 2). The stimulus consisted of nine faces - a central face at fixation surrounded by 8 flankers. The emotion of the central face was either varied (happy and angry randomly interleaved) or kept constant (a single emotion: happy, angry, neutral, scrambled, or absent) throughout a block of trials. In separate blocks,

the emotion of the flankers was either identical in a given trial (e.g., all flankers 80% happy) or mixed (a mix of happy, neutral, and/or angry). We found a strong fovea bias with varied but not with constant foveal faces. When the flankers were mixed, the fovea bias in the varied condition was strongly reduced. In Experiment 2, performance was similar in all conditions, showing that participants could ignore the foveal face. Our results suggest that the fovea bias in ensemble emotion perception is not ubiquitous, but can be overcome by constant foveal input and voluntary control.

Paradoxical frame stabilization with reverse apparent motion

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Moving frames produce a powerful but paradoxical stabilization (Cavanagh, Anstis, & Wexler, VSS 2020). Specifically, if two probes are flashed at the same location, one before and one after the frame's motion, they are seen as widely separated. Their perceived separation matches their locations in the frame's coordinates, as if the frame were not moving. At the same time, the motion of the frame is clearly seen (albeit much reduced), creating a paradoxical perceptual stabilization. Here we examine what kind of motion supports this stabilization. We first used a field of random dots moving back and forth. This again produced a large separation of the two probes even though they were physically superimposed on the display screen. We then reversed the contrast of the background of random dots on each step producing reverse apparent motion (Anstis & Rogers, 1986). The two probes now appeared separated in the direction of the reverse motion. The effects for both directions were similar in magnitude and equal to about 40% of the background motion. We conclude that the frame motion that drives the paradoxical stabilization does not depend on the change in the frame's position – reverse apparent motion has no trackable features moving in the direction of the perceived motion. Moreover, we can use the perceived offset as a measure of how much displacement the visual system judges is present – a feature of reverse apparent motion that has been difficult to quantify theoretically or practically. [NSERC and CFREF Canada, PBS, Dartmouth College (PC), UCSD Pathway to Retirement (DIAM, SA).]

The Psychophysical Limits of the Honeybee's Polarization Compass

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For many animals, skylight polarization forms part of a solar compass system, allowing them to hold their course when the sun itself is blocked from view. Honeybees, the first species shown to use this "polarization compass", integrate information from different sky regions to obtain a robust compass reference. While the interpretation of each region appears strongly influenced by sensitivity, the combined effects of skylight polarization's signal strength and intensity have received little attention. I present data from ongoing behavioural experiments aimed at better describing how the honeybee's polarization compass trades off flexibility against generalisation. I set out to determine the psychophysical limits for the honeybee's polarization compass, utilising semi-automated decoding of "waggle dances" performed by returning foragers to quantify the interpretation of artificial sky stimuli. [DFG Temporary Position for Principal Investigator (FO 1308/3-1) to JJF.]

Expansion rate in lightness perception is affected by the physical luminance range and area of the targets

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Expansion occurs whenever a group of gray surfaces has a smaller than the "black to white" range. Under these conditions, the perceived range of the grays is larger than their physical range. This mechanism has been part of the scaling process described by Anchoring Theory (Gilchrist et al., 1999) and has been employed to account for the apparent darkening of the white background target in Simultaneous Lightness Contrast (SLC). However, the precise co-efficient of expansion is not yet known. For example, the rate of expansion may theoretically increase, decrease or stay the same when the physical range of the surfaces increases. In order to investigate this, we showed observers 6 stimuli consisting of a white background and a gray target of varying luminance, so as to produce 3 different physical ranges (20:1, 5:1, 2:1). The size of the targets was also varied (large vs small). Observers matched the lightness of the targets

using an adjustable probe presented on a different computer screen. We report two main findings: First, expansion rate increases with increased physical range. Second, large targets show less expansion than small targets, indicating that area effects are obtainable even when a surface does not have the largest perceived area in the group.

I know I'm happy, and I'm right: Metacognition of emotion

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Can we be metacognitively aware of our emotions? Individuals experience a variety of emotions every day. Yet no previous study has provided an experimentally quantitative index of the metacognition of emotion. The present study aims to resolve this issue. We utilized 20 pictures from the International Affective Picture System (IAPS) to induce positive emotions. Participants were instructed to perform a two-interval forced choice task in which they chose whether the first or the second picture presented made them produce a more positive emotion. We then computed the psychological distance of how positive these pictures were according to the law of comparative judgment (Thurstone, 1927). After viewing each picture again, participants were instructed to judge if the picture made them produce a positive emotion higher or lower than the median of all the pictures and rate their confidence in this judgment. The metacognition of emotion was quantified by the M-ratio (ratio of meta-d' to d') based on signal detection theory. The d' (whether the induced emotion was higher or lower than the median) was positively correlated with the Oxford Happiness Questionnaire and negatively correlated with the Alexithymia Scale. These correlations verify that our paradigm indeed captures emotion production and not simply picture likability. Additionally, the M-ratio was significantly greater than zero, suggesting that individuals do have the ability to be metacognitively aware of their emotion production. Together, our results provide the first experimentally quantitative index of metacognition of emotion and further advance the understanding of awareness toward subjective feelings. [This study was supported by the Ministry of Sciences and Technology in Taiwan (MOST 107-2410-H-002-129-MY3).]

The influence of an atypical spatial-numerical configuration on the SNARC effect: the role of order in spatial-numerical associations is revealed by context and task demands

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Previous literature on spatial-numerical associations highlighted the importance of ordinality in the SNARC effect. However, further research is needed to understand how ordinality can be elicited and if it can modulate the direction of this association. The present study investigated whether ordinality can alter the commonly observed SNARC effect, by presenting numbers in the context of an overlearned numerical display in which the ordinal position of numbers differs from the mental number line, namely a mobile-phone keypad. Furthermore, three tasks with different levels of consistency with the order elicited by the context were employed, to determine whether the order elicited by task demands can interact with the one elicited by the context. In Experiment 1, the task required participants to judge numbers based on their spatial position on the keypad, hence it elicited the same order as the context. Results showed a spatial association consistent with the keypad configuration, indicating a spatial association driven both by the context and by the task. In Experiment 2a, participants performed a magnitude classification task and results revealed a lack of spatial associations, suggesting a conflict between the orders elicited by the context and by the task. In Experiment 2b, participants performed a parity judgement task and results revealed a SNARC effect, suggesting that the order elicited by the context did not modulate the spatial association. Taken together, results indicate that the consistency between the orders elicited by context and task demands is a key factor to determine spatial-numerical associations.

Can people draw with sounds? A novel system to evaluate the generation and recalling of audio-tactile spatial images

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The ability to represent and remember objects and their spatial relationships is crucial to interacting with the external environment. Blind individuals can generate and process spatial representations through acoustic and tactile

information, but some spatial processing is challenging for them. To date, there is a lack of proper systems to evaluate spatial skills in visually deprived people. Therefore, to study the generation and recall of multi-sensory spatial representations, we developed an audio-tactile tablet. This device consists of a set of spatialized speakers covered by tactile sensors to register touch positions. The subjects had to remember the locations of acoustic and tactile targets distributed on the tablet's surface. In the acoustic condition, the participant touched the cells and heard the sounds played, white noise and a dog's barking for the non-target and target cells, respectively. In the tactile condition, they received a continuous or discontinuous haptic stimulation on the hands. In the multi-sensory condition, they listened to the sound and received the haptic stimulation synchronously. To evaluate the ability to generate acoustic spatial representations, we designed a paradigm inspired by drawing. The participants listened to a set of sounds and placed each of them on a specific position of the tablet to create the actual acoustic image. This device has been tested on sighted and blind subjects who have managed to interact with it easily. We believe this audio-tactile tablet might help blind people develop and train those spatial skills needed to interact with the environment and to represent spatial layouts.

A Perceptual Reinterpretation of Non-Rigid Part-Length Change in Structure-From-Motion

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Research on structure-from-motion (SFM) typically studies rigidly moving 3D objects. In our exploration of non-rigid transformations, we've found that non-rigid length change is often misperceived. Here we used a two-part 3D object: an ellipsoid plus a narrower, protruding part perpendicular to it. As the whole object rotated back-and-forth about its vertical axis, the part changed in length. We observed that this dynamic length change was misperceived as a rigid part with an illusory horizontal slant relative to the body. In an experiment, observers viewed displays with different directions and amounts of part-length change. Using an adjustment task, they indicated the perceived horizontal slant of the part. We created a simple geometric model based on the assumption that length change is reinterpreted as a fixed horizontal slant with no length change. Under these assumptions the model makes predictions of perceived horizontal angle that would correspond to a particular magnitude and direction of length change. Even without any free parameters this model did surprisingly well at predicting observer responses. We also extended this to a Bayesian model that relaxed the assumption that observers accurately perceive the start and end orientation of the whole object. Our results show that, when possible, the visual system reinterprets non-rigid part-length change in other ways. In this study, it was as an illusory slant of the attached part. In a previous study it was as a dynamic orientation change of the attached part. The visual system appears to have clear preferences for some shape transformations over others.

Visual alterations following COVID-19

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COVID-19 is a highly contagious respiratory disease caused by a virus with high neuroinvasive potential. Both structural and functional alterations in the eye have been identified in post-covid patients. However, there are still gaps regarding the implications on sensory processing. Our purpose was to investigate sensory and perceptual alterations on sensory processing due to the course of the disease. The Covid-19 Subjective Sensory and Perceptual Anomalies Scale (CSSPA-19) was validated and used. The sample consisted of 240 participants (mean age 20-39 years), being 25.4% male and 74.6% female participants. Overall, 27.9% of the participants had some comorbidity, such as respiratory diseases, obesity, and high blood pressure. Approximately 37.1% of participants had experienced symptoms of COVID-19 less than one month before completing the scale. The results showed that 16.7% (n = 40) of the sample had some type of visual alteration. They were mostly related to visuospatial processing (related to impairments on brightness and chromatic discrimination). In addition, about 27 participants reported a prolonged impairment for about 4 days. Thus, our study demonstrates that, even on a small scale, COVID-19 can cause visuospatial impairments. Mapping these alterations, on a large scale, can help as a potential tool for the prognosis of the disease.

The cut-and-paste effect in rapid visual categorization

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Previous studies have shown that animal stimuli are afforded privileged processing in the human visual system, with reaction times to animal stimuli being faster than to other objects. However, pasting an object on a background can impair the reaction time in categorization tasks. This

study explores whether pasting an object on a natural scene background will affect the response time to animal stimuli differently than other object types. In the experiment, two types of target objects (animals vs. vehicles), on their original background and pasted on a different background, were presented briefly (16.7ms), in a rapid visual categorization task. For all images, reproducing previous studies, reaction times to the original images was significantly faster than to the pasted images (524vs. 540ms). For the original images, the reaction time to animals was significantly faster than vehicles (520vs. 528ms). However, for the pasted images, the reaction time to animals was slower than to vehicles (547vs. 535ms). We calculated the most salient zone of every image. For those animal images where the most salient zone was found on the animal, the reaction time after pasting was significantly slower than for the original (539vs. 522ms). For vehicle images where the most salient zone was found on the vehicle, the reaction time after pasting was also slower than original (537vs. 528ms), but not significantly so. These results may be caused by the pasting manipulation, involving the edges of the pasted objects and their transition into the background. [This work was supported by the National Natural Science Foundation of China (61263042, 61563056).]

ePsychology.online - a free open access architecture for online experimental psychology

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Online behavioral research boom has been even further boosted by the Covid-19 pandemic - due to limitations in access to work places and thus labs as well. A number of platforms (e.g. Gorilla, Lab.js, PsychoJS,jsPsych) allowed the reproduction of literature findings in a remote, unsupervised setup. In this work, we introduce ePsychology.online, a free accessible open-source framework for the development of online experimental studies which combines p5.js, a library for making coding accessible to everyone (while providing high-end visual and audio capabilities) with a gaze tracking library (Webgazer). We tested this approach in two proof-of-concept studies aiming at replicating findings: a random dot kinetogram (RDK) discrimination task and in a visual-probe task to measure attentional bias (AB) with respect to alcohol-related stimuli. Results from the RDK show a relation between coherence of the stimuli and reaction time in line with those found from previous, lab-based supervised studies. The AB task allows a quantitative measurement of AB, potentially leading towards an easy to access assessment of need or outcome for rehabilitation of alcohol related disorders. Since AI modules are already integrated within p5.js, the proposed architecture can be easily expanded by state-of-the-art platforms (i.e. TensorFlow). ePsychology.online will support the implementation of more studies by other contributors by facilitating behavioral researchers to develop their own original experiments with a simple and accessible programming framework.

JURICS Stimulus base - Joint Universal Real-world Images with the Continuous States

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In order to study perception and cognition in well-controlled settings, researchers often use simple objects as stimuli, such as colored circles or lines with different orientations. However, the visual processing of real-world objects may significantly differ from "simple" objects (Asp et al., 2021; Brady & Störmer, 2020). One of the complex features of real-world objects corresponding to realistic transformations of the object appearance without changing the object itself is the object's state. Researchers have previously suggested several stimulus sets with real-world objects from various basic categories, with each category represented by two distinct exemplars and in two different states (e.g., open-close, empty-full - Balaban et al., 2020; Brady, et al., 2013; Markov et al., 2021). These sets were used to study how complex features (exemplars and states) could be stored in visual memory. However, these stimulus sets were not standardized and could be used only in 2AFC tasks. We created a new stimulus set with real-world objects, where each category is represented by two exemplars with continuously changing states (20 steps per exemplar), allowing to conduct experiments with the continuous report paradigm. In accordance with previous validation studies (Snodgrass & Vanderwart, 1980), we will obtain the following norms for each object: the name of the object, the name of the changing state, the familiarity of the object, the familiarity of the changing state, and the complexity of the image. The stimulus set and norms will be available on the website: https://www.ymarkov.com/stimulibase [The study was supported by RFBR (№20-313-90064).]

Cortical neuronal connections implicated in mirror symmetry perception

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It is known from psychophysical studies that mirror symmetry is the most efficiently detected than other regularities

of visual patterns. However, the neural networks that can ensure this phenomenon have not yet been clarified. The homo- and heterotopic interhemispheric neuronal connections may participate in providing responses to mirror symmetry of images or their fragments located in different visual half-fields. Knowing a lack of mirror symmetry in interhemispheric direct (not mediated by interneurons) connections in visual areas of the first level of cortical hierarchy (areas 17, 18 in the cat), we have investigated the microstructure of outputs from these areas to areas of the next cortical levels. Neuronal marker injections into single cortical columns of areas 19, 21a and reconstruction of labelled cells on the cortical unfolded tissue of both hemispheres were done. Injected columns receive intrahemispheric inputs from two separate regions in areas 17, 18 (the transition zone (TZ) 17/18 and relatively large area outside the TZ) as well as from the TZ of opposite hemisphere. The patterns of afferent cells distribution along the projection of visual field horizontal meridian were similarly changed in TZs of different hemispheres. They depended on the azimuth of the injected column, proving the division of TZ into two retinotopically ordered subzones related to areas 17 and 18. Thus the mirror symmetry in neuronal connections was observed in direct inputs to areas 19, 21a from the TZs 17/18, where different visual half-fields are partially represented.

Binocular rivalry rate and EEG correlates

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Binocular rivalry begins when discrepant images are shown to the eyes. Under these conditions there is alternation of perceptual dominance between left and right eye. Perception of images will depend on how the brain selects one of the competitive images. The standard hand lens stereoscope, fixed on the head was employed for stimuli demonstration. Orthogonal square gratings (vertical and horizontal) were used as stimuli (width of stripes – 2 mm) which presented to the healthy subjects (N=20, from 18 to 28 years old) during 1 min. Dominance of the right image corresponded to pressing the button on the computer keyboard with the right hand; dominance of the left image corresponded to pressing the button with the left hand. EEG data were recorded with 16 electrodes (Fp1, Fp2, F3, F4, F7, F8, C3, C4, P3, P4, T3, T4, T5, T6, O1, O2) and evaluated the level of spatial synchronization (cross–correlative and coherent relations) of bioelectric activity of the brain. Two groups were extracted with the differences in the binocular rivalry rate. The group with high rate of alternations (0,6±0,06 Hz) are characterized by low level of spatial synchronization and interhemispheric integration of EEG. Participants with low rate of binocular rivalry (0,13±0,03 Hz) had increased level of spatial synchronization and significant strengthening of coherent in the frontal and central areas. We suppose that individual differences of conscious perception (time of decision-making in dual situations during competition of images) is associated with spatial synchronization of bioelectric activity of the brain.

An Expanded View of Prägnanz: Incorporating Additional Dynamics

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Gestalt principles of perceptual organization are considered to reflect dynamic aspects of mental representation and have been attributed to the principle of Prägnanz (a bias toward simplicity in interpretation of a stimulus). Two other phenomena in spatial representation suggested to reflect dynamic aspects of mental representation are representational momentum (memory for the final location of a moving target is shifted in the direction of anticipated motion) and boundary extension (stimuli likely present just beyond the boundaries of a previously viewed scene are remembered within that viewed scene). Several characteristics of Gestalt principles of perceptual organization also characterize representational momentum and boundary extension, and these include displacement in judged location, reflection of environmental regularities, consistency with isomorphism, decreases in amount of information processed, influence of surrounding context, interpretation as laboratory-based illusion or as successful adaptation, reflection of general rather than domain-specific principles, and automatic application even in observers instructed about the phenomenon and asked to guard against it. Although traditional Gestalt principles of perceptual organization address how stimuli are grouped or parsed, perceptual organization is not limited to grouping or parsing. Consideration of the similarities of characteristics of representational momentum and boundary extension and characteristics of traditional Gestalt principles of perceptual organization is consistent with suggestions that representational momentum and boundary extension could be considered Gestalt principles and that the principle of Prägnanz could be expanded to incorporate a bias to interpret a stimulus or scene as consistent with the subjective experience of physical dynamics attributed to that stimulus or scene.

Characterizing and Dissecting Human Perception of Scene Complexity

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It is evident from prior research that humans are capable of evaluating the complexity of images. However, this aspect of perception has not been explored in depth for natural scene images; the everyday complexity in which we are immersed. To address this, we introduce new scene datasets for the purposes of scene complexity analysis. We obtain complexity scores, and two-dimensional complexity maps from human observers, across an upright and inverted case. Inverting scene images is associated with destruction of scene characteristics, and allows analysis of the impact of semantics on scene complexity. A two dimensional analysis reveals that humans are capable of localising the complex and simple regions of scenes, and that scene inversion damages this localisation process. We then analyse perceptual complexity by evaluating a set of calculable and observable perceptual features based upon grounded psychological research (clutter, symmetry, entropy and openness). We consider these factors' relationship to complexity via hierarchical regressions analyses, finding that clutter and symmetry encode scene complexity. Further, by employing deep neural networks (DNNs), we use learned features to capture semantics, and through a combination of our explainable measures and DNNs we explain all human variance in our complexity dataset. Finally, we develop a deep neural model for 2D complexity prediction, which can both predict complexity scores, and generate complexity maps that indicate the complex and simple regions in an arbitrary scene image. We then dissect our prediction network to determine which semantic properties are encoded automatically by "black-box" deep neural features when predicting complexity. [Funded by EPSRC Research Grant.]

Sensation and imagery combine to form hybrid object representations

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A central question in perception research is how different visual processes interact, and perhaps nowhere has this question been more salient (and controversial) than in the context of sensation and mental imagery. Whereas previous work has explored whether sensation and imagery share various properties (from metric structure to brain activation patterns), we focus on interaction: can imagery and sensation combine to form *hybrid visual representations*? Here we demonstrate such interactions via 'object superiority effects', which generally occur with fully visible stimuli: when line segments are grouped into a closed shape, observers are better at discriminating properties (such as the orientation of one of the lines) of that shape. Would such effects arise when part of the shape is perceived, and another part only imagined? Observers saw four faint line segments in the shape of a square, with the corners punctuated by dots. On each trial, observers imagined one (two-segment) corner of the square by attending to the relevant sides and effectively 'connecting the dots'. A diagonal target line then briefly appeared inside the square (masked by a random jumble of lines), with its orientation either forming an object with the imagined contours (i.e. a triangle), or not — and observers reported the diagonal line's orientation. Across 8 experiments (with various shapes), performance was better for hybrid closed shapes. Such hybrid representations demonstrate how imagery and sensation can interact, perhaps even underlying everyday abilities as when we imagine how a new piece of furniture would fit in a room. [This project was funded by ONR MURI #N00014-16-1-2007 awarded to BJS.]

About common factors in vision

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Often, we intuitively assume that there are common factors in life. For example, we test people with a visual acuity test to determine whether they are allowed to drive a car or not-with the implicit assumption that the acuity test is representative of vision. Likewise, we make considerable efforts to exactly understand certain visual paradigms because we assume that they measure core functions of the human visual system. Contrary to many fields of psychology, researchers have paid very little attention to common factors in vision. In a series of studies, we tested batteries of standard visual paradigms in a variety of populations including the "normal" healthy population, video gamers, the older population, and schizophrenia patients. Even though test-retest reliability was generally good, all our studies indicate that most visual tests only weakly correlate with each other. Factor analysis supported this conclusion. Hence, we need to rethink to what extent common visual paradigms test what we implicitly assume they do. [Swiss National Science Foundation, NCCR Synapsy, Velux Foundation.]

Linking early to mid-level processes through EEG multivariate pattern analysis

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Spatial interactions between elements occur throughout the visual hierarchy. Different forms of 'visual fields' (e.g., perceptive, integrative, association fields) have been proposed to account for such interactions at each level. However, the link between these fields remain unknown. In this study, we used a common stimulus to determine the relationship between perceptive, integrative and association fields. We assessed participants' responses to masking, crowding and grouping tasks while recording their scalp electroencephalographic (EEG) activity and applied multivariate pattern analysis (MVPA) to these EEG signals. We found that MVPA classifiers can predict the trial-by-trial task type with reasonably high accuracy as early as ~100 ms, indicating that differences arise early-on in the visual processing hierarchy. This decoding performance was barely affected by inter-element spacing. Further, decoding performance was correlated with behavioural performance for all three tasks. However, the accuracy for predicting the masking task was lower than that for the other two tasks. Additionally, the two mid-level tasks, crowding and grouping, were slightly more confusable with each other than with masking. Traditional univariate analyses could not discern the same pattern. Event related potentials varied by spacing, but not much by task. In summary, the three types of fields are processed sufficiently differently to be distinguishable by MVPA, but mid-level processes such as grouping and crowding have more in common than low-level mechanisms such as masking.

Multiple Softness Dimensions from Material Names

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When observers judge softness of materials, visual and haptic stimuli reveal similar perceptual dimensions in everyday objects. Here we used written names, photographs and videos of 40 materials in a rating task to separate the roles of prior knowledge, optical, and dynamical cues for materials. In a semantic differentiation method, 45 participants rated the materials according to 29 softness related adjectives (e.g. "How malleable do you think the material is?"). In line with the literature, we found four softness dimensions: Fluidity, Granularity, Deformability, and Surface Softness (and Roughness) for each stimulus condition (separate PCAs). Highest consistency within subjects was for material videos (Mean Cronbach's alpha, α = .82), lowest for names (α = .74). Overall, ratings were higher for photographs, but the difference between words and videos were not significant. Separate analyses for highest loading adjectives and materials in each softness dimension demonstrated a clear pattern only in the fluidity dimension: Ratings for 7 materials (e.g. honey, shampoo) on 4 adjectives (e.g. gelatinous, sticky, slimy, gooey but not slippery) were higher for videos, compared to photographs and words. This pattern was the opposite for soft surface, deformable, and granular materials, with either names or photographs having higher ratings than videos. Our results show that four softness dimensions manifest themselves for different stimuli, even when only material names are present, but with better inter-subject agreement when we present videos. We observe an advantage of dynamic material cues over optic cues or prior information only when judging viscous materials. [UNESCO-L'Oréal For Women In Science Fellowship Awarded to DND (2020).]

Wednesday August 25th

Poster Session 5

Human Perception of Navigational Affordances in Real-world Scenes

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In daily life, we move with ease through our immediate environment: We can choose different paths through the same environment, and use a variety of navigational actions, such as walking, swimming or climbing. How do we represent navigational affordances of our immediate environment and which visual features drive these representations? Recent work, focusing on walking through indoor scenes, suggests that scene layout is an important determinant. Here, we investigated which scene properties predict a larger range of navigational affordances in both indoor and outdoor environments. To address this, we curated a diverse set of 231 naturalistic real-world stimuli and collected human annotations of readily identifiable qualitative scene properties (e.g., possible navigational actions, scene layout, material properties, contained objects, scene category and possible paths) in an online experiment (N=152). Using representational similarity analysis, we find that previously used properties are highly intercorrelated and only account for a small part of the navigational affordance representations (R2 <.21). Similarly, while CNNs trained for scene recognition are reasonably good at predicting human perception of objects (R2 =.41) and scene categories (R2 =.34), they perform rather poorly at predicting the navigational affordances of scenes (R2 =.21). While a visual inspection of the paths that participants drew, confirms that layout is a driving factor for consistent path annotations through the environment, this dimension alone does not seem to capture the affordances of different actions. Consequently, future models need to incorporate multiple relevant features that humans use to perceive the navigational affordances of natural scenes.

[VENI grant from the Netherlands Organisation for Scientific Research.]

Motion signals rather than surface interpretations drive the hand to follow the surrounding

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Hand movements are pulled in the direction of sudden motion near their anticipated endpoint. Is this an automatic response to motion near the goal, or does it consider what surface might be moving? We asked participants to hit a target that moved rightward across a screen when it was within a static ring. The ring was initially either at the centre of a solid blue square that occluded the static background of randomly distributed dots or at the centre of a blue square frame that did not occlude the background. There were three square sizes. The squares shifted leftward or rightward, 300 ms after the target appeared. If participants consider the scene in terms of surfaces, the response of the hand to such shifts would be larger when the solid square moves, because the surface near the goal is always part of the moving surface. If not, the response to the moving frame should be just as strong, and a larger frame should give a smaller response because the motion is further from the goal. The response of the hand (i.e., the difference in lateral hand velocity after leftward and rightward shifts), was similar for the two kinds of squares and was clearly smallest for the largest squares. Thus, the response is driven by any motion near the endpoint of one's action and does not involve a sophisticated interpretation of the scene in terms of surfaces. [This work was supported by the Netherlands Organisation for Scientific Research (NWO) under project number 464.18.111 awarded to Eli Brenner.]

Investigations of Prediction: Opposite neural consequences of different types of predictions

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We are interested in the neural and perceptual consequences of visual predictions. In a first line of research, we examined neural processing while viewing naturalistic scenes, that either support high-levels of predictive performance (upright basketball movies) or diminished levels of predictive performance (inverted basketball movies). We find that the former condition promotes a greater intensity of alpha-band activity in occipital brain regions, which may be a neural marker of inhibited information processing in conditions where the brain is better able to predict what information will be relevant in the next moment. In a second line of research, we constructed a paradigm that isolates the influence of expectations generated via repetition and probability, and which allows us to compare these two effects to expectations that are explicitly declared (e.g., "I think I will see X"). We find that the oft reported exaggerated P300 response following repetition violations (visual changes) is instead reduced for violations of declared predictions (incorrect guesses). This is consistent with contemporary psychophysical work, showing that the temporal oddball effect – the apparent extension in time of repetition breaking 'oddballs' – is reversed for declared predictions, with incorrectly guessed events seeming relatively contracted in time. This finding dispels the notion of a uniform mapping between prediction outcomes and neural consequences. [ARC Grant - GA68476.]

Gravity influences what is considered intuitive when using a computer mouse

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Most people find it quite intuitive that a cursor will move upwards on their screen if they push their computer mouse away across the surface of their desk. We wondered whether the direction of the cursor's motion with respect to the computer screen is critical, or whether the cursor had to move upwards with respect to the body or gravity. We therefore asked 30 participants to perform a simple task that involved guiding a cursor with a mouse. They each did so under eight conditions that only differed in the orientation of the screen and participant. We removed the data of 3 participants who reported that performing the task when their body was not upright was uncomfortable. Both the rotations influenced the performance of the remaining 27 participants, but the performance of rotated participants was indistinguishable from that of upright participants if the screen was rotated to a lesser extent in the same direction. This suggests that both the orientation of the screen with respect to the body and that with respect to gravity are relevant, while the orientation of the body itself is not. This is consistent with the idea that the coordinate transformation between the mouse and the cursor is effective because things that move away across a surface generally move upward in the field of view. Considering published estimates of the ocular counter-roll induced by head tilt it is possible that it is actually the retinal direction that is critical.

Prolonged exposure to feedback delay in Virtual Reality: subjective ownership and agency ratings rely on general task performance rather than genuine temporal adaptation

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Visual feedback delays between body movements and their visual consequences are known to be detrimental for subjective feelings of ownership, agency and presence in Virtual Reality (VR). However, it has been shown that prolonged exposure to such delays can help overcome these negative effects. Here we investigated whether this improvement in the subjective measures is linked specifically to temporal adaptation of movement timing or a more general improvement in task performance. Participants performed a target-tracking task in VR, whilst a 200ms visual feedback delay was added to their hand movements. For each trial, participants provided subjective ratings for ownership, agency and presence. We compared two conditions: 1) target movement was unpredictable in which case temporal adaptation is impossible, though spatial errors may decrease; 2) target movements were predictable by showing the target trajectory ahead of time, which should lead to genuine temporal adaptation. Baseline trials at the start of each session furthermore allowed for a test-retest analysis of the subjective ratings. The test-retest analysis showed a good overall correspondence between sessions for ownership and agency. Presence ratings were lower in the second session but were consistent when analysing differences between no-delay and delay baseline trials. During delay-adaptation the spatial tracking error decreased with delay-exposure time in both conditions, whereas a decrease in tracking lag was only observed for the predictable target. Interestingly, the subjective ratings improved in both conditions. This demonstrates that the subjective ratings are linked more to general performance levels, rather than being specifically linked to temporal adaptation.

The effect of flankers contrast adaptation on collinear facilitation

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In vision science, a well-known contextual modulation phenomenon is collinear facilitation, an increase in contrast sensitivity for a central target (i.e., a Gabor patch) when presented embedded between two collinear flankers. It has been proposed that the neural bases of this effect are the horizontal connections in the primary visual area (V1), connecting hypercolumns with similar orientation and spatial frequency selectivity. Another typical phenomenon observed in early visual areas is contrast adaptation, in which the response of early visual neurons to a stimulus is decreased after prolonged exposure. Here, we investigated the effect of contrast adaptation of the flankers on the magnitude of collinear facilitation. The rationale is that contrast adaptation might inhibit the response of units in the early visual cortex processing the flankers, thus reducing collinear facilitation. Results showed that when participants were adapted to the flankers, collinear thresholds were reduced. Furthermore, because adaptation to orthogonal flankers did not produce the same effect, the reduction in facilitation appears to be peculiar to the collinear configuration, and thus related to the functioning of early visual units selective for orientation. To conclude, the results show that contrast thresholds can be modulated by adapting portions of the visual field not directly involved in target processing and that adaptation of flankers can cause a shift along the dipper-shaped function characteristic of contrast discrimination with lateral masking.

Serial Dependence Compared on Responses Given With and Without Visual Feedback

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Despite the highly variable input that the human visual system receives from the external world, perception is stable and smooth. The continuity field may be one of the psychological mechanisms behind this perceptual stability by integrating the sensory evidence spatiotemporally. The continuity field can be quantified by serial dependence (SD), an attractive effect of recent stimulus history on current perceptual responses. SD is often measured by having participants match a visual response cue to a visual attribute such as orientation. The current study sought to determine the role of the response cue in the strength of the SD effect. We compared SD when responses in an orientation matching task were given in the presence and absence of visual feedback. In the visual feedback condition, responses were given manually by a lever whose orientation was mirrored via visual feedback on the screen. In the no-visual feedback condition, responses were also given by adjusting the lever, but there was no visual feedback on the screen. Results show that the strength of serial dependence is significantly smaller when the responses were given without visual feedback compared to the visual feedback condition. This suggests that the response cue acts like a recent stimulus and may contribute to reported SD effects.

Shape Familiarity Modulates Preference for Curved Object Drawings

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The shape of the objects influences our judgments daily. Preference for an object may depend on how familiar the resulting shape looks for that given object. In two studies, we explored the relationship between contour preference and shape familiarity using drawings of common-use objects. These drawings were pairs, each one with a curved, and a sharp-angled version of the same object. The pairs also differed in how they were made (computer-made or hand-made) and their shading (no shading or shading). In Study 1, 49 participants rated the drawings in a liking task. In Study 2, other 49 participants completed a two-alternative forced-choice task simulating approach/avoidance responses. Both studies also included a familiarity selection task in which participants decided which shape was the most familiar for the objects, or whether the shapes were equally familiar. Results supported the curvature effect in both studies. Participants also selected the curved shapes as the most familiar ones, then they selected both shapes as equally familiar, and last they selected the sharp-angled shapes as the least familiar ones. In both studies, preference for curvature was present when the curved shapes were selected as the most familiar, and when both shapes were selected as equally familiar. In contrast, the sharp-angled shapes selected as the most familiar did not show preference for curvature or preference for angularity. We conclude that familiarity with the shape of the objects modulates preference for curvature. We also interpret curvature as one of the fluency-enhancing variables that explain preference. [Funding: This research was supported by grant PSI2016-77327-P, awarded by the Spanish Ministerio de Ciencia, Innovación y Universidades, the Agencia Estatal de Investigación (AEI) and the European Regional Development Funds (ERDF). EGC work was supported by the predoctoral contract FPU18/00365, awarded by the Spanish Ministerio de Ciencia, Innovación y Universidades. Acknowledgements: We are grateful to Marco Bertamini and Michele Sinico for making the stimuli set available. Conflicts of interest: The authors declare that they have no competing interests.]

Tracking the neural dynamics of aesthetic perception

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Whether it's a scenic landscape, a spectacular building, or a beautiful face: many visual experiences are accompanied by aesthetic experiences. Despite recent progress in the spatial mapping of the neural correlates of aesthetic experiences, the temporal neural dynamics associated with aesthetic perception remain elusive. Here, I will present two EEG studies in which multivariate representational similarity analysis was used to temporally track neural representations of aesthetic quality. In the first study, participants rated the aesthetic quality of a set of highly controlled faces; in the second study, participants rated a set of varied natural scene photographs. Across both studies, sustained neural representations were predicted by participants' aesthetic quality ratings, starting already before 200ms of processing. In-depth analyses showed that these early representations reflect individual participants' personal aesthetic preferences and that they are only partly linked to visual image properties (as measured by deep neural network models of visual categorization). Our results reveal an early neural signature of aesthetic quality that is apparent for different stimulus categories, and which may underlie the rapid aesthetic evaluation of visual contents in the wild. [The author is supported by the German Research Foundation (DFG), grant KA4683/2-1. No conflict of interest is declared.]

Effects of dynamic factors of moving images and observer's expectation upon impression of sharpness ("Kire") in viewing body movement

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In aesthetic evaluation for body movements in dance, gymnastics, and "kata" in martial arts, sharpness of body movement ("Kire" in Japanese) is supposed to be very important factor. However, the basis of impression formation for the sharpness has not yet been understood empirically. We aimed to understand how the dynamic factor such as the speed of the body movement affect the impression formation for the sharpness of the body movement. In addition, we examined the effects of unexpected fast body movement on the sharpness impression. Participants (12 females, and 12 males) rated the expected sharpness of body movement in viewing static images (30 × 53 arc deg)of different nine persons with various degrees of Karate skill for three seconds, and then they rated the impression of sharpness in viewing 45 movies (30 × 53 arc deg) which showed "kata" performance of Karate for those persons for four seconds. We found that the rated sharpness of body movement increased with the increases of speed of the body parts, pause duration between sequential movements, and the decrease of distance of fist movement in those movies. Also, the rated sharpness of the body movement for the movies increased with the

difference of the rated sharpness between the static image and movies for each person. These results suggest that the impression of sharpness for body movement is affected not only by objective factors related to dynamics of performer's body movement, but also by subjective factors, such as observer's expectation for each performer's body movement.

The integrated effect of pre-cueing endogenous attention and statistical learning of target location

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The current study examined the integrated effect of history-driven target selection and top-down attention control on behavior and EEG markers related to general preparation (CNV) and target selection (N2pc). A visual search task was used, where participants searched for a tilted target and reported the position of a small gap within the target. Prior to the onset of the search array, an endogenous cue (valid/neutral) was presented at the center of the screen for top-down attentional guidance. Statistical learning of target location was manipulated by varying the frequency with which the target appeared across locations (high/intermediate/low). Results showed a strong cueing effect on RT, demonstrating a general facilitation of responses to validly-cued targets, and an interaction between cueing and target location frequency. Specifically, faster responses were found for targets presented in the high- vs. low-frequency location following a neutral cue. No such difference was found for validly cued targets. The EEG data revealed a cascade of processes related to the cuing of attention, and ultimate target selection, which was modulated by both cue validity and by statistical learning. Effects during target selection were particularly strongly modulated by cuing, which suggest that top-down allocation of attention via the central cue reduced the need for further attention at the target location. Additionally, statistical learning of the target location already affected preparation when a cue to that location was presented, suggesting an integration of statistical learning and attention already during top-down attentional orienting.

The Effect of Display Duration and Gender Differences on Perceptual Load vs Dilution

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The perceptual load (PL) theory (Lavie & Tsal, 1994) says that high task-related load reduces distractor processing. In contrast, the dilution account (Tsal & Benoni, 2010) says that simply adding neutral letters weakens the representation of the distractor and reduces the congruency effect, regardless of task relevance. The present study suggests that display duration and participant gender can play a role in attentional selection using a task similar to Chen et al.'s (2013) study. Cue-Size (2-6 cues) was an indicator of the PL, while Display-Size (2-6 letters) was an indicator of the dilution. Target display was presented 200 ms (Short-Duration) or until the response (LongDuration). The data of 51 participants (26 females) were analyzed. A 2(Cue-Size) x 2(Display-Size) x 2(Duration) x 2(Gender) mixed ANOVA was conducted on congruency scores (incongruent-minus-congruent). There were significant main effect of Cue-Size ($p=.000, r=.46$), and interaction effects of Duration*Gender ($p=.003$, $r=.17$), Duration*Display-Size ($p=.008$, $r=.14$), Cue-Size*Display-Size ($p=.047$, $r=.08$), and Duration*DisplaySize*Gender ($p=.040$, $r=.08$). The congruency effect was larger in 6 cues than 2 cues; that is, there was reversed load effect. Otherwise, high Display-Size decreases the congruency effect only for Long-Duration. Besides, the congruency effect was larger in Short-Duration than Long-Duration only for males. Additionally, high Display-Size reduced the congruency effect in Long-Duration while increased it in Short-Duration only for males. Consequently, display duration and gender are crucial for distractor interference. The distractor location (central/peripheral) and the parameters used (the way of determining the congruency effect) are also handled for the discussion.

Visuospatial attention in personal space in chronic upper and lower limb pain

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Changes in visuospatial attention may be relevant to understanding the mechanisms, symptoms, and treatment of chronic pain. There is mixed evidence whether people with unilateral chronic limb pain (complex regional pain syndrome) have deficits in attention to their affected limb and/or its surrounding space, with some indication that these deficits may be more prominent in personal (bodily) space. We examined whether visuospatial attention bias in

personal space is specific to the affected limb, or generalises to other parts of the affected side of the body. Using visual temporal order judgement tasks, we measured spatial attention in the region of the hands and feet in patients with upper (n=14) or lower (n=14) limb pain and pain-free controls (n=17). In separate blocks, participants judged the order of two identical light flashes presented with different temporal offsets on each of their hands, or each of their feet. Regardless of the location of pain or visual stimuli, patients showed less of a spatial bias to either side compared to controls, who prioritised the stimuli on their non-dominant (left) side, consistent with previously-reported "pseudoneglect" phenomenon. Exploring individual differences in the performance of patients, we found that more severe symptoms were associated with less pseudoneglect. Visuospatial bias was unrelated to other clinical or psychological characteristics. Our findings suggest that disruptions to visuospatial attention in personal space might not present as a bias per se, but as an attenuation of pseudoneglect that generalises to the entire affected body side.

Toward the characterization of a visual form of dyslexia: reduced visuo attentional field for symbols visual search

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Several studies have shown that some dyslexics cannot process multiple letters simultaneously. Tenants of the phonological theory of developmental dyslexia argued that this reduced visuo-attentional (V-A) span measured with letters can be a consequence of a poor reading experience in dyslexics. In this study, we moved away from the reading context and used visual search tasks. A study has shown that poor readers are slow in visual searches involving multifeatured shapes, i.e. when target and distracters are made of a combination of multiples lines (symbols) and not when they are made of a unique line or of filled objects. Dyslexic children and healthy children made visual search task with symbols or filled objects. We observed that some dyslexic children were slower for visual search involving symbols than full objects. In this study we showed that this slowness was due to a reduced V-A field in the symbol condition. They could not process simultaneously as many elements as in filled objects condition. The demonstration that some dyslexics exhibit a reduced V-A field out of a reading context is an argument for an independent V-A deficit that can lead to dyslexia. It also opens the way to early detection and remediation because visual search can be tested and trained before reading acquisition. [Funding : Fondation de France, Pulsalys.]

Reinforcement prediction in a multidimensional visual discrimination task by pigeons

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Eight pigeons performed a novel visual discrimination task involving two stages of stimulus presentation. Dimensional visual stimuli were presented and the pigeons had to indicate a choice by pecking or not pecking a touch-sensitive screen. A total of 16 visual stimuli were created from all possible combinations of four binary dimensions: brightness (dark/bright), size (large/small), line orientation (vertical/horizontal), and shape (circle/square). In the first stage, the pigeons learned an S+ and 4 S– stimuli, sharing one (brightness), two (brightness and orientation), three (brightness, orientation and size) or no dimension values with S+. Then, in the second stage, all 16 stimuli were presented. The probability of reinforcement in multidimensional stimulus discrimination underlay the categorisation. To a great degree, the decision of whether to peck or not to peck at the beginning of the stage 2 was dependent on the reinforcement dimensional expectancy learned in the stage 1. There was a strong relationship between the number of S– stimuli sharing dimension values with S+ in the stage 1 and the dimensional discrimination ratios during the first day of the stage 2. A smaller number of S– stimuli that shared a given dimension value with S+ in the stage 1 resulted in fewer mistakes being made with this dimension at the beginning of the stage 2. The shared features of a non-rewarded stimulus with a rewarded one resulted in pigeons' decision to peck based on the expectation of a reward.

How radiologists search for breast cancer using Automated Breast Ultrasound System (ABUS) – An eye tracking study

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Automated Breast Ultrasound System (ABUS) is a relatively new breast screening modality that produces 3D stacks of coronal and transverse slices through the breast. Radiologists scroll through the slices, search (mostly) for abnormal masses. ABUS yields higher hit rates than x-ray mammograms, particular for women with dense breasts.

However, it also adds significant time for each case. To better understand how experts spend their time when viewing ABUS, 15 experts were asked to read ABUS cases for 20 minutes at their own pace. Each case included three image acquisitions (three different coronal and transverse views). Readers selected among them. At the end of each case, readers rated the case's abnormality on a 100-point scale. Their eye positions and the currently visible slices were tracked. Results show that individual readers had consistent, somewhat idiosyncratic search strategies with coronal images typically used for search and transverse images used to identify what was found. Time spent on coronal and transverse images was nearly identical regardless of response types (HIT, MISS, FA, or True Negative) even though some cases could have been scored as normal using only coronal images. Using the Kundel et al. (1978) taxonomy, 71% of misses were "decision" errors (reader fixated the lesion but misclassified it as normal). This is unusually high. 29% were search errors (reader never fixated the lesion). ABUS reading might be speeded if readers could declare some cases normal after viewing only coronal images. Performance improvements may require more training on the classification of suspicious findings. [This work was funded by GE Precision Healthcare LLC and NIH grant CA207490.]

Task-irrelevant non-human agents capture attention as much as humans under different perceptual loads

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Attention is an important mechanism for solving tasks, but our environment can distract us with irrelevant information. As robots increasingly become part of our lives, one important question is whether they could distract us as much as humans do, and if so to what extent. To address this question, we conducted two experiments in which subjects were engaged in a central visual search task in two different difficulty levels: high perceptual load and low perceptual load. In experiment 1 (N=30), we used static images of a human, a human-like robot, and a mechanical robot as distractors while in experiment 2 (N=30), the same agents were presented in dynamic mode. Our results show that participants were significantly less accurate and had higher reaction times when the perceptual load was high than it was low. Importantly, we found that the robot stimuli were equally distracting as the human stimuli, shown by the lack of difference in accuracy rates, and reaction times for the three agents in both experiments. These results differed from our previous work (Urgen et. al, 2020) in which the same task was used with the exception that participants were informed about the identity of distractor agents prior to the experiment. That study revealed a significant interaction between the task difficulty and human-likeness of agents. Overall, our results suggest that non-human agents could distract us as much as humans as long as they are sufficiently human-like, and prior knowledge and task difficulty could modulate this effect.

Augmenting reality for visual field loss: integrating overlayed information to increase the field of view, a pilot study

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Visual field loss (VFL), such as hemianopia, is a debilitating yet common impairment following brain injury or stroke that seriously impacts daily activities. The advancement of augmented and virtual realities brings opportunities for potential sight aids for VFL. The demands of individuals with VFL differ from those individuals who have impaired acuity. Building on the functionality of optical prisms, we outline our proposed approach to make use of augmented reality as a substitutive intervention. In a proof-of-concept experiment, 30 observers were assigned to either left or right simulated scotoma conditions. All observers completed three conditions (baseline, scotoma, manipulation), where the baseline condition was always the first condition. The scotoma condition (baseline with the addition of a simulated scotoma) and the manipulated condition (baseline with the addition of a simulated scotoma, and a "minified window" providing information from the lost visual field) were randomised in order of presentation. We showed that we were able to replicate the impact of visual field loss on a line bisection task using a simulated scotoma. Our results show that observers with a simulated scotoma were successfully able to use our augmentation to make use of visual information falling into the blind field, to improve their performance on a line bisection task. We demonstrated in principle that this augmentation is helpful and may be a beneficial substitutive intervention in visual field loss.

Worst does not mean useless: The dynamics and rehabilitation of eye movements in macular degeneration

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Macular degeneration (MD) causes a central visual loss with an eccentric fixation and a radical change in the characteristics of eye movements. In this study, a mobile eye tracker was used to record fixation stability and saccadic eye movements with the head on a chin rest. By comparing the performance of a group of 11 subjects without any visual problem and a group of 20 subjects with MD to a task where they were asked to track the appearance of a circle of 1.5 ° of visual angle, repeated both in conditions binocular and in monocular conditions in which the best eye was used (or the dominant eye for healthy subjects), we observed that the ocular dynamics of people with MD present a heterogeneous picture in which some present only one eccentric locus of fixation, others have two or three relatively stable loci. The monocular data are compatible with those detected at microperimetry and are repeatable as shown in the retest. In all pathological cases, saccades were longer and slower and the fixation stability was lower than in non-pathological ones, and it is interesting to note that in the binocular condition these parameters approach that of healthy people. This observation has very important implications in the clinical practice since, generally, rehabilitation occurs only for the best eye, when instead even the worst eye seems important for people's quality of vision. [The authors have no conflicts of interest to declare.]

Visual acuity assessment with 3-bar optotypes: benefits and shortages

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Visual acuity (VA) measurements are always influenced by various factors, and one of the most important issues is usually the choice of a proper optotype. In our group, we have conducted several studies on comparison of 3-bar grating-like optotypes with Lea optotypes, tumbling-E, and letters (used in ETDRS and Russian Sivtsev-Golovin charts). In this work we want to overview and discuss the differences of VA assessment results obtained in three previous studies. One study was conducted on healthy young subjects (N=26, median age 17 yrs); another study was conducted on children with ophthalmopathology (N=42, median age 10 yrs); and the third study was conducted on cataract patients (N=79, median age 78 yrs). According to our results, there was significant overestimation of VA with gratings (compared to tumbling-E and ETDRS) only in the cataract patients; other groups showed no significant differences between grating and other optotypes. We suppose that such advantage of gratings could be explained by relative easiness in perception of gratings for cataract patients: their responses to the 3-bar optotypes were faster and more confident than to tumbling-E and ETDRS-letters. In contrast, in children with ophthalmopathology, 3-bar optotypes were not so beneficial, since the patients were sometimes bored by repetition and lost their concentration faster. We may conclude that 3-bar optotypes may be used in various age groups, show comparable results, and may be even more convenient in some patients. [We are very grateful to Prof. Rozhkova for her comments and very helpful discussion.]

Do smaller P300 amplitudes in Schizophrenia Spectrum Disorder result from larger phase variability?

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The P300 is an event-related potential (ERP) that is typically evoked about 300 ms after onset of a rare task-relevant stimulus. It is interpreted as reflecting context updating and/or perceptual decision processes. Several studies found reduced P300 amplitudes in patients with Schizophrenia Spectrum Disorder (SSD) compared to neurotypical controls (NTs). The purpose of the present study was to investigate whether reduced P300 amplitudes result from reduced neural activity or from reduced phase coherence across trials. Different sized checkerboards were presented as frequent and rare task-relevant stimuli in an oddball paradigm. Eight patients with SSD and 12 neurotypical controls observed the checkerboards and counted the number of oddballs. P300 amplitudes, power and inter-trial phase coherence (ITC) in the delta and theta frequency bands were compared between participant groups. An ERP analysis revealed a typical P300 with a tendency for smaller amplitudes in the SSD group compared to the NTs. In the frequency domain, we found reduced ITC ($p = 0.0049$, $d = 1.142$) and even a tendency for larger power in the delta band in the patients compared to the NTs. The present results are yet constrained by the small sample size. The preliminary results indicate either equal or larger P300 amplitudes in the single trial but more variability in P300 latency in patients with SSD

compared to NTs. Future studies need to show whether the smaller P300 amplitudes in SSD, reported in the literature, are generally based on larger variability in the timing of neural processes across trial repetitions. [We thank Neurex and the Deutsch-Französische Hochschule (DFH) for their financial support of the PhD project of Ellen Joos.]

Effect of the interaction between lighting diffuseness and object surface characteristics on object impressions

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Illumination, object shape, material, reflectance, and other factors determine the impression of an object. The perception of the gloss and roughness of an object tends to be weakened as lighting diffuseness increases. It has also been shown that there is an interaction between illumination and surface properties on the appearance of those textures (Kiyasu et al., 2018). This study investigates the effect of lighting diffuseness on various impressions of objects with different lightnesses, colors, and curved surfaces. The stimuli were plates with sinusoidal-wave surfaces. We tested different lightness, color and glossiness conditions. We also used achromatic cylinders with different wave frequencies. Each stimulus was observed under three lighting diffuseness conditions. The eight types of impressions were evaluated, including glossiness, roughness, hardness, and weight. Our result showed a trend that the glossiness impression was weakened as the lighting diffuseness increased, which is consistent with the previous studies. The roughness impression didn't show a clear trend. Stimuli with curved surfaces have a different tendency at different frequencies; a stimulus with low-frequency waves showed the opposite trend in glossiness, suggesting that the impressions were determined by the interaction of the object's shape, surface properties, lightness, color, and lighting conditions. In addition, there was a correlation between hardness and gloss, weight and roughness. These results suggest that changing the diffuseness of lighting can change the impression of an object, but it is necessary to consider the interaction with object characteristics. [JSPS KAKENHI JP19H04196, 20H01781.]

Neural correlates of density-size cross adaptation: An fMRI study

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How does the visual system estimate space? A novel adaptation study by Hisakata et al. (2016) revealed that the perceived size of objects reduces after adaptation to dense textures (density-size cross aftereffect). This suggests that visual space is encoded relative to an adaptable spatial metric that uses internal density representations as "rulers". In the present study, we investigated the neural correlates of this phenomenon using fMRI. In the experiment, a texture stimulus consisting of either 9 or 100 black-and-white dots was presented as an adaptor for 1 second in either the left or right visual field. After various delays, a test stimulus was presented for 300 ms at the same location as the adaptor. The test stimulus was either a black circle used to elicit cross adaptation or a texture stimulus consisting of 49 dots used to invoke simple density adaptation. After regressing out any BOLD activity evoked by the adaptors, we analyzed which areas in the brain exhibited adaptation-induced changes in BOLD signals related to the test stimuli. We especially focused on the comparison between simple density adaptation and density-size cross adaptation. We found that the bilateral supramarginal gyrus and the left angular gyrus showed differential activation to the two types of adaptation, suggesting the involvement of the inferior parietal lobule (IPL) in density-based space encoding. Our results are consistent with previous fMRI literature showing this region's critical role in spatial processing. We will further discuss neural computations of space through density to object size. [20H01783 Grant-in-Aid for Scientific Research(B).]

EEG rhythms in long-lasting spatio-temporal feature integration

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Pre-stimulus brain activity is thought to modulate visual perception. However, the nature of this modulation remains debated. In particular, the use of paradigms with very brief and weak stimuli complicates a univocal understanding. Here we focus on phenomena of long-lasting feature integration. We analyzed electroencephalography recordings (EEG) from a sequential metacontrast paradigm (SQM). In the SQM, participants discriminate the offset of a central line followed by flanking lines. Because of metacontrast masking, the central line itself is invisible but its offset can be perceived in the motion stream created by the lines. When a second line in the stream has an offset in opposite direction, the offsets integrate. We investigated whether pre- and post-stimulus brain activity can predict the perceived offset. When comparing trials in which the first or the second offset was reported, we observed no influence of pre-stimulus activity. However, by applying a linear classifier to post-stimulus activity, we were able to decode the relative dominance between the two offsets. The decoded signal was linearly related to

pre-stimulus power increases in the alpha-theta band (7-12 Hz). This initial result suggests that low-frequency pre-stimulus power may modulate the relative weighting of visual stimuli embedded in a continuous stream.

Estimating the contributions of pictorial, motion and binocular cues to the perception of distance

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Multiple visual cues are available for the estimation of distance. According to the modified weak fusion model, information from these cues is combined through weighted averaging, with the weights determined by the relative reliability of each cue. Empirical tests of this model tend to isolate a small number of cues, in order that their reliabilities can be manipulated. Weights measured in this way are specific to the testing environment, and do not allow us to quantify the contributions of individual cues in natural viewing. To address this, we used estimates from the literature of sensitivity to a wide range of distance cues to predict the contribution of pictorial, binocular and motion cues to relative distance. The cues assessed included convergence, accommodation, height in the field, texture density, relative size, height in the field, binocular disparity and motion (assuming a walking observer). We used the modified weak fusion model to estimate the contribution of binocular and motion cues for distances between 2 and 10m. For a static observer, the binocular weight varied between 20 and 40% in this distance range, and binocular viewing provided a predicted increase in sensitivity of between 10 and 20%. For a walking observer, the weight for motion perspective varied between 20 and 40%, and the binocular weight reduced to between 15 and 25%. The improvement in sensitivity from binocular cues for a walking observer reduced to around 10% . These calculations provide estimates of the expected contributions of individual depth cues in everyday viewing conditions. [This work was funded by the Leverhulme Trust (Research Project Grant RPG-2016-361).]

Correlation between Fusional Vergence and Maximal Stereoangle

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The single fused image of the world is the result of complex processes that our visual and neural system must go through. There must be a coordination between eye motor stabilization, known as motor fusion, and sensory mechanism of eye stabilization, known as sensory fusion or stereopsis. Nevertheless, in real life, we rarely experience diplopia thanks to the motoric fusional vergence that acts to reduce double vision. The neural mechanism of their co-function remains unknown, but they sure do share a common stimulus. The study aimed to develop the method and find the correlation between fusional vergence and maximal stereovision angle. The measurements of vergence and stereoscopic disparities were performed on the computer screen (53x30 cm at 1 m distance) using two stripes test (7 minutes of arc width and 35 minutes of arc length) and the developed anaglyph random-dot stereovision test. 22 participants (from age 18 to 40 years) performed two tests. The average of the convergent fusion was 242.2±104.8 arcmin, the divergent fusion – 149.7±53.4 arcmin, and in the case of stereovision – the average of the maximal crossed disparity was 65.0±35.9 arcmin, and the uncrossed disparity – 42.1±13.4 arcmin. We found the correlation between convergent and divergent fusion and between the crossed and uncrossed disparities. However, we did not find the correlation between fusional vergencés amplitude and the maximal crossed and uncrossed disparities stereovisioń s amplitude. We concluded that the direct connection does not exist between motor retinal stabilization and sensory compensatory mechanism to prevent double vision. [Funding: This work was supported by KC-PI-2020/10, UL Y5-AZ77, UL Y9-B003.]

Peripheral detection performance is predicted by pupil size

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When the eye's pupils are changing their size, basic visual intake is altered. Not only the near response and incoming light affects pupil size, but also non-optical factors affecting the arousal system. This raises the question on the perceptual consequences of pupil size changes in general and how they could potentially provide an evolutionary edge. In the present study we investigate the impact of pupil size on peripheral visual detection performance. In Experiment 1, pupil size was manipulated by irrelevant background brightness (bright, dark) randomly in a trial-based manner while detection performance for a low-contrast stimulus at an eccentricity of 7.7° on a constantly grey local background was measured in a web-based study. Replicating earlier findings, we found better detection performance for dark compared to bright background, demonstrating the robustness of the effect and supporting the notion that increasing pupil size improves detection performance. In Experiment 2, this was tested directly in a controlled eye tracking experiment in the lab. Indeed, we found that pupil size predicts peripheral detection performance with large pupils associated with

better detection performance. Moreover, detection performance was predicted by the interaction of pupil size in the preceding trial (n-1) and pupil size in this trial (n): detection performance in a trial was best when pupils in the preceding trial were small, but large in this trial. In other words: the more pupils dilate the better stimulus detection. The results are discussed in the light of low-level sensory, as well as higher-level arousal driven stimulus processing.

Inhibition of return and directional effects in an extended saccade sequencing paradigm

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In the current study, we wanted to test the time course of saccadic inhibition of return and its interaction with effects of saccade direction. To this end, we extended a saccade sequencing paradigm, originally developed by Ludwig et al. (2009). In each trial, the 27 participants were required to make eight saccades in a display that consisted of 16 circles as possible fixation locations. The gaze of the participants was guided by an arrow cue which was presented at each fixation location and which indicated the location to be fixated next. Because the circles were placed at the vertices of (invisible) adjoining equilateral triangles, all possible next fixation locations had an equal distance to the current one. The saccade to the next fixation location could have an angular difference of either 0°, 60°, 120° or 180° from the preceding saccade. Critically, after the sixth fixation in the sequence, the gaze was either directed back to a location fixated up to five fixations earlier (fixation lag) or directed to a new location. We found longer saccade latencies for lags of up to three fixations back compared to fixations of new locations, indicating the presence of inhibition of return. Moreover, latencies of upward saccades were in general faster than those of downward saccades. We will discuss these results in the context of a more refined analysis that includes all saccade direction changes, i.e. saccadic momentum.

Effect of visual and auditory stimuli in cortical activation during saccadic eye movements

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Study of cognitive functions directly relating to saccadic eye movements is less explored. We aimed at studying the same with event related potentials (ERPs). The study comprises 20 healthy adult participants examined with two independent experiments. The first experiment was a visual Go/No-Go task with participants requiring to make Prosaccade (PS) – frequent, and Antisaccade (AS) – infrequent, according to the visual cue. Our second experiment used auditory stimuli (words – 'right', 'left') with two speakers at right and left of the screen to create congruent (right-right, left-left) and incongruent conditions (right-Left, left-Right) inducing Spatial Stroop, requiring participants to make an eye movement according to audio, ignoring the spatial location. ERPs were recorded using 32 channel active electrode system with Cz as reference. In first experiment, we observed P300 and P200 elicited for both tasks, the former being prolonged and the latter being early, with statistical significance ($p < 0.05$), in AS task. This suggests that AS condition demands increased cognitive function than PS task. In second experiment, we observed N200 with smaller amplitude at Cz electrode and prolonged P300 in Pz electrode, resulting in near to significance for both ($p = 0.059$ for negativity, $p = 0.064$ for P300), in incongruent tasks. The N200 potential observed, is believed to be involved in cognitive conflict in congruency tasks and our paradigm resulted in this potential varying between the congruency tasks. Thus, our study confirms that the above paradigms using eye movements can be used in studying cognitive function in an individual.

The role of facial expressions on different aesthetic judgments of facial beauty

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What makes one face beautiful? Is it symmetry, averageness or it is a facial expression? We wanted to explore how facial expressions affect aesthetic judgments in the context of facial beauty. A total of 61 students took part in the research. Their task was to evaluate each face separately (10 males and 10 females from the FACES database with angry, happy, neutral, and sad expressions) on a 7-point scale. We used 4 different scales: Beautiful, Pleasant, Attractive, and Harmonious. Results showed that although, ratings on the Attractive scales were significantly lower compared to the other 3 scales ($F(180)=12.045$, $p<.001$) the patterns were similar among all 4 scales. Regardless of the scale, faces with sad, and angry expressions were rated lower compared to neutral and happy expressions. However, it seems that the presence of the same facial expressions will differently affect ratings of female and male faces. Male faces with sad expressions comparing to female faces were consistently rated lower on each

scale. That was also the case for angry faces but only on the Beautiful scale. The fact that sadness significantly more decreases the rating of male faces perhaps could be explained by social norms where men are not encouraged to show sadness that is seen as weakness. Further examination of this possibility is required. Results of our study suggest that even different aesthetic scales behave in a similar way, the Beautiful scale could be better in detecting gender differences.

Emotional face categorization: Autistic traits in healthy individuals attenuate the integration of visual context

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Categorization of emotional facial expressions is key for social interactions and valuation of situational demands. It has been shown that processing of emotional expressions is modulated by contextual cues. This modulation might be subject to individual differences. Visual perception in clinical individuals with Autism Spectrum Disorder is characterized by a bias towards local information, while context information is disregarded. Here, we investigated whether healthy individuals who differ in autistic traits show differential susceptibility to the valence of visual context. A total of 203 participants (62 males, age range 18-38 years) took part in our study which was implemented on the online platform Testable. We presented happy and sad faces that had to be categorized. Faces were embedded in a sequence of natural scenes that were of positive or negative valence, respectively. All participants run through both context blocks. Autistic traits were measured by two autism questionnaires. In line with previous findings, we overall observed a positivity bias in the categorization task, i.e., a speed and accuracy advantage for happy faces. However, this positivity bias was subject to a significant interaction effect of context valence and autistic traits. Less pronounced autistic traits were associated with a positivity bias only in the positive context condition and a negativity bias in the negative context condition. In contrast, individuals with pronounced autistic traits showed a robust positivity effect independent of visual context. Our findings suggest that autistic traits in the general population critically shape the impact of visual context when processing emotional facial expressions. [This research was supported by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) – project number 222641018 – SFB/TRR 135 TP B5.]

Disordered use of alcohol is associated with impairments in face memory

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Disordered alcohol use is related to a variety of cognitive impairments, including memory difficulties (Woods et al., 2016). Remarkably, no prior work has assessed whether problematic usage of alcohol is associated with deficits specific to face memory, or if they extend to problems perceiving subtle differences between faces too. We aimed to test this in the current study. In this study 244 participants completed an online 20-item Prosopagnosia Index (PI20) (Shah et al., 2015) questionnaire to assess face memory ability, and the Alcohol Use Disorders Identification Test (AUDIT) (Saunders et al., 1993) as a measure for alcohol usage. Among them, 130 participants also completed the Cambridge Face Perception Test (CFPT) (Duchaine et al., 2007) to investigate face perception. A partial correlation controlled for age, gender and ethnicity was initially performed showing a significant association between disordered alcohol use and face memory ($r = .2$, $p = .002$) but no between alcohol use and face perception ($r = .165$, $p = .064$). Participants were then grouped by their AUDIT score ("Low-risk", "Risky", "High-risk") and Kruskal-Wallis tests were run to compare them on face memory and perception. Data showed a significant difference on PI20 score ($H(2) = 7.201$, $p = .027$) but not on the CFPT ($H(2) = 5.888$, $p = .053$). In conclusion, greater disordered use of alcohol was associated with poorer face memory ability, but not face perception difficulties. Future works testing a larger CFPT sample may confirm the presence of this latter link.

Relationship between Types of Anxiety and the Ability to Recognize Facial Expressions

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The study aimed to examine whether three subtypes of anxiety (trait anxiety, state anxiety, and social anxiety) have different effects on recognition of common facial expressions of emotion. One hundred and thirty-eight participants were shown face images of six basic types of facial expressions with three levels of intensity (20%, 40%, 100%). They matched each face image with one of the six emotion labels ("happy", "sad", "fear", "angry", "disgust", and "surprise"). When we used conventional method of analysis, we found significant correlations between each score of anxiety and recognition performance for facial expressions. However, when we used partial correlation to eliminate the complex effect of each anxiety, only the correlation between anxiety and categorization errors was significant. This was characterized by the tendency of miscategorizing a sad face as an angry face in social anxiety, and a surprised face as a disgusted face in trait anxiety and state anxiety. These results show that

each subtype of anxiety differentially influenced on the recognition of facial expressions especially when the intensity of the expression is low. Our eye tracking data also show that state anxiety may be associated with reduced fixations on the eye regions of low-intensity sad or fearful faces. Results from our partial correlation analyses cast some doubts on some effects reported in the previous studies because they are likely to reflect a mixture of influence from the highly correlated anxiety subtypes.

Face Recognition in Autism Spectrum Disorders (ASD)

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While it is well-established that people with autism experience face recognition problems, the nature and origin of these difficulties remains unclear. According to one view, these deficits reflect aberrant face memory. People with autism may form accurate perceptual descriptions of faces, but be unable to retain those descriptions in memory for more than ~10-20 seconds. A rival view is that face recognition problems, where observed, are caused by co- occurring developmental prosopagnosia (a separate condition associated with face recognition problems). Importantly, developmental prosopagnosia is associated with impaired perceptual encoding of faces. According to this view, therefore, the face recognition problems seen in autism have a perceptual, not mnemonic, origin. In order to test these rival views, we examined whether autistic individuals (N = 50) and matched controls (N = 50) perform poorly on a face recognition task with minimal memory demands. On each trial, participants were presented with a display divided into four quadrants. Within each quadrant, we presented an "ambient" facial image (i.e., naturalistic facial images that vary widely in their pose and expression). Three of the images depicted the same person, while the fourth depicted a different "oddball" identity. Having inspected the four images for 5 seconds, participants were asked to identify which of the images was the oddball. Contrary to the view face recognition problems in autism have a mnemonic origin, we find clear evidence of impairment at the group-level. These results suggest that face recognition problems seen in autism closely resemble those seen in developmental prosopagnosia.

The effect of emotion on the own-age memory bias

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Previous research has found that children, young and older adults show an Own Age Bias (OAB). However, results have reported no differences in recognition of middle- and young-age faces between young and older participants. Consequently, it has been suggested that young adults display an OAB when there is a substantial age gap in the stimuli used but not when the difference is smaller. Another line of research has suggested that if people tend to have greater contact with others who belong to the same group, it follows that preferential processing is given to in-group faces as they are deemed socially relevant, which results in more accurate recognition. Recently, research has also used emotional stimuli to disentangle the relative contribution of both perceptual-expertise and social-categorisation perspectives. However, evidence is not consistent as some studies have reported emotion-specific OAB for sad faces in older people, while others have failed to observe an emotion specific OAB either for young or older adults. It is still unclear whether happy expressions eliminate the OAB because they are more visually salient stimuli, or whether other expressions would have the same effect. The present study investigated whether young adults showed an own-age memory advantage for neutral faces but not for emotional faces. To this end participants completed a face-task, in which they were instructed to categorise per age-group each face -that could display either neutral, angry, or sad expressions-. After a brief break, they were asked to respond if the faces had already been presented or not.

Effect of eye and mouth movement in dynamic face perception

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The human visual system process faces holistically, rather than processing it as a collection of separate facial features. Even though studies of face perception have been at the center of vision science studies, only a little is known about the effect of partial information in dynamic face processing. We, therefore, examined the importance of partial information during dynamic face perception through manipulation of the spatial layout, partial dynamic cue, and the temporal aspect of speech. The participants (N = 53) were presented with short monochromic videos (on mute) in which models were vocalizing a well-known text, and were asked to indicate the direction of the timeline of each video. We disrupted (i) spatial layout of the faces (upright or inverted), (ii) timeline of the videos (sequence or reverse), (iii) partial dynamic cue (blink or no-blink). We found the main effect of all three factors (spatial layout, timeline, partial dynamic cue) both in accuracy and reaction time. The results showed that artificial (reverse) dynamic information revealed longer reaction times compared to natural (sequence) dynamic information ($p=.002$). The responses to inverted faces were found to be less accurate than responses to upright faces ($p<.001$). Moreover, the presence of blink improves both the accuracy and the reaction time ($p<.001$). This was more

prominent when the videos were presented upside down and reverse. Our results suggest that dynamic part base information (eye blink) enhances face processes in unrealistic scenarios, and holistic processing overwrites the part base information which operates on upright faces. [This work was supported by Tübitak 3501 (Career Grant 220K038 to NA).]

Using eye-tracking to examine attachment-related differences in facial emotion perception and face memory

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Attachment theory attempts to explain how our childhood relationships can have a lasting effect on our personalities. Individual attachment style may influence how we process emotionally significant stimuli, possibly through attentional orientation or stimulus coding. As one of the most important sources of emotional information are facial expressions, we often rely on these to understand our partner's intentions and to adapt our reactions accordingly. Therefore, we examined whether there is an association between adult attachment styles (i.e., scores on the ECR questionnaire, which measures the avoidance and anxiety dimensions of attachment), facial emotion perception and face memory. Eye-tracking was used during the emotion decision task ("happy" vs. "sad" faces) and the subsequent facial memory task; performance and reaction time were also measured. The study included neurotypical individuals (19-36 years, N=50, 24 female). Based on eye movement data, a general difference can be observed in the length and order of fixations to the different areas of interest (right eye, left eye, nose, mouth) during both the emotion recognition and the memory task. Correlation analyses suggest that these differences may result from alternative fixation patterns in individuals with different attachment orientations. The results of our research may contribute to a more accurate understanding of face perception in the light of attachment styles.

The Friend Effect Framework: Modelling Perception of Facial Attractiveness in Social Contexts

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Understanding the perception of facial attractiveness in social contexts has been challenging due to the lack of an overarching model. For instance, being viewed in the company of others makes a target face typically appear more attractive; however, researchers are still debating the mechanisms behind this 'cheerleader effect'. We recently showed that cheerleader effects are shaped by both the target and group's own attractiveness (Burns et al., 2021; Ying et al., 2019), with the least attractive groups and targets producing the largest effects. From this, we presented a Friend Effects Framework within which these predictors and effects could be better understood, and to provide researchers with testable hypotheses derived from its assumptions (Burns et al., 2021). Here in a new study, we tested a key prediction of our Friend Effects Framework, i.e., that cheerleader effects occur in a fashion consistent with divisive normalization, whereby a target face's attractiveness is normalized by dividing its value with that of all of the faces in the scene. Confirming this hypothesis, we show that divisive normalization negatively predicts the magnitude of the cheerleader effect: targets that exhibited the lowest worth in the group context gained the largest cheerleader effects. This finding supports our Friend Effects Framework in suggesting cheerleader effects and divisive normalization are linked, and provides new insights into the computations carried out by our brains when judging facial attractiveness in a social context. [Supported by the Social Science Foundation of Jiangsu Province (17JYC006), the City & University strategy-Soochow University Leading Research Team in Humanities and Social Sciences (H. Ying).]

RELAY: Robotic EyeLink AnalYsis of the EyeLink 1000

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The assumption that human saccades in the dark are up to 10% slower than those made in lit conditions was challenged by Felßberg and Dombrowe (2018), as the opposing studies supporting the assumption incorrectly compared memory guided saccades in the dark with visually guided saccades in the light, which are in general slower (Smit et al., 1987). Their research suggests a non-linear, but a roof-shaped correlation between peak velocities and brightness conditions. A study by Nyström et al. (2016) found similar results for measurements with P-CR technique but not for CR only. Their finding of a monotonically increasing pupil deformation as cause for the different peak velocities under changing brightness conditions, cannot explain the roof-shaped correlation. In order to eliminate the pupil deformation and to examine the possible effects of the eye-tracker setup by gaze direction, we developed the RELAY (Robot EyeLink AnalYsis) System, based on an artificial eye and precision stepper motors and repeated the study with 199 artificial participants under the same brightness conditions used by Felßberg and

Dombrowe. Both, peak velocities and pupil size of the saccades performed by RELAY, while being similar to those of a human, show no relation to brightness conditions, confirming a well functional eye-tracker setup and method. Our system furthermore evaluated the eye tracker EyeLink 1000 and comes to the positive result of an overall satisfying precision while including the imperfections of the robot.

Images as a possible moderator for the disfluency effect

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The disfluency effect is that information which is difficult to read due to low perceptual clarity (e.g. certain fonts, italics) is remembered better than information written clearly, and it can lead to better learning outcomes (Diemand-Yauman et al., 2011). This effect was demonstrated in several studies, whereas their results were not replicated in subsequent researches (Xie et al., 2018). It has been suggested that this effect may not be apparent in certain contexts, since it has moderators. We assumed that one of these moderators might be the presence of images accompanying the texts. The following experiment was conducted online. Seven fictional facts about the Earth, consisting of two sentences in Russian, were presented for participants (N = 142), they had to assess the plausibility of each fact. After that, a short distracting task was given, and finally, the subjects solved a test of 14 questions. The subjects were divided into four experimental groups. In two groups, the facts were written in the Arial font (fluent), in others, Comic Sans (disfluent) was used. In addition, in two groups, the facts were accompanied by relevant images, while in the others they were not. We found a significant influence of images on memory, namely, their presence worsened memory, they were probably a distractor for reading facts. There were no differences depending on disfluency, and the interaction of factors was also insignificant. Moreover, the plausibility score did not depend on fluency or the presence of images. [The study was implemented in the framework of the Basic Research Program at HSE University in 2021.]

Two-phase reactions of perceptual confidence in the task of continuous presentation of blurred images

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Assessment of perceptual confidence requires improvement of methodological approaches. We present the results of assessing perceptual confidence using blurry images. White images of objects on black background were blurred by software using the Gaussian blur algorithm to the level of a uniform light spot and presented to the subjects (N = 22) with a gradual decrease in the degree of degradation. The subject's task was to recognize the object as quickly as possible. The answers were registered verbally, the moment of hypothesis emergence and confidence in it (from 0 to 100) were pointed by subjects on a special area of the screen - the «confidence panel». The subjects were not limited in the number of guesses; the feedback on the accuracy of the answers was not carried out. Such a procedure, presumably, requires a low level of mental effort on the subjects' self-estimation of confidence. Under the conditions described, the subjects repeated the correct answer optionally in 58% of cases. Analysis of speech recordings suggests that in the first case a guess was expressed, while later the subject expressed confidence in the answer more definitely. The average confidence of the guess was 63.50 $\pm$ 11.17 for a blur radius of 20.61 $\pm$ 4.33. The average confidence for an accurate answer was 96.13 $\pm$ 1.63 for a blur radius of 12.20 $\pm$ 4.70. Since the confidence of the obvious answer is close to 100%, this allows one to indirectly estimate the error in measuring of perceptual confidence by this method.

Gaze directed towards salient objects in scenes induces intrusion errors in visual working memory

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Visual perception in the real life occurs in an environment with abundant information. Focusing and memorizing important information in a scene may thus depend on an individual's ability to control gaze so that s/he do not see just salient objects in the scene. In the current study, we investigated how individual differences in gaze control in a complex scene can explain visual working memory capacity. We used an ecologically-valid visual working memory task -Picture Span Test (PST)- and investigated the participants' gaze direction while they observed each scene. PST not only provides a measurement for the visual working memory performance (accuracy) but that for inhibitory control as 'intrusion errors'. Intrusion errors are, by definition, failures that one remembers a non-target item presented together with the target object. To examine the effect of bottom-up attention on task performance, we calculated an index of gaze direction toward salient objects; Normalized Scanpath Saliency (NSS) in each trial from the eye-tracking data. The results showed that the successful recognition of the target in PST was followed by

relatively long gaze in the corresponding area in the encoding phase. In addition, the rate of intrusion errors was significantly explained by the participant's NSS in the corresponding scene. The results suggest that gaze control in viewing a complex scene can explain the individual's visual working memory capacity in a realistic environment.

Perceptual similarity judgments predict the precision but not the distribution of errors in working memory

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Models based on population coding have been shown to provide a parsimonious account of empirical distributions of error in visual working memory (VWM) tasks. Inspired by electrophysiological observations, these models account for VWM errors based on two key properties of neural response functions, the tuning width and activity level. A new perspective on this class of models has recently been presented in the form of the Target Competition Confusability (TCC) model. The core claim of TCC is that the distribution of recall errors on e.g. a colour wheel, can be accounted for by the perceptual similarity of values in that feature space, i.e. the perceptual similarity function takes on an equivalent role to population tuning, obviating the need to fit a width parameter to the recall data. Here we set out to verify this claim by testing the correspondence between population coding and TCC components that predict the shape of VWM error distributions. Using four different visual feature spaces, we measured psychophysical similarity and working memory errors in the same participants. The results revealed no consistent relationship between perceptual similarity functions and VWM error distributions. In contrast, we found strong evidence for a correlation between the variability (noisiness) of similarity judgements and the activity level (signal-to-noise) in the population coding model fit to VWM errors. Our results suggest that perceptual similarity functions are not predictive of VWM errors, but that a common source of variability affects perceptual difference judgements and recall from VWM, perhaps related to broader cognitive ability. [Wellcome Trust.]

Multisensory Integration of Audio-Visual Motion Cues during Active Self-Movement

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Sensory measurements in vision and hearing begin in different coordinate frames, which complicates the integration of spatial cues when head and/or eyes move. We propose that audio-visual integration in active perceivers is performed in body-centred coordinates: specifically, audio and visual cues are separately transformed ('compensated') using self-movement signals, before being integrated as body-centred cues to audio-visual motion. As a first pass, we tested whether body-centred audio and visual cues are optimally integrated during active self-movement. In all conditions, participants rotated their head back-and-forth while sitting in the centre of a multiple speaker/LED ring. They fixated a head-centred fixation-point to minimise eye rotation, and judged whether a moving audio, visual, or audio-visual target travelled left or right. The target's speed was scaled by a proportion of the ongoing measured head movement and appeared during one head-sweep only. In some conditions, audio and/or visual positional jitter was added to the target's motion to make cue(s) less reliable. Estimates of precision and bias were obtained via psychometric functions, with parameters from unimodal conditions used to predict optimal audio-visual estimates. Preliminary findings suggest that audio-visual motion perception during active self-motion is near-optimal, with greater precision in the bimodal conditions. Moreover, reducing the reliability of one or both unimodal cues caused dynamic re-weighting of sensory information, with a higher weighting given to the more reliable modality. Thus, while self-movement creates a compensation problem for vision and hearing, our findings suggest that principles of optimal multisensory integration still apply during perception of audio-visual motion.

Effects of colors of container upon the taste intensity of drinks

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Previous studies have demonstrated that the color of the food and drink, as well as colors of dishes may affect the taste of those food and drink. This study aimed to understand how the color of container affect the taste for the drink within the container. Participants evaluated the intensities of four basic tastes (sweetness, bitterness, sourness, and saltiness) for different solutions (sugar, magnesium chloride, citrus acid, and sodium chloride), which was supplied with a container totally enveloped with colored paper cylinder (white, black, red. yellow, blue, green, pink, and brown). Also, they evaluated subjective matching between colors and tastes. After these evaluations, they spat out the solution to a backet without drink it to maintain their body homeostasis at the same level. The concentration of the solution corresponded to a taste intensity of 3 out of 10 in a preliminary test. The temperature of the drink and lab room was kept at 25 degrees Celsius. Analyses for the evaluated intensities of tastes showed that colors of container affect the tastes of drinks; bitterness was

emphasized with black and green containers; yellow container would emphasize the sourness for which participants evaluated as strongly matched with yellow while black, blue and green containers reduce the sweetness for which participants evaluated as negatively matched with those colors. These results suggest that the effects of color of container on taste intensities for inner drinks depend on degree of subjective matching between the color and taste. [This study is supported by JSPS Grants- in-Aid for scientific research (#20H01781 to MI).]

Crossmodal correspondence between audio waveforms and visual shapes

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Crossmodal correspondence is the tendency to map information across sensory modalities. We investigated whether simple visual forms (circle, triangle and rectangle) would be mapped on tones that are generated from audio carrier waves with the same geometry (sine, sawtooth and square wave). In two different experiments, participants were asked to choose a matching tone for a given visual form, or a matching form for a given tone. Audio frequency and loudness as well as size and orientation of the visual forms were varied. In a third experiment depictions of cartoon characters with predominantly round, triangular or rectangular body shapes were used as visual forms. Cross-tabulations revealed increased counts of round-sine, triangle-sawtooth and rectangle-square mappings. The mapping was strongest between sine waves and round forms, and was most pronounced for audio frequencies between 1250 and 2250 Hz. The results suggest that audio waveforms can share representations with simple visual shapes.

How the sense of number is influenced by auditory deprivation

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Despite the numerous studies dedicated to unveiling how numerosity is processed in the human brain, to date, it is not clear whether the representation of numerosity is supported by a single general mechanism or by multiple mechanisms. Regardless, according to the framework proposed by "A Theory of Magnitude", numerosity is linked to space and time in a generalized magnitude system. Since deafness has been known to create a selective impairment in temporal information processing, we assessed the approximate numerical abilities of deaf individuals to disentangle these two hypotheses. We used a numerosity discrimination task (2AFC) and an estimation task, in both cases using sequential (temporal) or simultaneous (spatial) stimuli. The results showed a selective impairment of the deaf participants compared to controls (hearing) in the temporal numerosity discrimination task, while no difference was found to discriminate spatial numerosity. Interestingly, deaf and hearing participants did not differ in spatial or temporal numerosity estimation. Overall, our results show that the numerosity-processing mechanism is neither entirely composed by multiple systems nor completely generalized, but likely organized in a hierarchical fashion of increasing complexity. The absence of early auditory experience, as in deaf individuals, may affect the processing of temporally defined numerosity at the lower step of this hierarchy. However, downstream to sensory processing, the system is likely to compensate for such an impairment when participants are engaged in tasks entailing a more abstract mapping of numerosity information.

Familiar faces induce a stronger McGurk effect than unfamiliar faces

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The other-race effect—or cross-race effect—refers to the perceptual phenomenon whereby adults are able to recognize the individual faces of members of their own race better than the faces of members of other races. Previous studies have assumed that the other-race effect would not be limited to the recognition of face identity but would be observed in other face-related processes. Here, we tested the other-race effect in the aspect of facial speech by examining the magnitudes of McGurk effect between two race stimuli (own-race vs other-race). The stimuli were created from simultaneous audio and video recordings of four speakers' utterances (two East Asian and two Caucasian) of three syllables (/pa/, /ta/, and /ka/). In the experiment, 30 East Asian adults participated in a speech recognition task for visual, auditory, and audiovisual stimuli. Our results showed that East Asian face induced a stronger McGurk effect than Caucasian faces, which implies the other-race effect in the McGurk effect. Furthermore, no difference was found in both visual-only and auditory-only condition, which implies that the race of face did not influence neither lip-reading nor voice perception. Our findings demonstrate that familiar faces enhance the use of facial

information in audiovisual speech perception, and provide evidence of the own-race effect in the McGurk effect among adults. [This study was supported by Grant-in-Aid for JSPS (Grant No. 19K20650, No. 20KK0054, No. 19J00722, and No. 17H06342).]

Shape-Related Size Biases in Visual Volume Judgements

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The ability to accurately estimate object volume is critical for action preparation and size estimation but little is known about the cues we use to make volume judgements. Previous studies have reported clear shape related biases when judging the volumes of objects both in vision and touch, e.g. tetrahedrons are judged to be larger than cubes or spheres. However, these studies are not able to fully explain why such biases exist. In two experiments, we investigate shape-related volume biases and the geometric features that provide a likely explanation. Our stimuli consist of a range of shapes which differ across geometric properties, e.g. height, width, compactness, convex hull. Participants (n=35 & n=30) were shown two objects and were asked to make 2AFC volume judgments. Similar to previous research, we find certain shapes to be judged larger than others, e.g. tetrahedrons are judged to be larger than cubes and cubes are judged larger than spheres. Our results suggest that the shape related biases are best explained by a weighted combination of object compactness and height with compactness being the dominant predictor. [This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 76512.]

Multilingual Online Teaching Material of Psychophysical Methods on Mobile Devices

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We updated our multilingual (English and Japanese) website (http://psyche.mind.tohoku-gakuin.ac.jp/psy3/psycho/index.html), which is called "Precision and Accuracy with Three Psychophysical Methods," from a beta version (English only) presented at Fechner Day 2017. Under the COVID-19 pandemic, this update allows students off-campus access to the website with their own mobile devices such as smartphones or tablets, which have become common ICT tools for education. This website provides an interactive package for students to learn 3 basic methods (method of limits, method of constant stimuli, method of adjustment) by themselves, and the conceptual differences between precision (JND) and accuracy (constant error). To learn the three different methods, students measure the precision and accuracy of the perceived length of a horizontal line. To learn and appreciate the differences in precision and accuracy, (a) they measure the precision of different lengths of lines to examine Weber's Law, and (b) they measure the extent of Müller-Lyer illusion. Although this online teaching material has been used in university classes by many students for more than a decade, the previous version became out-of-date because it relied on Java technology which is not compatible with modern mobile operating systems. Therefore, we replaced a large portion of the original package written in Java with JavaScript to support the more modern and ubiquitous HTML5 standard, while keeping the same look and feel as the previous version. [Supported by JSPS Grant-in-Aid for Scientific Research (C) Grant Number 17K04498, 21K03145, and by the Cooperative Research Project of the Research Institute of Electrical Communication, Tohoku University.]

Does perceptual categorization affect early perceptual visual processing or not? Two ERP studies using Bayesian statistics

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Perceptual categorization is an important cognitive function. In the visual domain, categorization based on, for instance, symmetry (in contrast to the lack thereof) was observed within the first 200 ms of information processing, as indexed by the so-called visual mismatch negativity (vMMN). We assessed whether or not categorical information (based on rotation and reflection) are mirrored by the vMMN. To examine this, we used five-dot patterns with characteristics that allow for the formation of categories which are not based on physical properties. To assess whether or not between-category and within-category vMMN differ in amplitude, the data was analyzed with the Bayesian approach. We choose this statistical approach to reflect both alternative answers to our research question (i.e., "yes" or "no"). In two experiments, we observed

both a between-category and a within-category vMMN. However, both vMMNs were comparable in magnitude. Since we observed both vMMNs, we can conclude that early processing steps in the visual domain can represent differences that are based on an abstract sensory rule. However, the findings suggest that abstract categorical information is not automatically processed at early visual stages. This implies that ad hoc perceptual categorization in the visual domain may affect later processing steps rather than the early perceptual processing step under investigation here.

Similarity based grouping also leads to numerosity underestimation

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Humans can rapidly and approximately enumerate the number of objects. While several mechanisms have been proposed to account for this ability to estimate objects, the fundamental units over which these mechanisms act remain unclear. Previous studies have argued that estimation mechanisms act on topologically distinct units or units formed by spatial grouping cues such as proximity and connectivity, but not on units grouped by similarity. Over two experiments (n=46), we challenge this conclusion by systematically testing and demonstrating that similarity grouping leads to underestimation, just as spatial grouping does. Further, the underestimation caused by spatial and similarity grouping appears to be additive. We can account for these findings by considering that grouping typically leads to representations of individual objects and veridical estimation, but when multiple objects are grouped into bound units, underestimation ensues. We conclude that estimation processes act on representations constructed after one or more Gestalt grouping principles have organised incoming visual input.

Emergence of crowding: the role of contrast and orientation salience

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Crowding causes difficulties in judging attributes of an object surrounded by other objects. We investigated crowding for stimuli that isolated either S-cone or luminance mechanisms or combined them. By targeting different retinogeniculate mechanisms with contrast-matched stimuli, we aim to determine the earliest site at which crowding emerges. Discrimination was measured in an orientation judgement task where Gabor-targets were presented parafoveally among flankers. In the first experiment, we assessed flanked and unflanked orientation discrimination thresholds for pure S-cone and achromatic stimuli and their combinations. We confirmed that orientation sensitivity was lower for unflanked S-cone stimuli. When flanked, the pattern of results for S-cone stimuli was the same as for achromatic stimuli with comparable (i.e., low) contrast levels, replicating Coates and Chung's (2016) findings. Additionally, we also observed a high degree of inter-observer variability in performance under flanker interference. Therefore, we conducted a follow-up experiment on a larger sample, to capture individual differences in performance driven by low-contrast stimuli that contained luminance only or combined with S-cone contrast. We measured unflanked detection and orientation sensitivity and perceived contrast, along with performance under flanker interference. We found that flanker interference exhibited a genuine signature of crowding only when orientation discrimination threshold was reliably surpassed. Crowding, therefore, emerges at a stage that operates on signals representing task-relevant featural (here, orientation) information. Since luminance and S-cone mechanisms have very different spatial tuning properties, it is most parsimonious to conclude that crowding takes place at a neural processing stage after they have been combined. [This project was supported by grant BB/R009287/1 from UKRI BBSRC.]

Audiovisual Saliency Prediction in Uncategorized Video Sequences based on Audio-Video Correlation

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Substantial research has been done in saliency modeling to develop intelligent machines that can perceive and interpret their surroundings. But existing models treat videos as merely image sequences excluding any audio information, unable to cope with inherently varying content. Based on the hypothesis that an audiovisual saliency model will be an improvement over traditional saliency models for natural uncategorized videos, this work aims to provide a generic audio/video saliency model augmenting a visual saliency map with an audio saliency map computed by synchronizing low-level audio and visual features. The proposed model was evaluated using different criteria against eye fixations data for a publicly available DIEM video dataset. The results show that the model outperformed two state-of-the-art visual saliency models.

Sensitivity to changes in interpersonal distance: the effects of dyad arrangement and orientation

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Proxemic cues are used by observers to infer whether two people are interacting, the nature of their relationship, and the valence of their current interaction. Despite the wealth of information conveyed by interpersonal distance, however, little is known about the representation of proxemic cues within the human visual system. Recently, it has been suggested that pairs of upright individuals arranged face-to-face engage configural processing that permits accurate and efficient representation of social interactions. Where observed, configural processing is thought to improve perception of the spatial relations between constituent stimulus elements. If upright, facing dyads engage configural processing, participants should therefore exhibit heightened perceptual sensitivity to changes in interpersonal distance, compared with judgements of inverted or back-to-back arrangements. Across four experiments, we find no evidence for this view. Participants' sensitivity to changes in interpersonal distance did not differ for face-to-face and back-to-back dyads (Experiments 1 and 2). Similarly, participants' sensitivity to changes in interpersonal distance did not differ for upright and inverted dyads (Experiments 3 and 4). Participants' sensitivity to changes in interpersonal distance in the face-to-face and back-to-back conditions correlated strongly, as did their sensitivity to changes in interpersonal distance in the upright and inverted conditions. Together, these findings suggest that the proxemic evaluation of dyads is mediated by a common mechanism irrespective of dyad arrangement or orientation.

Individual differences in eye drift and high-acuity vision

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During fixation, ocular drift continually shifts the retinal projection of objects across the foveola, where visual acuity is highest. Previous research showed that the spatiotemporal modulations introduced by ocular drift enhance high spatial frequencies dependent on drift characteristics; smaller drifts enhance higher spatial frequencies. Based on these findings, we hypothesized that differences in high acuity thresholds across observers are linked to individual variations of ocular drift. To investigate this issue, we measured visual acuity thresholds of 10 observers while monitoring ocular drift with a high-precision eye-tracker. Subjects performed an adaptive 4AFC discrimination task to calculate acuity. To quantify the amount of retinal motion generated by ocular drift, we calculated its diffusion coefficient, defining how rapidly the line of sight moves away from its current location. Ocular drift diffusion coefficient varied by a factor of four across the tested observers (average; 14 ± 5 arcmin2/second). Therefore, the range of spatial frequencies being enhanced by drift varied between 10 cpd to 60 cpd across individuals. Consistent with our prediction, we found a significant correlation ($r = 0.73$, $p = 0.02$) between acuity thresholds and drift diffusion coefficients across subjects: higher visual acuity correlated with lower drift diffusion coefficient. Importantly, the spatial frequencies enhanced by drift matched with the most informative frequencies for discriminating digits in the task. These findings show that differences in ocular drift relates to individual variability in acuity. This supports drift luminance modulations impact acuity, suggesting acuity could be inferred by the characteristics of eye drifts. [NIH R01 EY029788-01, F31EY029565.]

Consideration of Factors Affecting Gloss Perception Using Independent Scenes to Each Eye

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This study considers factors affecting gloss perception using a head-mounted display (HMD) to observe independent scenes to each eye. To this end, we conducted experiments on gloss perception in complex scenes with movement and parallax and analyzed the results. The experimental stimulus was an object with a smooth surface or irregularities. The experiment was conducted using objects with the following patterns: (1) still images or moving images, and (2) parallax or non-parallax. We created three types of computer graphics stimuli to consider the relationship between gloss difference and perception. In the experiment, two arbitrary patterns were presented on HMD as a pair of stimuli and the glossier felt pattern was selected by a two-alternative forced-choice task based on Thurstone's law of comparative judgement. Eight subjects participated in the experiment. The results showed that parallax did not significantly affect gloss perception. Conversely, gloss perception was found to be affected by movement. We hypothesized that temporal changes in specular reflection intensity were related to gloss perception and calculated the amount of luminance change for each pixel. By investigating the correlation between gloss perception and the luminance change of each pixel, it was revealed that the

magnitude of gloss perception could be explained by the number of pixels with large deviations in the luminance change. [Funded by JSPS KAKENHI Grant Number 20H05957.]

Texture synthesis by two-stage phase scrambling

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Texture information plays a critical role in the rapid perception of scenes, objects, and materials. By extending of the dimensionality of the Filter-Rectify-Filter model, we here propose a computational theory in which visual texture perception is essentially determined by the 1st-order (2D-luminance) and 2nd-order (4D-energy) spectra. The theory also corresponds to the frequency representation of the Portilla-Simoncelli statistics. As a support of the theory, we also introduce a very simple texture synthesis method, in which we randomized the 1st- (2D) and 2nd-order (4D) phase spectra of a natural texture image. Psychophysical experiments with 300 achromatic natural textures showed that this two-stage phase scrambling successfully produced perceptually similar texture with a quality comparable with the PS synthesis. We further show that, by incorporating the spectrum of color signals (RGB) as an additional dimension, the two-stage phase scrambling also worked for chromatic textures images, without any ad-hoc color analysis and conversion as used in the previous syntheses. Based on only two single spectral spaces, this theory provides a simpler framework to describe and predict texture representations in the primate visual system. The idea of multi-order spectral analysis is consistent with the hierarchical processing principle of the visual cortex, which is approximated by a multi-layer convolutional network. [This study was supported by the Commissioned Research of NICT(1940101) and JSPS KAKENHI JP20K21803.]

Contribution of local chromatic configuration to the perception of a golden object

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In general, the perception of a glossy object is influenced by statistical features of the luminance profile. However, we reported that local luminance configuration played a crucial role in deriving the perception of golden objects rather than just detecting the local shining of the gold surface. Thus, this study sheds light on the contribution of local chromatic information in the perception of golden objects. We tested whether observers could perceive a golden object in a stimulus image in which the chromaticity, but not luminance, of pixels was randomly shuffled with a certain probability (20 to 80%). The observers were asked to this task under three different background luminance levels in three different resolutions of the test images. Under most of the conditions, shuffling local chromatic information did not affect the perception of a golden object. However, some observers reported that when the images having vastly shuffled local chromaticities were perceived as a golden object, those were recognised as a golden object having an unknown different texture pattern surface against the original golden object. However, in some cases where considerably local chromaticities were shuffled in the image under the white background condition, the observers did not always perceive them as golden object. These results indicate that local chromatic cues give individual features in the object recognition with having a different surface pattern of the golden object. Therefore, these cues are not seemed to play a critical role in producing the perception of a golden object per se. [Japanese MEX Grant-in-Aid for Scientific Research (B) 17H01806 to HK.]

Poster Session 6

Dissociating mechanism underlying selection history for goal-directed reaching movements using a reach tracking and CoRLEGO modelling approach

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Selection history refers to the changes in behavioral performance that arise when the target/distractor features are repeated or swapped in the subsequent trials. Previous trials can influence the performance on the current trial in multiple ways; by leveraging the preactivated target representation (i.e., target facilitation), or continuing the suppression on distractors (i.e., distractor inhibition) or both. However, the exact mechanisms underlying selection history is poorly understood specifically in the context of goal-directed reaching movements. To dissociate the effect of target facilitation and distractor inhibition, we used a modified priming-of-pop-out (PoP) paradigm. The basic PoP paradigm has only two conditions "full-repeat" (target and distractor roles are maintained on subsequent trials) and "full-swap" (target and distractor roles are switched), which does not allow to tease apart the relative contribution of target facilitation and distractor inhibition. In the

modified version, we introduced two more colors which provided five additional conditions ("partial-repeat-target", "partial-repeat-distractor", "partial-swap-target", "partial-swap-distractor" and "no-repeat-no-swap"). This enabled us to evaluate the relative contribution of target facilitation and distractor inhibition with respect to the neutral "no-repeat-no-swap" baseline. Compared to the conventional reaction time studies, the reach tracking approach provides additional measures such as the reach-curvature that captures online competition between target and distractors influencing the trajectory. Results from twenty-two participants showed that trajectories were more deviated towards the distractors in the following order: full-swap>-partial-swap>no-repeat-no-swap>partial-repeat>full-repeat, suggesting that both target facilitation and distractor inhibition contributes to the selection history. Our results were also simulated by a neurologically inspired robotics model of color priming (CoRLEGO). [This project is funded by the grant NSF BCS 1849169 to Dr. Joo-Hyun Song and the grant ES/T002409/1 to Dr. Dietmar Heinke.]

The Influence of Attentional Priming in Metacontrast Masking Tasks with Verbal Responses

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Three explanations may account for the priming effect present in metacontrast masking studies: motor, attentional, and perceptual priming. We aimed to (1) find more support for attentional priming, (2) investigate whether observed activation can be considered as purely attention-related, and (3) determine whether the previously observed difference between a prime localization and prime identification task to assess prime awareness is present without motor priming. Participants performed a metacontrast masking study with verbal responses, thereby excluding the contribution of hand-motor activation. The posterior contralateral negativity (PCN) related to attentional orienting was also present after invisible primes, indicating that the priming effect cannot be solely due to motor priming. Although the attention-related explanation is supported, we cannot exclude the influence of perceptual priming. No differences were observed between the prime localization and prime identification tasks, which suggests that differences in previous studies may be due to motor priming. [This work was financially supported by the Polish National Science Centre (2016/23/N/HS6/00793).]

When color "counts": evidence of color-selective numerosity adaptation

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Perceptual adaptation is considered a key mechanism enabling reduced computation of redundant environmental information to allow increased sensitivity to deviants. Like other primary visual properties, the perception of numerical quantities is susceptible to adaptation. Previous findings showed that numerosity adaptation is not linked to the basic, non-numerical, perceptual features of the items such as contrast, size, and orientation, suggesting that numerical-related short-term plasticity has a rather coarse environmental tuning. In the present work we investigated whether numerosity adaptation is sensitive to a highly salient visual feature such as color. Our results revealed that the magnitude of numerosity adaptation strongly depends on the perceived color similarity between the adaptor and the test stimulus. Specifically, when the two stimuli shared the same color, the perceived numerosity of the test was compressed by around 25% but remained close to veridical when the adaptor had a different color. In agreement with previous findings, our data also showed that such a selectivity did not occur when a less salient visual attribute, like orientation, was used. Taken together, our results support the idea that short-term visual plasticity associated with visual numerical cognition is selectively tuned to highly salient visual attributes like color. This selectivity may have evolved through its behavioral relevance. [This research was funded from the European Union (EU) and Horizon 2020—grant agreement no. 832813—ERC Advanced 'Spatio-temporal mechanisms of generative perception—GenPercept'; from the Italian Ministry of Education, University, and Research under the PRIN2017 programme (grant no. 2017XBJN4F—'EnvironMag' and grant no. 2017SBCPZY—'Temporal context in perception: serial dependence and rhythmic oscillations'). The authors declare that there is no conflict of interest.]

Motion after effect is perception-based, not only signal-based

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We consider motion after effect (MAE) in the context of multistable visual dynamic stimuli, more specifically whether MAE is uniquely driven by the signal (visual stimulus), or whether MAE can also be induced by the percept (visual

interpretation of the stimulus). We use a plaid composed of two gratings as a dynamic visual stimulus. We modulate the transparency of the gratings to create an ambiguous plaid (1 signal with 3 possibles percepts: lines that move upward - called 'coherent'-, the right or the left), and three unambiguous plaids (1 signal with 1 possible percept - coherent, right or left - for each plaid). 22 subjects are presented in each trial with either ambiguous plaids (12 trials) and non-ambiguous plaids (12 trials, four of each type). A trial consisted of two phases: the plaid is dynamic during the first 20 seconds of the trials (induction) and held fixed during the remainder (test). The subject is asked to report the perceived movement of the stimulus (keyboard, continuous reporting) during the whole trial (induction and test). We investigate whether the illusion of movement during the test is opposite to the perceptual history obtained during the induction. To do this, we model the perceptual sequence as a Markov Renewal Process (MRP) with percepts as states. In the non-ambiguous trials, the signal induces the desired MAE. An effect based on percept is measured in the ambiguous trials. This shows that MAE can be induced by percept and are not limited to mere signal adaptation. [JL's thesis funded by Univ. Grenoble Alpes, IDEX IRS (Initiatives de Recherches Stratégiques), Grenoble, France.]

Coworkers or competitors? The case of symmetry and prototypicality

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The two 'old buddies' of visual perception are still in the focus of preference studies. There is multiple evidence on the significance of symmetry and prototypicality, either. As it has already been showed in empirical aesthetics, lateral symmetry is one of the main predictors of aesthetic judgements, especially in the case of abstract pictures. It is also known that this preference decreases with visual expertise. Experts seem to prefer abstract pictures more, as well as non-figurative over figurative. The other above mentioned important factor is the prototypicality of the stimuli. According to the prototype preference model, the cognitive processes of recognition and categorization contribute to a positive aesthetic judgement. With this study we aim to investigate the preference depending on these variables and find out which of them tend to dominate in aesthetic processing. We also try to find out how visual expertise modify these preferences. Therefore, we created special visual stimuli in which the same elements are present in a symmetric/asymmetric and a figurative/non-figurative form. In case of half the visual stimuli the symmetric version is also the prototypical one, in case of the other half, it is the asymmetric one. Our main question is whether symmetry or prototypicality is more dominant in the aesthetic judgement. Using these picture series made of the four different constellations of the same elements, we measure the preferences of experts and non-experts. The results bring us closer to understanding the hierarchy and codependency among the factors of the visual aesthetic judgements.

To see or not to see: camouflage and human processes of detection

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Humans are prone to failures when it comes to detecting objects in their environments which may require action or evasion, even in high consequence situations such as road traffic scenarios. The current study draws upon concepts from evolutionary theory and animal camouflage in order to computationally evolve targets to either be visible or camouflaged in naturalistic environments. The efficiency of these stimuli was then validated using human observers during a visual search task. A genetic algorithm was used to evolve targets with phenotypic variation in stripe number and alternating stripe luminance. Targets were evolved to be either visible or camouflaged in various locations within grey scale suburban road scenes. Individual fitness was evaluated using both a Canny edge model and Gabor filter model. Online testing with human observers (n=52) showed that there was a significant effect of computation evolution, with final generation camouflage targets eliciting longer reaction times and a greater number of failures (no detection after 15s) compared to first generation (and therefore random) targets. Conversely, final generation visible targets elicited significantly shorter reaction times and fewer failures. Furthermore, using a Gabor filter model to evaluate phenotypical fitness was superior to Canny edge for camouflage, i.e. these targets elicited the longest reaction times/ most failures. Overall, this study suggests it is possible to use computational means to create stimuli which may be optimally visible or camouflaged in naturalistic scenes. These findings have direct implications for the design of safety garments in the real world, such as (motor)cyclist apparel. [Funded by the Leverhulme Trust.]

A novel saccadic re-referencing training with simulated central vision loss

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Patients with central vision loss (CVL) adopt an eccentric retinal location for fixation, a preferred retinal location (PRL), to compensate for vision loss at the fovea. While most patients with CVL can rapidly use PRL instead of the fovea, saccadic re-referencing to PRL develops slowly. Here, we introduced a new method to train saccadic

re-referencing to a predefined, "forced" retinal location (FRL), 5° below fixation. The training was a visual search task that had target(s) ("X") among distractors ("O") in the presence of a gaze-contingent scotoma of 8° diameter. Participants' response was to fixate targets with the FRL. In Experiment 1 (N=24), comparing single-target classical search and multiple-target foraging search, the participants underwent training for 5 days (1 hr /day). Experiment 2 (N=6) investigated the effect of marking the FRL during search and optimal training gain; the participants underwent foraging training for 25 days. In both experiments, performance estimated in the form of reaction time, number of fixations, and scan-path ratio improved after training. Overall, training gain was comparable for single-target search and multiple-target search. These improvements were observed even in the absence of an FRL marker. After 25 days of training, search performance with simulated scotoma approached normal search in the non-scotoma control group, but the scan-path ratio was still significantly less efficient. As a next step, we aim to test this re-referencing training in patients with central vision loss. [The project was funded by the federal state Saxony-Anhalt and the European Structural and Investment Funds (ESF, 2014-2020), project number ZS/2016/08/80645.]

Spatio-temporal dynamics of foveal visual search

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Visual search is normally associated with large saccades, which are used to explore the visual scene. However, we previously showed that, once the object of interest is foveated, observers engage in active exploration of foveal details using precisely guided microsaccades. Here we investigated the spatiotemporal dynamics of foveal exploration, and the contribution of top-down and bottom-up factors in driving visual-search. Subjects (n = 8) were instructed to search for a target, a small tilted bar (1x8 arcminutes in size), in an array of 7 similar items presented foveally (0.5 deg,half the size of the foveola). The task-relevance and salience of each item was manipulated independently. Salience was modulated by changing the contrast, whereas task relevance was modulated by changing the similarity of each item to the target. Gaze position was tracked using a high-precision eye-tracker. Our results show that, even if the stimuli were presented foveally, subjects engage in active visual search, using microsaccades as small as 10 arcminutes. When multiple items of similar relevance are presented, it takes ~500ms for the system to establish a priority map and drive an eye movement toward the search target. This is reduced on average by 150ms, and the accuracy of fine oculomotor behavior increases, when the target is perceptually salient. Furthermore, salient distractors do not influence oculomotor behavior and performance in the task. These findings suggest that the search pattern is modulated by saliency at the foveal scale, and that salient distractors are actively inhibited at no-cost for the visual system. [Facebook Reality Labs.]

The underlying mechanisms of processing multiple attentional control sets: a neuro-computational modeling study

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Over the last ten years, several studies have explored how human subjects allocate their attention to two different targets at two specific locations. While reaction time data lead to a rather conflicting picture, ERP data suggests that subjects can not attend to two conjunctive targets of color and location. Here, we present a neuro-computational model to investigate how attention develops during attending to two different features at two different locations. Our model is composed of two components: an attention component to show the underlying neural mechanisms of attentional processing during the task and a decision making component to show the underlying processing to make a decision about the response. We simulated a classical task in which subjects are required to respond to one of the two defined targets, called attentional control set (ACS), where each target is defined by a specific color and a specific location. Targets were preceded by non-predictable cues which were congruent or incongruent to the target in location, or in color, or in both. By means of our model, we discuss the conditions under which behavioral reaction time data can be inconclusive with respect to the number of ACSs. Further, we replicate ERP data and thus shed more light on the dynamics of attention in these tasks. Our results suggest that initially, attention is allocated globally to two features, regardless of their locations, and then converges on the target by spatial reentrant processing. [This research has been supported by the grant of Cognitive Sciences and Technologies Council of Iran, European Social Fund (ESF), and DAAD Scholarship STIBET III.]

Does attending to a time point result in temporal suppression at other time points?

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The Selective Tuning (ST) model of visual attention proposed that selection of an attended element includes suppression of

the visual network portions that surround the attended element. When attending to a particular location or feature, processing of visual information at nearby locations or features is suppressed. Here, we investigated whether attending to a point in time leads to suppression at nearby time points. We presented a sequence of 10 letters at the screen's center (SOA 100 ms). One of these letters was the target T, and observers indicated its orientation. In the informative blocks, the target appeared in the same frame within the sequence on most of the trials ('expected' condition). On the rest of the trials, the target appeared one or two frames before/after the most-probable frame ('unexpected' condition). The most-probable frame varied between blocks. The observers were told which is the most-probable frame at the beginning of the block. In the neutral block, the target appeared randomly in one of the frames. We found significantly higher accuracy in the expected condition than in the neutral and unexpected conditions, indicating that participants allocated temporal attention to the most-probable frame. Furthermore, in blocks where the target was expected to appear in the 4th or 5th frame, there was a significant decrease in performance when the target appeared two frames after the expected frame. Consistent with ST's predictions, such an attention-driven temporal suppression may play a role in the precise timing required for dynamic visual behaviors. [Funded by Air Force Office of Scientific Research (FA9550-18-1-0054), the Canada Research Chairs Program (950-231659), the Natural Sciences and Engineering Research Council of Canada (RGPIN-2016-05352), and the Israeli Council for Higher Education - Planning and Budgeting Committee.]

Hue and chroma discrimination of matte rendered objects

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Our understanding of the chromatic discrimination of hue and saturation is largely based on uniform patches, which have low ecological validity. The distributions of real-world objects vary in chroma and luminance due to interactions between their material properties and the illuminant (e.g., shading). Here, we explored the chromatic discrimination performance of realistic rendered objects for chroma (changes radial from the adaptation point) and hue (changes tangent to the hue circle) in DKL space. Stimuli were either uniform discs (controls) or matte rendered amorphous blobs with the chromaticity of their diffuse component defined in one of two quadrants of the isoluminant plane (positive L-M and either negative ("orange") or positive ("violet") S-LM). The rendered blobs exhibited a chromatic distribution varying largely in chroma and luminance. Ten observers completed a 4AFC task controlled by the adaptive staircase method QUEST, receiving feedback after every trial. Supporting previous results, we showed that in the negative S-LM quadrant, hue thresholds were much smaller than chroma thresholds ($p<0.001$), while in the positive S-LM quadrant, hue and chroma thresholds were comparable. This pattern arose for both discs and blobs, albeit thresholds were higher for the blobs ($p<0.001$). Observer variability for hue and chroma was also higher for "violet" colors (SD=0.0135) compared to "orange" colors (SD=0.0051). Notably, for the blobs, chroma thresholds did not increase significantly more than did hue thresholds, despite their chromatic distributions exhibiting greater variability in chroma. The use of natural objects does affect color discrimination, but the source of the above disparities remains unclear. [Supported by ERC Advanced Grant Color 3.0 (project number 884116).]

Colour vision aids for Colour vision deficiency patients: A Systematic Review

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Colour vision deficiency is the inability to distinguish certain shades of colour and there is no cure for inherited colour deficiency. The current review aimed to compare different colour vision aids available for colour vision deficiency (CVD) and whether these devices improve their colour perception. However, there is insufficient evidence supporting the use of electronic or optical colour vision aids that improve colour perception with the current advanced technology although devices such as Enchroma CVD device, Cytochromic oxide filters are commercially available. We used search strategies in, PROSPERO, PRISMA and Cochrane Central Register of Controlled Trials (CENTRAL) (which contains the Cochrane Eyes and Vision Trials Register) databases available till (2020) followed by PUBMED, MEDLINE Ovid; Embase Ovid; BIREME LILACS, Open Grey, the ISRCTN registry; ClinicalTrials.gov and the World Health Organization (WHO) International Clinical Trials Registry Platform (ICTRP), US National Institutes of Health Ongoing Trials Register Clinical trials. National Institute for Rehabilitation Engineering (NIRE) database from 1967 to 1987, has a registry of all the colour vision devices manufactured. From the (N=26) reviewed studies and analysis, we found that only a few studies reported clinical trials with colour vision aids and found colour vision scores improved. There is poor and low level of clinical evidence to claim that commercially available colour vision aids improve the colour perception. The analysis informs further exploration and studies in this area related to the title of the presentation. [Acknowledgements: PROSPERO Systematic review database, University of York for registering the Systematic review title: Colour Vision aids for Colour vision deficiency patients and outcome in colour perception. CRD42020155169 (PROSPERO-2020) https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42020155169.]

Lighting color preferences in Czech drivers – do they matter in subjective glare evaluation?

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Lighting color preferences have been extensively studied regarding new light sources, especially LEDs (e.g., Dangol et al., 2013; Jost-Boissard et al., 2015; Huang et al., 2020a,b; Muramatsu et al., 2017), but apart from the ongoing work of Flannagan and colleagues, rarely in the context of car headlamp glare. The aim of our research was to determine whether some sort of association exists among the preferred color rendering of a light source (halogen bulb, „white", „blueish" and „yellowish" LED) in a whitebox, illuminating a Munsell color chart, and the subjective evaluation of discomfort glare from the same light sources mounted into car headlamps (low beams) using the deBoer scale. Together, n = 46 participants with various quality of sight (23 males, 23 females, age range 20–71 years, M = 35 years, SD = 14 years) took part in the laboratory experiment. Using descriptive and inferential statistics, we were able to determine their preferences regarding car headlamps color rendering, as well as the associations between these preferences and the perceived glare by different light sources from the „oncoming vehicle". [This article was supported by the Technology Agency of the Czech Republic, Project No. TL02000183, „Human and traffic safety in the development of lighting technologies" [Člověk a bezpečnost v dopravě v souvislosti s rozvojem světelných technologií]. The partner of this project is Hella Autotechnik Nova, s.r.o., a company manufacturing, among others, car headlamps, where one of the authors has previously been employed. The company intends to use the results of the proposed research in order to improve its products and service offered to its customers. For this purpose, valid and reliable data is required, and we therefore do not assume a conflict of interest in terms of data distortion.]

Computational Modeling of Human Multisensory Source Localization by a Neural Architecture

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Our brain constantly receives inputs from different sensory modalities and, to build a functional representation of the environment, it must often combine perceptual information. To date, multisensory integration has been extensively studied using neuroscientific approaches. The works that used such approaches focused on the neural correlates at the basis of this mechanism – while computational applications have been seldom implemented. Thereby, we developed a deep neural architecture that can mimic humans' audio-visual source localization to fill this gap. The ventriloquist illusion, in which the source localization of an audio-visual stimulation is shifted towards the visual information, was used as an adequate benchmark to test our architecture's plausibility. We modified our architecture to receive as input auditory, visual, and audio-visual data (rather than creating one able to localize stimuli regardless of the sensory modality) since audio, visual, and audio-visual source localization are separate mechanisms within the brain. We trained our deep neural networks using ground truth coordinates for localization, and then we compared their performance with the humans' ability to pinpoint the position of either auditory, visual, or misaligned audio-visual stimuli. All three networks accurately reproduced humans' performance: visual localization was more precise than the auditory one, and the audio-visual localization was strongly biased towards the position of the visual information, replicating humans' ventriloquist illusion. Taken together, these networks represent a veridical approximation of the brain's ability to integrate audio-visual information. These results can be considered as a starting point to link perceptual and computational models of multisensory processing.

Causal link between the phase and amplitude of spontaneous alpha oscillations, cortical excitability and visual perception

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The phase and amplitude of spontaneous alpha (~10 Hz) oscillations independently modulate both cortical excitability and visual perception. The causal role of alpha phase-amplitude tradeoffs is, however, still ill-defined. The Pulsed Inhibition theory (Klimesch et al., 2007; Jensen & Mazaheri, 2010) makes two clear predictions: 1) high alpha amplitude induces states of cortical excitation at optimal alpha phases and cortical inhibition at the opposite, non-optimal phases, leading to periodic perceptual performance;

and 2) low alpha amplitude induces overall higher cortical excitability, decreasing susceptibility to phasic pulsed inhibition, and leading to overall higher perceptual performance. Here, we reanalyze the data of a previous study that uses transcranial magnetic stimulation (TMS) applied over the visual cortex (V1/V2) in human participants to elicit phosphene (illusory) perception at threshold (50% detection), with simultaneous electroencephalography (EEG) recordings (Dugué et al., 2011). We investigate the causal role of alpha phase-amplitude tradeoffs on cortical excitability and visual perception. The results show that the phase of spontaneous alpha oscillations modulates the probability to perceive a phosphene (with a non-optimal phase between -π/2 and -π/4), predominantly for high alpha amplitude trials. Additionally, the post-pulse event-related potential (ERP) increases in phosphene-perceived trials when the pulse is applied at the non-optimal phase of alpha oscillations. Together, these results provide strong evidence in favor of the Pulsed Inhibition theory, demonstrating a causal link between the amplitude and the phase of spontaneous alpha oscillations, cortical excitability, and subsequent visual perception. [This project has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation program (grant agreement No 852139 – Laura Dugué), the Agence Nationale de la Recherche (ANR) - Deutsche Forschungsgemeinschaft (DFG) program (grant agreement No J18P08ANR00 – Laura Dugué), and the ANR program (grant agreement No ANR-19-NEUC-0004 – Rufin VanRullen).]

Investigating perceptual rhythms across retinotopic space

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Perception is not stable over time. Studies have shown that the probability of detecting a stimulus fluctuates periodically. Performance tends to rise and fall depending on the phase of spontaneous brain oscillations at low frequencies (<20 Hz). However, previous research reports that phase accounts for less than 20% of the variability in perceptual performance. Here, we aim to better characterize the mechanism underlying perceptual rhythms. Using psychophysics, we investigate whether the spatial organization of alpha (~10 Hz) oscillations modulates perceptual performance across the retinotopic space (Sokoliuk and VanRullen, 2016; Fakche and Dugué, in prep). Participants were asked to detect near-threshold dots (50% detection) while their alpha brain activity was tagged at 10 Hz (simultaneous electroencephalography recording) using a checkerboard annulus (interior radius: 3° eccentricity; annulus width: 12°; spatial frequency: 0.63 cycles/degree of visual angle) around a central fixation (pattern reversal at 10 Hz). Target dots were presented at random delays and at three possible eccentricities between the annulus and the fixation cross (2.16°, 2.45°, and 2.81°; dot's size and eccentricities adjusted according to cortical magnification). We assess whether (1) performance is modulated periodically at each target position; and (2) the optimal phase (phase at maximal performance) shifts as a function of target position. Our study systematically evaluates the influence of alpha brain oscillations on visual perception across the retinotopic space. [This project has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation program (grant agreement No 852139 – Laura Dugué).]

The spatial leaky competing accumulator model

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The Leaky Competing Accumulator model (LCA) of Usher & McClelland (2001) is able to imitate the time course of perceptual decision making with use of arbitrary amounts of visual stimuli as an input. We propose a new implementation called Spatial Leaky Competing Accumulator (sLCA), which exploits this LCA ability, but uses a saliency map as an input instead of multiple items abstract in space. The sLCA shares such parameters of the original model as leakage, recurrent self-excitation, randomness and non-linearity but also includes the novel version of lateral inhibition parameter. It allows only inhibition of immediate neighbors instead of all processing units, which is motivated by a better biological plausibility. All parameters of both original and improved models were optimized using the genetic algorithm, and their performance was compared in simulating human RT distribution in the visual search task. According to the Kolmogorov-Smirnov statistic, only the sLCA was able to fit the positively skewed human temporal data distribution.

The role of population receptive field size and recurrent processing in learning to "de-crowd"

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In crowding, the perception of a target is impeded by surrounding clutter. While traditional models are feedforward

and local, there is increasing behavioral and neural evidence for a critical role of recurrent processing across the visual hierarchy in crowding. Our recent fMRI findings suggest that higher visual areas, sensitive to global context, determine whether target and flanker features are combined within a single population receptive field (pRF) or rather the target is separated from the flankers in a smaller pRF, likely through recurrent processing. Here, we investigated the neural correlates of perceptual learning to "de-crowd". Twelve participants trained on an orientation discrimination task under crowding, with the stimulus always presented in the top-right quadrant. Performance on the crowding condition improved substantially in the trained quadrant, but only to a lesser extent in an untrained quadrant. No significant improvements were seen in a no-crowding condition. We used fMRI to estimate pRF sizes in visual areas V1 to V4, separately in areas representing the four visual quadrants. We used dynamic causal modeling to compare bottom-up, top-down, and recurrent models of learning-related modulation of connectivity between visual areas. We found a substantial decrease in pRF size only in left ventral V3, corresponding to the trained visual quadrant. Learning to de-crowd modulated recurrent connectivity across the visual hierarchy, whereas only bottom-up connectivity was modulated in no-crowding. Our findings suggest that improvements in target discrimination under crowding are mediated by top-down processing, which determines the segmentation of the target and flankers through pRF size adjustment. [We would like to thank our funding sources: Swiss National Science Foundation (NCCR Synapsy, project grant numbers 32003B_135679, 32003B_159780, 324730_192755, CRSK-3_190185, 176153), the Leenaards Foundation, Fondation ROGER DE SPOELBERCH, and the Partridge Foundation.]

Crowding occurs at different stages of visual processing

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Crowding refers to the inability to recognize objects in clutter, setting a fundamental limit on conscious visual perception. Prevailing theories of crowding attribute crowding to the integration or "pooling" of low-level features at a single, relatively early stage of visual processing. More recent research suggest that crowding occurs at different levels of visual processing, even between configural representations of objects. In this study, we investigated the processing stage at which crowding occurs by exploring whether crowding errors depend on the level of visual processing. Observers performed an orientation estimation task of a target (a rectangular black shape with subtracted edges) when presented alone, or in two crowding conditions. In one condition, the flankers were aligned to create a coherent illusory rectangular configuration, whereas in the second condition the flankers were misaligned, so no illusory shape was formed. For each trial, we calculated the estimation error for orientation by subtracting the true value of the target from the estimation value and analyzed the error distributions by fitting probabilistic mixture models. Results showed that in many trials participants misreported the orientation of a flanker instead of that of the target. Interestingly, in some trials the orientation of the global configuration was reported instead of the target, the probability of which was higher when the flankers formed an illusory rectangle than when the flankers did not form an illusory rectangle. The present results suggest that crowding occurs simultaneously across multiple stages of visual processing and depends on the spatial configuration of the stimulus.

Investigating the integrality of face perception with the Garner selective attention paradigm

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The human face carries rich information about social dimensions such as sex, age, and expression. A key element of models of face perception is the proposal that some such dimensions are processed independently of others. The current experiments were designed to better understand the relationship between representations of sex and age from facial appearance. To do so, Garner effects and Stroop effects were measured in a selective attention task performed online by adult observers. On each trial, a single face was presented and participants were asked to make binary judgements about either sex or age. In different blocks, the other, task-irrelevant dimension was either held at a fixed value (control blocks) or varied orthogonally to the task-relevant dimension (orthogonal blocks). A Garner interference effect – slower/less accurate responses in the orthogonal relative to control blocks – would indicate a failure of filtering, providing evidence for integral processing of the two dimensions. In contrast, Bayesian analyses revealed evidence for no Garner effect in comparisons between each of the control and orthogonal blocks (all $BF10 < 0.46$), suggesting parallel processing of age and sex. In turn, within the orthogonal blocks, we compared performance on stereotype-consistent pairings (male/old, female/young) with inconsistent pairings (male/young, female old) – a Stroop-like measure. Here, the age task (but not the sex task) revealed a significant Stroop disadvantage for inconsistent vs consistent pairings, $p<0.001$. These findings suggest initial parallelism in processing of face age and sex, with downstream cross-dimension effects that may reveal the influence of semantic associations.

Do facial cues of body weight influence perceptions of happy and sad facial expressions? Evidence from an Arab sample

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Facial expressions of emotion play an important role in social interactions. Recent work has suggested that experimentally increasing body-weight cues makes faces displaying happy expressions look happier and makes faces displaying sad expressions look sadder. These results were interpreted as evidence that a 'heavy people are happier' stereotype influences emotion perception. Because this original study was carried out at a university in the USA, and emotion perceptions can differ across cultures, we undertook a conceptual replication of this study in an Arab sample. We found that experimentally increasing body-weight cues made faces displaying happy expressions look significantly happier, but did not make faces displaying sad expressions look significantly sadder. These results present partial support forthe proposal that a 'heavy people are happier' stereotype influences emotion perception and that people integrate information from face shape and facial expressions in person perception. [We thank Lisa DeBruine and Vanessa Fasolt for assistance with computer graphics, Kieran O'Shea for feedback, and Noura Al-Moubayed for assistance with translations.]

Effect of Varying Facial Region Visibility on Perception

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With the rise of COVID-19, masks have become crucial to our lives. Studies show impairments of face memory by masking. Here, we address the effect of masking on the perception of face identity, focusing on immediate recognition of faces rather than relying on long term memory storage. Because information about the eyes and eyebrow region drives face identification in younger individuals, it remains possible that medical masks will have less impact on face identity perception compared to face identity memory. We further asked whether masks act as a feature that interferes with face processing in and of itself, rather than a lack of access to information about facial features. To test the effects masks had on perception, each participant completed 400 trials (200 upright) in a 5-AFC task. A target face stimulus was presented, followed by 5 selection faces; the participant chose the face that matched the target. Each participant was randomly assigned to one of three facial conditions: full (full visible face), masked (medical mask covering the nose, mouth and chin), and blurred (the lower half of the face was removed, starting at the upper location of the mask, and blended into the background). Each group viewed both upright and inverted faces. Our initial results show better identification of full faces than masked faces, and better for masked than blurred. Inversion effects were seen in all cases. Thus, masks hinder immediate face perception but appear to provide some protection for face identification compared to the removal of facial features. [NSERC.]

Behavioral and computational assessment of the role of spatial frequencies in emotion detection

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Models of emotion processing suggest that threat-related stimuli such as fearful faces can be detected thanks to the rapid extraction of low spatial frequencies. However, this remains debated, and other models argue that the decoding of facial expressions occurs later, with a more flexible use of spatial frequencies. In this study, we used a saccadic choice task to investigate the detection of emotional (happy or fearful) and neutral faces. Emotional-neutral pairs of faces were presented, and participants were asked to saccade toward the emotional or neutral face. Faces were displayed either in low spatial frequency, high spatial frequency, or without filtering. In parallel, we implemented a convolutional neural network to simulate this task. The network classified each pair of images depending on whether the emotional or neutral face was on the right or left side of the pair. Results showed that participants were better to saccade toward the emotional face. They were also better for high than low spatial frequencies, especially with a happy face. The analysis of CNN-based class saliency maps indicated that the mouth region was crucial to succeed in the task. Moreover, the mouth importance, calculated from these maps, was a significant predictor of human performance. This suggests that (1) the simple statistical properties of images, with regard to a specific task, can explain emotion detection in humans, and that (2) CNN-based class saliency maps can be used as tools to understand and predict human behavior in a particular task.

Impact of face covering on the formation of first impressions from faces

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The emergence of Covid-19 as a global public health crisis has resulted in the legal requirement to wear face coverings in public spaces. Although face covering can reduce our ability to recognize other's face identity and facial expressions, little is known about its impact on the formation of first impressions from faces. In this online study, we presented unfamiliar male and female faces displaying neutral facial expressions with and without face masks, and asked participants to rate the perceived approachableness, trustworthiness, attractiveness, and dominance from each face on a 9-point scale. The State-Trait Anxiety Inventory and Social Interaction Anxiety Scale were also used to measure participants' anxiety level. Our analysis revealed in comparison with no face mask condition, face covering increased the perceived approachableness, trustworthiness, and attractiveness; but decreased the dominance rating. Such face mask-induced modulatory effect was more evident for male than female faces. Furthermore, participants with higher trait and state anxiety scores tended to have higher dominance ratings for unmasked female faces than their masked counterparts. It seems that the presence of a face mask can distort our first impressions of strangers. Although the ratings for approachableness, trustworthiness, attractiveness, and dominance were positively correlated, they were subject to different influences from face coverings and participants' anxiety levels.

When every face feels familiar: A case of hyperfamiliarity for faces and other categories

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Hyperfamiliarity for faces is a condition in which many or all unfamiliar faces feel familiar. In August 2020, Nell, a 49-year-old woman, experienced a migraine that produced visual disturbance in the left visual field, followed by a severe headache on the right side. This pattern reverses the laterality of her normal symptoms. Since the migraine, all faces feel familiar to her and her feelings persist even when she knows she has not encountered a face before. For example, while walking along the seaside several hours from her hometown, nearly everyone she passed felt familiar. To formally assess Nell's hyperfamiliarity, we tested her with a face old-new test; she was perfect with old faces but false alarmed on 63% of new faces. When asked to choose the celebrity from a pair of faces consisting of a celebrity and a doppelganger of the celebrity, Nell scored at chance. She reported that both faces felt familiar. In contrast, when presented with the CFMT, in which test items are simultaneously-presented triplets of faces made up of a target face and two distractor faces, Nell scored a standard deviation better than the control mean. Interestingly and unlike previously reported cases of face hyperfamiliarity, Nell reports that unfamiliar faces often morph in the cheek region toward familiar faces. Nell does not show hyperfamiliarity for voices or for any of the 3 object categories tested, but she does report hyperfamiliarity for names and license plates so her condition does not appear to be face-specific.

Behavioral Oscillations in Rapid Face Detection

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Theories of rhythmic perception propose that perceptual sampling operates in a periodic way, with moments of high and low responsiveness to visual stimuli interleaving with each other. This rhythmic sampling seems to be modulated by brain rhythms and leads to oscillations in behavioral outcomes. Previous studies have revealed behavioral oscillations in low-level visual tasks and object categorization. However, little is known about the oscillatory effect in face perception, for which the human brain has a highly dedicated network. To investigate this, we adopted a dense sampling technique and the dual-target rapid serial visual presentation (RSVP) paradigm. In each trial, a stream of object images was briefly presented at 30 Hz. Two identical face images (the target) were embedded among the baseline images with a randomly selected inter-stimulus interval (ISI) in between. The ISI varied from 0 to 646 ms in steps of 34 ms. The task was to indicate the presence of the target and its gender if present. Face detection performance decreased as the ISI increased and reached a plateau at 127.6 ms, consistent with a temporal integration window at around 100 -150 ms. A strong oscillation was found in face detection task at 7.5 Hz, presumably driven by a rhythmic attentional sampling at the theta range. Grouping the trials by target's gender, we found different oscillations for female and male faces at 10 and 7.5 Hz respectively, suggesting that people might rely on different features in the detection of female and male faces.

Perisaccadic visual identification of facial expression: Psychophysics basis

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A series of gaze-contingent eyetracking experiments for visual perception under extreme temporal conditions was

held. Saccadic suppression phenomena was investigated with a naturalistically valid stimulus in mind (i.e. facial expressions). Both peri- and intrasaccadic identification rates were measured. Evidence is found supporting notion that visual identification of facial expressions during saccades is possible. Very few signs of saccadic suppression were found. No V-shaped suppression curve was observed in temporal proximity to saccade onset (Zherdev & Barabanschikov, 2021). Control study have shown that visual performance during saccade is similar to that during fixations, provided all other psychophysical parameters are equalized. [Funded by Russian Scientific Foundation, project #18-18-00350-P 'Perception in the structure of nonverbal communication']

Empirical evaluation of computational models of lightness perception

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Lightness of a surface depends not only on its physical characteristics, but also on the properties of the surrounding context. As a result, varying solely the context can significantly alter surface lightness, an effect exploited in many lightness illusions. Theoretical models of lightness perception attempt to explain lightness illusions by using wide range of mechanisms (i.e. lateral inhibition, decomposition, perceptual grouping). Computational models implement algorithms that operationalize proposed mechanisms, thus allowing us to calculate precise quantitative predictions for each input stimuli. Four illusions: Simultaneous lightness contrast (SLC), Maniatis SLC (2015), Reverse contrast (Economou et al., 2015) and White's illusion (1979), each consisting of the same three luminance levels (0.15, 9.41, 45.58 cd/m2) were shown to human participants and tested with four computational models (Oriented Difference of Gaussians (Blakeslee & McCourt, 1999), High-Pass (Shapiro & Lu, 2011), RETINEX (McCann, 1999) and Markov Illuminance and Reflectance (MIR (Murray, 2020))). Our results (included in Appendix) show that all tested models correctly predicted (i.e. match the human data) the direction of the illusion for the SLC and the Maniatis SLC. The High-Pass model successfully predicted the absolute lightness levels, while MIR was the best at predicting the perceived illusion size. Only the High-Pass model correctly predicted obtained effect for the White's illusion. The tested models could not predict the illusion direction of the Reverse contrast. It appears that while the tested models are able to predict human data for classical contrast effects, they struggle with the reversal of the classical contrast effect.

How do we measure visual response to light?

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Measuring our visual response to light is a fundamental step in both psychophysics and physiology. But the different ways we measure the visual response gives us different response functions (e.g. lightness = cube root; receptors = logarithmic). Natural Scenes with nonuniform illumination generate very High-Dynamic Ranges (HDR) of scene luminances. This talk describes how intraocular glare transforms scene luminances into very different retinal luminance. Next, iwe report observers match to a variety of different ~ 6 log10 unit complex test targets. Then, it analyzes our visual response function using the quanta catch of receptors as input, observer matches as output. The results show that different HDR scenes have substantially different input/output visual response functions. The paper concludes with a summary of the visual mechanisms that give different responses to the different light distributions (scene content) in different scenes. Visual response functions vary in different parts of a single HDR scene.

Automaticity of taxonomic and functional knowledge activation during real-world visual scene processing

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Although vision guides our everyday actions, the role of functional (action-based) knowledge in understanding real-world visual scenes has long been neglected. Typically, research has focused on taxonomic knowledge, related to the scene's context and the expected objects within it, and suggested that its activation is automatic and obligatory during scene processing. We compared functional and taxonomic knowledge, examining automaticity, obligatoriness and the time course of their activation when they are task irrelevant. In two lexical-decision experiments (50% words, 50% pseudowords), we manipulated the relationship and Stimulus-Onset Asynchrony (SOA) between scene images and words. The words were either consistent (naming the scene image, or a highly plausible object or action) or inconsistent (naming another scene image, or an implausible object or action). No named objects and actions were depicted in the images. Experiment 1 used a picture-word interference paradigm, with the word or pseudoword superimposed on the scene image (0ms SOA). Experiment 2 used a priming paradigm, with the

scene image presented as prime at 100ms, 200ms, 400ms, 800ms SOAs. Responses were faster for consistent than for inconsistent words, independently of the word type (scene, object, action) and only at 0ms or 100ms SOA. These results show that knowledge activation about the scene's name and expected objects and actions is automatic and obligatory, but can subsequently be suppressed by endogenous processes. Moreover, they do not corroborate previous suggestions of primacy for functional over taxonomic understanding, indicating that predictions guiding visual scene processing similarly encompass all knowledge highly associated with the scene.

Transfer of abstract structural knowledge across distinct stimulus domains aids learning of novel concepts

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Recent work in structural learning and meta-learning claim that humans can transfer abstract structural knowledge to aid learning across domains. This may also apply for learning new concepts, where learning a new concept structurally similar to an existing concept is easier than learning an entirely novel concept. However, analogical reasoning studies suggest that humans typically fail to do this unless they are given explicit pointers to the relationship, or sufficient perceptual similarity highlighting the parallel across tasks. To test if people can apply abstract, structural knowledge of existing concepts to aid the learning of new concepts, we tested participants (N=152) on two concept-learning tasks that either shared (experimental group) or did not share abstract category structure (control), and provided no hints. The tasks involved learning object-based or room-based concepts, avoiding any perceptual link across tasks. The experimental group completed a concept-learning task with a rule-plus-exception structure, then completed another concept-learning task with the same structure. The control group performed a concept-learning task with an exclusive-or (XOR) structure then a rule-plus-exception structure. We found that the experimental group discovered the concept structure in the first task and applied this knowledge to speed up learning in the second task (d=0.51). The speed up in learning was greater than the control group (d=0.38). Our results show that humans can extract the abstract category structure from perceptual features of existing concepts and apply it to aid the learning new concepts across entirely different stimulus domains, even without explicit pointers to the common underlying structure.

[Funded by the Leverhulme Trust, Medical Research Council, and Wellcome Trust.]

Iconic memory in auditory impairment-ISL & BSL study

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Sign language involves signs and gestures which are routinely used by people who are deaf and have a verbal disability. Communication through sign language is an important aspect and the sign enacted will not be merely based on the word but is based on the context of communication. In the current study, we investigated similarities between the Indian Sign Language and the British Sign Language to determine its role in communicating through sign language. This is a questionnaire-based, cross-sectional study. Visual stimulus constituting images of eleven signs in Indian sign language and British sign language was presented to subjects(n=30) and they were asked to rate the similarities for each sign on a visual analog scale. 15 responses were taken from the sign language teachers' group and 15 responses were collected from age-matched normal subjects. The mean age of the teachers and the normal group was 30.6 years (SD 6.49) and 30.7 years (SD 4.6) respectively and the ratings of similarities given to the six signs (Diet, Elbow, Heart, Math, Salt, Weight) were statistically significant between both groups ($p < 0.05$) and it was not statistically significant ($p > 0.05$) for the rest of the five signs(Flow, Heat, Insect, Permanent, Sea). We found that for the limited set of signs, there was (60%) similarity between British and Indian Sign Language.

Adaptation to walking direction in biological motion

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Walking direction provides critical information on the disposition and intention of other people, but little is known about how the brain encodes walking direction across a neuronal population. This study used an adaptation technique to investigate the sensory coding of walking direction in biological motion. In two experiments, we tested how the strength of adaptation effects differ across adaptor and test directions. In Experiment 1, a forced-choice response was made on each trial as to whether the direction of a point-light walker was to the participant's left or right. An adaptive staircase procedure was used to measure

the point of subjective equality before and after adaptation to 13 walking directions ranging from +/-90 degrees. We found that adaptation resulted in repulsive aftereffects, with +/- 30 degree adaptors producing the largest effect. Experiment 2 was conducted using stereoscopic stimuli on a 3D monitor to allow unambiguous representation of the full gamut of walking directions. We chose -30, 0 and 30 degrees as adaptor directions. Participants responded by using a spherical on-screen pointer that could be rotated in the horizontal plane to indicate perceived walking direction. We found that adaptation to all 3 directions was well fit by a single tuning curve as a function of the difference in adapting and test directions. Our work shows repulsive aftereffects after sensory adaptation whose magnitude depends on the difference between adapting and test directions. The observed pattern of data indicates the existence of neural mechanisms in human visual system tuned to specific walking directions. [Funded by the Australian Research Council.]

Temporal characteristics of visual processing of agents in action observation

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To investigate the effect of prior knowledge and presentation mode on the temporal characteristics of visual processing of agents during action observation, we conducted two EEG experiments in which human participants were shown videos and images of 3 agents (robot, human, android) performing 8 actions. The main distinction between these experiments was participants' knowledge about the agent identities before the experiment (called naive or prior experiments). We performed time-resolved representational similarity analysis and modeling to reveal when agent information becomes available in EEG during action observation. To this end, we created a categorical Agent model as well as an Action model and two low-level visual models; and performed multiple regression analysis at each time point. We found that the timing of the agent information depends on the experiment type and the presentation mode. In the naive experiment, agent information was available for a longer duration during the processing of images than videos (66–418ms vs. 90–130ms). In the prior experiment, agent information was present for similar durations in image and video conditions (82–296ms vs. 90–242ms). In summary, our results suggest that prior information and presentation mode modulate the onset and duration of agent information in EEG data.

Simultaneously seeing both vertical and horizontal motion in apparent motion quartets during passive and volitional perception

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The apparent motion quartet is an ambiguous stimulus where motion is typically seen either vertically or horizontally. Previous studies have claimed that only one direction can be seen at a time. Here we report that it is possible to perceive both vertical and horizontal motion simultaneously. In Experiment 1, participants passively viewed a single presentation of two frames of the quartet motion sequence, then reported whether they experienced vertical motion, horizontal motion, or "both". We identified the aspect ratio where each participant was equally likely to report vertical or horizontal motion – the point of subjective equality (PSE). Across all aspect ratios, participants reported "both" on an average of 11% of trials. The mean aspect ratio across all "both" trials did not differ significantly from the PSE. Experiment 2 examined volitional perception, the ability to will to see one or the other direction. When the stimulus was set to their PSE from Experiment 1, participants had 75% success in willing horizontal motion (above chance) but failed to will vertical motion better than chance rates. Interestingly, these vertical trials produced more "both" percepts, though fewer than in passive viewing (5.4%). Our results show that it is possible to simultaneously see horizontal and vertical motion in apparent motion quartets as a split in both directions away from the two initial corners. During passive viewing, these split percepts were most common near the PSE. During volitional perception, the split percepts were reduced in frequency and more frequent when willing vertical than horizontal motion. [The research was supported by National Science Foundation Grant 1632738 (P.T.), funding from the Department of Psychological and Brain Science, Dartmouth College (P.C.), a grant from NSERC of Canada (P.C.), and funding from the Women in Science Project at Dartmouth College.]

Functional connectivity of cortical visual-vestibular hub regions

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Self-motion sensation relies on the multisensory integration of perceptual features including vestibular and visual motion cues. Several cortical areas contribute to this multisensory

integration and can be considered together as a visual-vestibular network. Here, we examined the intrinsic functional connectivity between different areas of the visual-vestibular network based on resting-state functional magnetic resonance imaging (fMRI) in human participants (n = 30) and quantified these connections by graph theoretical measures. We collected resting-state fMRI runs (10 minutes each) while participants kept their eyes closed as well as task-based fMRI while participants received vestibular and visual motion cues. Task-based fMRI was used to localize different areas of the visual-vestibular network. Functional connectivity was then calculated between the nodes of this network. Finally, graph theoretical measures for centrality of the network components were assessed. Our results showed that the cingulate sulcus visual (CSv) area, vestibular areas in the postcentral gyrus, the frontal eye fields (FEF), as well as areas in the posterior insular cortex (PIC) and the middle temporal (MT+) complex exert a high node strength and eigenvector centrality. Our results suggest that areas CSv, PIC, MT+, FEF, and postcentral areas might be considered hubs within a visual-vestibular cortical network, emphasizing their critical role in visual-vestibular processing related to self-motion sensation. [This study was supported by the Deutsche Forschungsgemeinschaft (DFG) - Project: GR 988/25-1.]

Vestibular and visual brain areas in the medial cortex of the human brain

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Self-motion perception involves a network of subcortical and cortical vestibular and visual brain regions, including the cortical areas PIVC (parieto-insular vestibular cortex) and PIC (posterior insular cortex) located within the lateral cortex. In the medial cortex, the cingulate sulcus visual (CSv) area has been found to process visual-vestibular stimuli. Here, we report evidence suggesting that the vestibular network of the medial cortex possibly extends beyond area CSv. We examined brain activation in the medial cortex of 30 healthy right-handed human participants by means of functional magnetic resonance imaging during stimulation with visual motion, caloric vestibular cues, or thermal cues. We observed that area CSv responded to both visual and vestibular stimulation but not to thermal stimulation. In addition, we observed a region inferior to CSv within the peri-callosal sulcus (vicinity of anterior retrosplenial) that primarily responded to caloric vestibular cues and which appears to be a vestibular region distinct from other known areas of the medial vestibular cortex. This 'peri-callosal' vestibular brain region did not respond to either visual or thermal cues. Together, our results suggest that the vestibular network in the medial cortex not only includes the visual-vestibular area CSv, but potentially also other previously ignored brain regions such as a region within the peri-callosal sulcus that responds to vestibular but not to visual or thermal cues. [This study was supported by the Deutsche Forschungsgemeinschaft (DFG) - Project: GR 988/25-1.]

Modalities interact across low-levels but not at higher-levels in auditory bistable competition intervened by visual stimulus

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Visual and auditory modalities follow similar mechanisms in multistable perceptual competition in terms of involuntary perceptual switches. It has been suggested that these modalities do not interact with each other across modalities in low-level competition. We hypothesized that cross-modal interactions between audio-visual modalities would occur even if there is a conceptual common ground between them and even if the competition between the conceptual correspondences of the interpretations of a bistable percept is present. Here, we question at which level the core competition between each interpretation takes place. Most studies have focused on the role of auditory intervention onto the visual bistable percepts. Here we took an opposite approach and conducted an experiment in which the auditory stimulus recorded in a repeating manner that will create bistability (i.e. 'fly-fly-fly' becoming 'life-life-life') is intervened by visuals that cause an after-effect and visuals which are semantically congruent or incongruent with the interpretations of the auditory stimulus. Our results show that images with an after-effect lead to an instability in auditory modality, as perceptual switches are a lot more rapid compared to when images with higher-level interpretations — both congruent and incongruent — are presented for equal amount of time. We conclude that the competition at lower-levels are open to intervention across modalities. Our results also support that the core competition occurs at low-levels since the lower-level intervention caused more instability when the visuals are presented for equal duration although there might still be a competition at higher-levels taking place in parallel.

When the happy Krks met the angry Mova – Effects of shape and emotion on object naming

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Köhler showed that people tend to name sharp objects as "takete“ and round objects as „maluma", which is known as sound symbolism. Other researchers have shown a tendency to associate the pseudo-word „takete“ with bad and „maluma“ with a good mood. According to that, our study aimed to investigate possible mediation effects of emotions in associating pseudo-words and object shapes. We used 4 simplified representations of facial expressions of human faces (emoticons) as stimuli, in which the shape of the face (sharp/round) and the type of emotion (happiness/anger) were varied. The experiment was conducted on psychology students (N=30) whose task was to name all 4 stimuli as „krsk“ or „mova“. Results show that both factors, stimuli shape and emotion it depicts, were significant for name choice, while the interaction of the two was not significant. Congruent stimuli show a clear naming preference: round and happy were named as „mova“, and sharp and angry as „krks“. Incongruent stimuli (round/angry and sharp/happy) did not show any preference in naming. We can conclude that the shape of the figure and the emotion it depicts are equally important when choosing a pseudo-word as a name and that their effects are additive.

A Cognitive Study of Tactile Perception in Blind Bilinguals

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Sense of touch becomes an important source of information when the visual status is poor. According to recent studies tactile perception enhanced in blindness after visual deprivation (Wong M et, al.2011). Previous studies reported that visual movement also responds to language that describes motion, sensory perception, and memory (Martin, A., et.al 1995). We aimed to investigate the relationship between tactile perceptions and language proficiency (L1 Telugu) and (L2 English) in blind bilinguals and to see tactile perception influence in blind bilinguals with a second language (English) when compared to (Telugu) as mother language participants while using Braille. This Experimental comparative study is executed with N=30 bilingual participants consisting of both male and female gender of 18-28 years. A self-paced reading task is used as a tactile stimulus with a Braille scripted passage with an equal readability score of Telugu and English scripted Braille. Variables such as reading speed, reading error, reading time to complete tactile sensation tasks were analyzed. We found that poor significance is seen when the reading rate, reading speed, and reading time were observed in (Telugu) [p=0.456] when compared with (English) [p =0.317] whereas a weak positive correlation (r=+0.268) observed within the groups of blind Bilingual participants. A repeated measure ANOVA showed that the bilingual participants had very little mother tongue influence while using English Braille and there was no significant result found [p= 0.673]. The current study emphasizes that Blind bilingual participants do not have the influence of mother tongue in tactile sensations. [NONE.]

Parchment Skin Illusion for Haptic Perception of Viscous Materials

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Multisensory studies show that the way we perceive the surface softness of our hands (i.e., the way the palmar skin feels) becomes more paper-like as the auditory signal levels and high frequencies increase, known as the Parchment Skin Illusion. There is also evidence that manipulating the sound alters the wetness perception of the hands, hence the perceived moistness of the surfaces changes. Here we investigate whether this effect carries on to everyday viscous materials. We measured rheological characteristics of 12 materials (viscosities at room temperature and low shear rates, 2 1/s), and used these from the most viscous slime (184.05 Pas), to e.g. mayonnaise (44.08 Pas), honey (14.95 Pas), shampoo (10.91 Pas), liquid soap (6.11 Pas), olive oil (0.06 Pas), and to the most runny, water (which has a known viscosity of 0.001 Pas). Participants listened to either pink noise (mean loudness = 81 dB) or the noise of water flowing (mean loudness = 54 dB) through noise-canceling headphones while they haptically explored the materials that they cannot see. During exploration, participants rated the materials in 10 softness related (slimy, gooey, gelatinous, moist, sticky, slippery, airy, fluffy, spongy, roughened), and two unrelated adjectives: warm, expensive. We found that when water sound is present, only viscosity-related adjective ratings increase, and this is observed for most materials but not slime or water (most and least viscous). Our findings suggest that the Parchment Skin Illusion is not limited to audiotactile setups with two-dimensional textures, but transfers to active exploration of everyday materials. [Supported by UNESCO-L'Oréal For Women In Science Fellowship Awarded to DND (2020).]

Can Individual Differences in Audio-Visual Binding Predict the Varied Severity of Motion Sickness?

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Motion sickness refers to the feeling of sickness that typically occur during travel. Current explanations focus on

the sensory conflict in the perception of motion, primarily between the vestibular and the visual systems. One intriguing observation is that different people report very different levels of motion sickness under identical conditions for reasons that are currently unknown. To account for these individual differences, we hypothesized that people feel motion sickness only when the conflicting stimuli are perceived as bound together. Accordingly, people with "persistent binding", i.e. those who keep binding multi-sensory stimuli with large inconsistency will suffer more than those who "disconnect" the senses to ignore the mismatch. To test this hypothesis, we measured the persistence of audio-visual binding using the McGurk effect in which a visual presentation of the moving mouth alters the auditory perception of phonemes. We examined the McGurk effect in 3 different tasks: syllable Identification (McGurk), simultaneity judgement, and syllable synchronization judgement. To assess the severity of motion-sickness we used 2 subjective symptom questionnaires. We found that the temporal binding window of the McGurk stimuli in all three tasks varied across individuals and was significantly positively correlated to the motion-sickness questionnaire scores (syllable identification: R=0.86, N=19 adults, simultaneity judgement: R=0.94, N=14 adults, syllable synchronization R=0.71, N=14 adults). These results support our hypothesis and explain for the first time the enigmatic differences between individuals in the susceptibility to motion-sickness. Our method could be used in the future to predict motion sickness and guide appropriate employment.

Radial bias alters perceived object orientation

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A bias for radial orientations has been demonstrated for low-level visual features using measures such as discrimination thresholds for line orientations (Westheimer, 2003) and contrast sensitivity for sine gratings (Sasaki et al., 2006). Here, we observed an object-based illusion that is likely related to this bias. Participants including three trained observers and 30 undergraduate students judged the orientation of a peripherally placed Landolt C presented in one of eight orientations and in one of eight locations along four meridians (vertical, horizontal, 45° and 135°) centered on the fixation point. Participants responded by clicking on a centrally placed ring to indicate the location of the gap in the Landolt C. The distributions of the errors (the angle between the position of the actual gap and perceived gap) across different orientations and locations indicated that the perceived gap was often aligned with the radial axis. For instance, the gap in a regular C would often be wrongly perceived as tilted 45 degrees corresponding to the oblique meridian where it was placed. This pattern of results extends the radial bias findings by providing a novel example of early visual biases altering object perception and recognition. [Funding: NSF BCS 1849169 to JHS.]

Semantic knowledge affects object memory, but not object-location binding

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The recent study demonstrated that object similarity affected object-location memory, but not object memory (Markov & Utochkin, 2021). However, it is not clear to what extent object and object-location memory rely on the independent resources or not. Studies demonstrated mnemonic benefit for familiar objects (Starr et al., 2020). Here we investigated the effects of familiarity on object and object-location memory. We used familiar and unfamiliar objects and their morphs to control for low-level differences. We presented three objects located on the invisible circumference for 1.5 seconds. After a 1.5-second delay, we presented two objects (one previously shown from the set and one new) and asked observers to recognize which was presented. After the recognition task, observers reported the location of the target. We replicated the effect of familiarity on object memory - higher performance for the recognition task was observed for familiar objects. We applied the mixture model with swap (Zhang & Luck, 2008; Bays et al., 2009) and our own MLE model to the data of localization task. We didn't find any differences between morphed versions of familiar and unfamiliar objects for object and object-location memory, suggesting that our results can't be explained by low-level differences in stimuli. The number of object-location swap errors was stable across all types of stimuli. Semantic knowledge influences object memory, however the localization errors observed for unfamiliar objects and morphs appear due to "weak" object representation and good guessing strategy (Pratte, 2019). [The study was supported by RFBR (№20-313-90064).]

Role of local features in fast discrimination of fragmentary images

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The ability to process quickly and reliably visual information is fundamental for survival. It is widely recognized that the

visual system must operate a drastic reduction of information at an early stage, to efficiently process relevant visual information within limited available resources. In past work, we utilized the principle of constrained maximum-entropy to define a small number of specific local features that are optimal carriers of information. Experimentally, we found that images where only these features are kept (sketches), are still as recognizable in fast vision conditions as the original images. Here we explore whether these specific local features still play an important role in a more natural setting, where all existing features are kept, but the overall available information is drastically reduced by showing only a fraction of the image. An alternative possibility is that of global information becoming more important in these different conditions. We measure natural image discrimination (2IFC) based on brief presentation (25 ms) of a limited number of small patches, randomly extracted from the image, as a function of their number and size. Results show that a very small fraction of the area of an image (0.5-2%) is sufficient to discriminate it from others. We also find that the probability of correct discrimination directly correlates with the number of optimal features contained in the visible patches. This indicates that these special local features keep an important role in image discrimination even in such limiting conditions. [Funding: from ERC under the European Union's Horizon 2020 research and innovation programme (Grant Agreement No 832813 GenPercept "Spatio-temporal mechanisms of generative perception").]

Ocular dominance can predict performance during interocular conflict from a monocular augmented reality task

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Monocular see-through augmented reality systems generate a particular perception since a monocular virtual image is superimposed on the real binocular environment. Different information is projected to corresponding regions of the two eyes creating an interocular conflict. The latter can have an impact on user comfort and performance, as a function of projected image or environment characteristics or user's ocular dominance. In this study, we tested the differences in performance when the monocular image was presented on the right eye or on the left eye. Using a game controller, the participants had to match a monocular element with a binocular moving target. At the same time, the participants were asked to detect and identify a special event. So, three variables can be measured from the task: tracking performance of the target, time of detection and time of fixation the events. These variables were studied as a function of five ocular dominance tests: hole-in-card test, visual acuity, Worth 4-dot, +1.5 δ blur test and form rivalry test. Although only 8 of the 18 participants had a significant difference in performance between their two eyes, it was observed that for 7 from them, the better eye could be predicted via the blur test. Blur test, considered to assess sensorial dominance, is quick and easy to implement and seems predict performance during monocular see-through augmented reality task. It will be necessary to determine whether its interest is confirmed in an ecological situation. [This study was funded by Thales AVS, France SAS. There is no conflict of interest.]

Time's arrow and entropy: Violations to the second law of thermodynamics disrupt time perception

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What accounts for our perception of time passing in one direction, from past to future? Modern physics claims that the reason for time's unidirectional physical arrow is the relationship between time and entropy, the degree of disorder in the universe, which is evolving from low entropy (high order; thermal disequilibrium) toward high entropy (high disorder; thermal equilibrium), the second law of thermodynamics. Here we explored this proposed relationship between entropy and the perception of time's arrow. We predicted that if the brain has some mechanism for detecting entropy, violations of entropy would lead to measurable behavioral effects, namely changes in duration perception. To test this hypothesis, participants were shown briefly-presented (500 or 1000 ms) computer-generated visual dynamic events: novel 3D shapes that were seen either to evolve from whole figures into parts (low to high entropy condition) or in the reverse direction: parts that coalesced into whole figures (high to low entropy condition). On each trial, participants were instructed to reproduce the duration of their visual experience of the stimulus by pressing and releasing the space bar. To ensure that attention was being deployed to the stimuli, a secondary task was to report the direction of the visual event (forward or reverse motion). As predicted, duration reproduction was significantly longer for the entropy violation condition compared to the entropy condition ($p=.03$). This suggests the presence of a mechanism that detects entropy, which is used by other processes to construct our perception of the direction of time, or time's arrow.

Thursday August 26th

Poster Session 7

Peripersonal space is a spatiotemporal window rather than a fixed space

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Peripersonal space (PPS) has been often described as a single, distance-based, in-or-out zone within which neural and behavioral responses are enhanced when potential harm is presented. As an alert and defense against dangerous stimuli, the time-to-contact and distance of the imminent danger could be equally important for human beings. In this study, we used the classical paradigm of measuring PPS and systematically examined the effect of imminent danger's speed on PPS. In Experiment 1, we asked participants to respond to an auditory stimulus with a task-irrelevant visual object looming toward their faces with different velocities. We manipulated the distance of the visual object away from a participant when the auditory stimulus appeared to estimate his/her PPS. We found that the PPS became significantly larger when the visual object moved faster, indicating that the size of PPS is varied with the speed of the moving object. In Experiment 2, the auditory stimulus appeared when the visual object reached a specific time-to-contact (TTC) towards the participants. We found the size of PPS almost kept unchanged across different speeds if the TTCs were fixed, suggesting PPS could be temporally represented. In Experiment 3, we asked participants to respond to a tactile stimulus while a visual object loomed towards their faces with different velocities. We found similar results to experiment 2. In sum, our findings indicate that the peripersonal space could be not a fixed space around humans but more likely to be a spatiotemporal window for defending dangerous stimuli. [This work was supported by the National Natural Science Foundation of China (grant numbers 31771209, 32022031).]

Electroencephalography activity patterns after saccades during visual tracking of visible and occluded parabolic-moving targets

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Our objective was to clarify the differences in electroencephalography (EEG) activity patterns after catch-up saccades during visual tracking of a visible, parabolic-moving target and after saccades during visual tracking of an occluded parabolic-moving target. To achieve this objective, we simultaneously measured EEG activity and eye-tracking with millisecond temporal resolution during a task that required tracking partially occluded parabolic-moving targets. Fifteen participants aged 18–23 years were instructed to track parabolic-moving targets that were partially occluded. For each recorded EEG channel, we computed the instantaneous log amplitude of the complex analytic signal using the Hilbert transform method. We subsequently derived event-related averages and grand averages of log amplitudes, similar to that in ordinary event-related potential data analysis. After the catch-up saccades during the visual tracking of the visible parabolic-moving target, activation in the posterior parietal lobe was observed. Meanwhile, after the saccades during visual tracking of the occluded parabolic-moving target, activation in not only the posterior parietal lobe but also the right temporal lobe was observed. These results during visual tracking of the occluded parabolic-moving target indicate that this activation may correspond to the memory-guided saccades of moving targets.

The View From Somewhere: Perspective and Relational Foundation of Outer Space Perception

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Seeing Earth from outer space has been described as a trigger for transforming effects accompanied by intense cognitive and affective experience. In this study, we followed an exploratory approach to investigate which factors shape the aesthetics of outer space. N = 67 participants rated 42 space pictures on eight scales: Awe, loneliness, danger, liking, thoughtfulness, spirituality, technicity, and beauty. The set of images was systematically compiled on the factors whether they showed stars/the moon, the Earth, or people/technology. One-half of the images were taken from an Outside perspective, i.e., from space, while the other half was taken from Inside, i.e., looking up to the sky. This was done to induce a virtual change of perspective. We revealed a clear influence of perspective, image content and the framing of content on numerous variables. Images taken from an outside perspective evoked general feelings of danger, strongly modulated by the presence of humans/technology in the picture. These findings suggest that the aesthetics of space pictures relies not only on perspective, i.e., physical position, but also on the available frame of reference, i.e., the entities represented.

Furthermore, aesthetics is not about perceiving something from somewhere but rather about the balanced combination of percept, perceiver, and perspective. Given the literally astronomical dimensions of space, this context provides a unique background that puts the well-known in a new light, challenging the dimensions of everyday perception and its aesthetic valuation.

On kitsch and kawaii :-) A cross-cultural comparison of popular aesthetic concepts from Germany and Japan (*^‿^*)

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In the early 20th century, the German word "kitsch" quickly entered many modern languages. Today, the Japanese term "kawaii" (cute) proves equally successful. The two aesthetic concepts seem related through their close ties with cuteness. And yet, they represent contrary evaluations: kawaii is used to express aesthetic appreciation, while kitsch is clearly a derogatory term. How do Japanese observers assess German kitsch objects? This question was explored in a cross-cultural study, including 97 psychology students (64 women; M_{age}=20.46; SD_{age}=1.39) from Kanazawa University (Japan) and 100 psychology students (50 women; M_{age}=22.27; SD_{age}=4.98) from the University of Bamberg (Germany). All participants rated 56 images of everyday objects from the Bamberg Repository of Contemporary Kitsch (BAROCK) with regard to liking, familiarity, determinacy, arousal, and perceived threat. In Japan (Germany) students also rated these images in terms of kawaii (kitsch). Independently of cultural background, kitsch and kawaii were perceived as non-threatening. Apart from this commonality, complementary responses were observed. While kawaii showed positive intercorrelations with familiarity and determinacy, the opposite was the case for kitsch. Differences were particularly pronounced for liking and arousal: liking and kawaii were positively linked (M_r=.69; SD_r=0.16), while liking and kitsch were connected by a negative correlation (M_r=-.39; SD_r=0.26). Analogously, arousal related to kawaii by a positive correlation (M_r=.33; SD_r=0.30) and to kitsch by a negative one (M_r=-.26; SD_r=0.22). Factor analysis revealed a similar factor structure for kitsch and kawaii ratings. Kawaii-like kitsch objects appeared trendy with smooth round shapes, childlike proportions, and bright plain colors.

Electrophysiological Investigation of Attentional Modulation on Metacontrast Masking

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The relationship between visual masking and attention has been extensively studied since both mechanisms control sensory and perceptual processing. Although early studies using different types of masking paradigms emphasize the interaction between masking and attention, recent and more precise investigations of metacontrast masking revealed only an overall modulatory role of spatial attention. Therefore, the relationship between masking and attention mechanisms is still subject to debate. In the current study, we examined the effects of spatial attention on metacontrast masking using electroencephalography (EEG). We employed an orientation discrimination task on a visual target under different masking conditions and manipulated spatial attention by changing the set size in the visual field. The behavioral results revealed a main effect of both set size and metacontrast masking with a two-way interaction that suggests differential effects of spatial attention on metacontrast masking. The EEG analyses revealed significant effects of set size and masking on a negative component (early VAN range, 160-210 ms) and only a two-way interaction in a positive component (late VAN range, 270-310 ms) located over occipital and parieto-occipital scalp sites. There was no two-way interaction in the late positivity (LP, 350-550 ms) centered over centro-parietal electrodes, but the main effect of set size was dominant in this component range. Overall, these findings indicate that spatial attention takes place at different stages of sensory and perceptual processing. Regarding the relationship between attention and metacontrast masking, they further suggest that the effect of spatial attention may also have distinct characteristics at different stages. [This work was supported by The Scientific and Technological Research Council of Turkey (TUBITAK Grant 119K368).]

Effects of display segmentation in visual foraging for feature and conjunction targets

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Humans and other animals frequently explore their environments and often use systematic processes to do so. In visual search there is evidence that people search in a spatially systematic manner, such as avoiding searching the

same location twice. In visual foraging tasks, individuals must search for multiple instances of target types in an array. We present two online experiments in which sensitivity to spatial structure in the array is varied to investigate spatial systematicity. We asked participants to forage segmented, non-segmented or previewed-as-segmented displays for forty targets that were either defined by a simple feature, or a conjunction of features. In all trials there were two target types and two distractor types, with twenty instances of each stimulus present in the array. In experiment one, participants foraged the segments of segmented displays near-exhaustively before foraging the next segment. In experiment two, we found that this effect was even present when the segmentation was only briefly previewed. As per previous literature, both experiments showed a significant difference between feature and conjunction foraging. When targets were conjunctions (e.g., green circles and red squares), people switched less frequently between the target type they were foraging for, than when foraging for feature targets (e.g., green and red objects). Overall, we found that participants were sensitive to the structure of the array, whereby segmentation encouraged spatially systematic foraging. One possibility is that spatially systematic foraging strategies are adopted to reduce spatial memory load for previously searched locations. [Peter Goodwin's PhD is funded by Nottingham Trent University.]

Implementing the theory of visual attention as a Bayesian model in a foraging task

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Foraging as a natural search for many targets has increasingly been studied in humans in recent years. We aimed to investigate changes in the search strategies during the foraging task showed in Kristjánsson et al. (2014) study. Bundesen (1990) proposed TVA as a computational system that divides the selection process into filtering and pigeonholing, connected to a front-end system that supplies the strength of sensory evidence concerning the nature of elements in its visual field. We combined these two ideas into augmented Naïve Bayesian classifiers using data from Kristjánsson et al. (2014) study as input. We attempted to answer whether it is possible to predict switch rates during feature and conjunction foraging through Bayesian classifiers. We formulated 11 new parameters to represent key sensory and bias information that could be used for each selection during the foraging task and tested them with multiple Bayesian models. Separate Bayesian networks were trained on feature and conjunction foraging data, and parameters that had no impact on the model's predictability were pruned. We report high accuracy for switch prediction in both tasks, though the model for conjunction search was the most accurate. We also report on our Bayesian parameters in terms of their contribution to TVA, $\eta(x, i)$ (denoting the strength of sensory evidence) and β_i (denoting the decision-making bias), since they best represent bottom-up and top-down attentional processes. The overall result of this study suggests that TVA can be adapted to the foraging task with a Bayesian approximation learned from experimental data.

Visual search for targets on naturalistic cluttered backgrounds

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How do we find objects in complicated scenes? Scenes containing many excess items may be 'cluttered', especially those with highly variant characteristics, e.g. colour, luminance or orientation. Here, searchers cannot rely on finding the target by searching scenes for 'deviation', as there is high deviation throughout. Several holistic measures of clutter have been developed. We investigated whether one of them, Feature Congestion (FC, Rosenholtz, Li and Nakano, 2007), predicts human behaviour in a naturalistic search task. This study sought to assess: (1) how creating clutter through increasing variance affects search performance; and (2) FC score's ability to predict this behaviour. In an online experiment, participants searched for single, grey, ovoid targets, oriented at 45°. Targets appeared on simulated 'leaf litter' backgrounds, manipulated in three ways: number of leaves (50-450); maximum variance in Michelson contrast of leaves (compared to target, 0.1-0.9); maximum variance in orientation of leaves (compared to target, 5°-85°). We also ran the FC model over these stimuli. Reaction time (RT) data were analysed via comparison of linear mixed models. Increasing leaf number produced significantly longer RTs. Increasing contrast variance produced a significant U-shaped RT function. Increasing orientation variance produced a significant inverted U-shaped RT function. Image FC scores significantly predicted RT where leaf number varied, but did not reach significance for orientation or contrast. Our results suggest clutter may affect search in natural scenes, but does not always increase difficulty. While FC remains an appealing way to predict behaviour, fine tuning such models is necessary for future work. [Funded by the Biotechnology and Biosciences Research Council (BBSRC).]

A response-locked classification image analysis of the perceptual decision making in contrast detection

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In many situations, humans make decisions based on serially sampled information through the observation of visual stimuli. Previous RT-based studies have not sufficiently clarified what information in the stimuli the observer relies on to make decisions during dynamic observations in the real world. To quantify the critical information used by the observer in such dynamic decision making, we here applied classification image analysis (CI) locked to the observer's reaction time (RT) in a simple detection task for a luminance target that gradually appeared in a dynamic random line noise (c.f. Neri & Heeger, 2003, Nat. Neurosci., 8, 812-816). We found that the response-locked CI shows a spatiotemporally biphasic weighting profile that peaked about 300 ms before the response, but this profile substantially varied depending on RT; positive weights dominated at short RTs and negative weights at long RTs. These diverse results were unpredictable solely from the response properties of the early visual system. However, we found that they can be quantitatively explained by a simple computational model that incorporates the early visual process approximated by a biphasic spatiotemporal filter and the perceptual decision-making process (drift-diffusion model) that accumulates its output. The results support the idea that on-the-fly dynamic behavioral responses to a visual target in noise can be explained by a simple combination of the standard perceptual detection model and the standard perceptual decision-making model. [This study was supported by the Commissioned Research of NICT (1940101) and JSPS KAKENHI JP20H01782.]

Does selective attention modulate the C1 ERP component? A meta-analysis

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The C1 event-related potential (ERP) captures the earliest stage of feedforward processing in the primary visual cortex (V1). It is yet under debate whether or not selective attention (i.e., top-down attention control) can modulate this earliest stage of feedforward processing and thus the C1. In general, null findings appear to outnumber positive findings suggesting that selective attention does not influence the C1. However, this conclusion is not based on a systematic review and meta-analysis of the existing literature. To fill this gap, we conducted a meta-analysis of studies investigating the effects of selective attention on the C1. A total of 442 articles were screened and 48 studies involving a sum of 795 subjects were included finally. Despite a large heterogeneity found across them, results showed that attention had a moderate modulatory effect on the C1 (Cohen's $d = 0.47$, $p < 0.0001$), expressed by a consistently larger C1 component for attended than unattended stimuli. When reducing this heterogeneity (i.e. removing excessive effects sizes identified as outliers) and correcting for a publication bias, the effect of attention on the C1 remained significant. Further moderator analyses suggested that this effect was not influenced by the type of attention (i.e., spatial, load or other). These findings suggest that the C1 is modulated by top-down attention control.

Task Difficulty Regulates the Attentional Gain Modulations in Human Early Visual Cortex

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Task difficulty is thought to influence perceptual performance by mediating the gain of neural responses in early sensory areas. In support of this idea, a study in non-human primates found that increasing task difficulty enhanced the gain of the single-unit activity of neurons in the early visual cortex. However, other research groups have reported either null or even reversed effects of task difficulty on gain modulations in single-unit activity. Derived from Yerkes-Dodson's Law, it is possible that this discrepancy emerged from an interaction between task difficulty and attentional gain modulations that occurs in a non-linear inverted-U fashion. Here, we used EEG to measure modulations in visual cortex of male and female human participants performing an attention cueing task where we systematically manipulated task difficulty across blocks of trials. Consistent with Yerkes-Dodson's law, our behavioral and neural data implicate an inverted-U relationship between task difficulty and selective attention. Specifically, when task difficulty was adjusted to an intermediate level (~76% accuracy), a focused-attention cue led to larger response gain in both neural and behavioral data compared to when behavioral tasks were harder (~65% accuracy) or easier (~91% accuracy). Moreover, difficulty-related changes in response gain modulations in early visual cortex positively correlated with those predicted by quantitative modelling of the behavioral data. Taken together, these

findings suggest that task difficulty mediates attention-related changes in perceptual performance via different modulations of attentional gain in human visual cortex. [Funding was provided by NEI R01 and a James S. McDonnell Foundation award to John T Serences. This project was also funded by the National Research Council of Thailand grant (fiscal year 2021), the Thailand Science Research and Innovation Basic Research grant (fiscal year 2021 under project numbers 64A306000016 and fiscal year 2020 under project number 62W1501), the Asahi Glass Foundation grant, the research grant from the Research & Innovation for Sustainability Center, Magnolia Quality Development Corporation Limited, Thailand, the KMUTT Partnering initiative grant (fiscal year 2021), and the startup fund for junior researchers at King Mongkut's University of Technology Thonburi (KMUTT), and the KMUTT's Frontier Research Unit Grant for Neuroscience Center for Research and Innovation to Sirawaj Itthipuripat.]

Variance perception is affected by different visual features only within same set of objects

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We can grasp various features of the outside world by summary statistics efficiently. Variance constitutes indices that represent diversity within categories, and has a unique characteristic in that the magnitude of variance can be compared, to some extent, among different stimulus property. Recent researches have shown that the possibility of a domain-general variance-enconding mechanism in visual domain (Maule & Franklin, 2020; Payzan-LeNestour et al., 2016). Here, we examined whether variance of task-irrelevant feature dimension affect the variance perception of task-relevant feature dimension in order to clarify the role of selective attention on variance perception. Each display consisted of eight lines and eight circles arranged randomly on a 4 x 4 grid. The lines varied in orientation and the circle varied in size. Participants were asked to attend to either the orientation of the lines or the size of the circles, and to judge which of the two successive stimuli set has the larger variance for the attended feature. We found that variance of unattended feature of task-irrelevant items did not affect the perceived variance of the attended feature of the relevant items. However, when both of orientation and size varied independently in single item (i.e. the line varying in both of orientation and in size), perceived variance of the attended feature was systematically biased toward variance of the ignored feature. These results suggest that variance perception in different visual domain may interact with each other, but it is relatively attention-required process.

Statistical learning of most likely distractor location: plastic changes in priority map or strategic suppression?

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Humans have the ability to use regularities in the environment. This is exemplified by statistical learning (SL) of distractor location in visual search. If observers are exposed with higher likelihood to salient distractors at one location, in time they learn to inhibit that location, which attenuates unwanted capture, but at the same time target selection at that location is impaired. One open question is whether this is due to the proactive strategic maintenance of the suppressive signal at the previous most likely distractor location, or suppression has induced plastic changes in the priority map. To answer this question we trained observers to resist distraction from a color singleton that appeared with higher probability at a specific location, while they performed a shape singleton search. In a subsequent test phase we removed the shape singleton and the color singleton became the target. Besides confirming the SL effect on distractor location and target location in the training phase, we found that in the test phase observers were still slower to respond to color singleton targets that appeared at the location that had been more often associated with distractors in the training phase. This rules out the possibility that the observed impairments at the previous most likely distractor location were caused by a suppression that was strategically maintained. Rather, the results reveal that the inhibitory signals cause long-lasting changes in the priority map, affecting future computation of the target salience at the same location, and therefore the efficiency of attentional selection.

Peripheral visual acuity measured with two optotypes in various viewing conditions

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Investigations of peripheral visual acuity (VA) are not numerous because multiple hurdles hinder performing reliable measurements. The main difficulties are caused by the necessity to divide attention between the foveal fixation stimulus and the peripheral test target. One of the approaches to exclude the task of central fixation is to create an artificial central scotoma by means of contact lens with implanted occluder. Applying this approach, we have measured the peripheral VA in 3 participants in the range

of eccentricities up to 60° by means of two different optotypes – tumbling-E and modified 3-bar target on a specially constructed computerized perimetric setup. It appeared that occlusion of the fixation stimulus per se did not lead to the anticipated increase in the VA, probably because the effect of the instruction "to keep gaze direction straight ahead" is similar to that of the instruction to fixate a visible foveal stimulus. More than that: contact lens with occluder (4-5 mm in diameter) could exert negative effect, supposedly due to veiling the peripheral test target in the cases of uncontrolled involuntary increase of the pupil diameter leading to significant increase of the completely blind zone and its half-transparent border. In all participants, the peripheral VA values appeared to be somewhat higher for the modified 3-bar optotypes measuring "resolution acuity" than for the tumbling-E measuring "recognition acuity". The reliability of the data obtained for the peripheral VA was similar to that of the foveal data. Inter-individual variability of data was larger at lower eccentricities. [Research was partially funded by Russian Foundation for Basic Research (19-015-00396A).]

Grating, letter, and picture optotype visual acuity in healthy young observers

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Visual acuity (VA) assessment results depend on the setting, method used, chart design, and especially on the optotypes. There are data available in the literature that VA assessed with grating is usually higher (better) than that assessed with letter or picture optotypes, though most of the authors referring to the grating acuity were using gratings much larger in angular size than the optotypes used for comparison. Will there still be any overestimation of VA if the grating angular size will be similar to the size of letter/picture optotype? In this work we compared VA values obtained with grating stimuli (3-bar optotypes), Lea chart, ETDRS chart and Russian letter chart. We assessed VA binocularly and monocularly in 26 teenagers and young adults (Median = 17 yrs, 20 emmetropic participants and 6 cases of low myopia). Using non-parametric statistics and Bland-Altman analysis, we revealed that grating optotypes show no prominent difference from both letter optotype charts. Lea chart showed better (higher) VA results compared to grating and letter charts. We have not found results supporting the hypothesis that grating stimuli may show better visual acuity than letter/picture optotypes. The results are especially interesting in view of the possibility of spurious resolution manifestation, though in our study there were cases of reporting this optical effect (Strasburger et al., 2018). Nevertheless, we could conclude that there was no overestimation of VA in case of gratings in comparison to the letter and picture optotypes in our group of participants. [We are very indebted to Prof. G. Rozhkova for her support, help, and mentoring.]

Global but not local luminance and color contrast elicits stronger pupil responses

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Pupil responses to stimuli reflect local visual field sensitivity. For most accurate sensitivity measures, pupil responses need to be strong and robust. Here we study how stimulus color may enhance pupillary responses by searching for an optimal balance between luminance and color contrast between stimulus and background. Two experiments were conducted with 17 and 19 healthy adults using a gaze-contingent flicker pupil perimetry paradigm. Stimuli flickered at 100% luminance across different angles and eccentricities in random order. In experiment 1, stimuli consisted of yellow disks superimposed on a blue background or vice versa. Background luminance varied between 0 - 45% to trade off global luminance and color contrast. Differences in perceived brightness between blue (low) and yellow (high) stimuli allowed to explore the generalization of the trade-off optimum. In experiment 2, the stimulus-off region was either colored or black to test local effects of luminance and color contrast on pupillary responses. An optimum was found for a background luminance of around 25-30% for both complementary colors, and pupil response amplitudes decreased by 25% outside this range. Furthermore, a black stimulus-off region amid a blue background evoked 23% stronger responses than a colored stimulus-off region. These findings imply that stronger and therefore most sensitive pupil responses can be achieved by adding global color contrast in the background but not local color contrasts in the stimulus-off region.

Considerations of socio-emotional impacts of X-linked colour-vision deficiencies: A thematic analysis

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Congenital colour-vision deficiencies (CVD) are common affecting 1 in 12 males and 1 in 200 females. Considering an anecdotal account of having CVD, Snyder (1973) explained how his inability to learn colour names 'annoyed' his teacher, triggering anxiety and feeling different. Current research into the emotional impacts of people living with CVD is wide ranging, however qualitative analyses that capture expressive information on the potential social and emotional burdens of CVD are rare. The aim of this qualitative study was to better understand CVD individuals' experiences and the potential effects these may have on their self-esteem. The study involved using a combination of focus groups and interviews with 26 adults and 12 children with CVD, as well as 12 parents with CVD children. Data were transcribed and analysed using thematic analysis with a combination of a codebook and reflexive approach (Braun and Clarke, 2006). Four overarching themes were identified in relation to the social and emotional impacts of CVD: (1) "negative reactions of others"; (2) "negative impacts on emotions and self-view"; (3) "psychological coping mechanisms" and (4) "support and strategies" with particular focus on the subtheme "support from friends and family". These themes emphasise the importance of having adequate support and a more empathetic attitude from others which can help alleviate negative emotional feelings. Overall, our findings suggest that an increased awareness by family, peers and teachers of what it means to be colour deficient can improve the social and emotional wellbeing of CVD individuals.

New estimates of human cone fundamentals based on the CIE XYZ 1931 2-degree standard observer's colour matching functions

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To use a common computer display in psychophysiological experiments to demonstrate colour stimuli to subjects one needs to characterize its radiation in terms of human cone excitations. This could be done by two different ways: (1) one can carefully measure the emission spectra of primary colours (R, G, B) and, using known human cone sensitivity curves, calculate the matrix transformation between linearized pixel values and corresponding cone excitations; (2) or one can perform several colorimetric measurements, such as chromaticities of primary colours and the chromaticity of white colour ("white point"), and calculate matrix transformation to be able to express display colours in the XYZ colour space. The first way is the most accurate, but it looks difficult. For each experimental setup one needs to measure three monitor emission spectra, calculate the conversion matrix and store it in the presenting program. These steps make the installation and verification procedures highly unclear. The second way looks easier. In this case the presenting program transforms designed cone excitations into XYZ colour space and then to RGB pixel values. Nearly all colorimetric measurements are based on the CIE 1931 standard observer's colour matching functions (CMFs). However most modern estimates of cone spectral sensitivities are based on other CMFs – due to the known inaccuracy of CIE 1931 functions. Here we propose the linear combinations of CIE 1931 2-degree CMFs that fit the Stockman & Sharpe (2000) cone fundamentals. The proposed curves are compared with previously suggested cone fundamentals based on the same CMFs. [The study was funded by RFBR, project number 20-015-00063.]

Spectral measurements of reflectance and transmittance of natural objects and daylight in Japan

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Spectral measurement of natural objects and illuminations are fundamental to vision research as they dictate daily physical inputs to our visual system. This study aimed to spectrally characterize the reflectance and transmittance of natural objects and daylights in Japan under a variety of conditions. First, we measured the reflectance of 307 natural objects (bark, flower, fruit, leaf, stone, and vegetable) and the transmittance of 93 leaves. It was shown that the colors of natural objects were spread across a color space, but data points were absent around the saturated bright green region. Second, we measured daylights from sunrise to sunset on four different days at non-shaded ground and at shaded ground. Daylights were also measured at 5 different locations (including a soil sports ground, a space between tall buildings and a forest) at nearly the same time to reveal the influence of surrounding environments on the spectral composition of lights reaching the ground. We found that throughout a day the color temperature of direct sunlight largely varied between 4000K and 20000K, and this trend was roughly consistent across different days. The skylight measured from a shaded ground had much higher correlated color temperatures and lower intensities than those of direct sunlight. The chromaticity of daylights measured in a forest systematically deviated from the daylight locus, implying that past daylight models do not fully account for the variation of natural daylight. All measured data will be publicly available, expanding past datasets measured in Northern America and Europe. [This work was supported by JSPS KAKENHI Grant Number JP19K22881 and JP17K04503. TM is supported

by a Sir Henry Wellcome Postdoctoral Fellowship 218657/Z/19/Z and a Junior Research Fellowship from Pembroke College, University of Oxford.]

Steady-state visual evoked potentials (SSVEPs) to color and luminance: effect of temporal frequency

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Steady-state visual evoked potentials (SSVEPs) are widely used in vision research, and recent studies have employed SSVEPs to examine chromatic mechanisms (e.g., Kaneko, Kuriki & Andersen, 2020). However, characteristics of the chromatic SSVEPs remain largely unknown. The present study examined the temporal characteristic by recording SSVEPs at various flickering frequencies (1.5, 3, 5, 7.5, 15 and 30Hz). The target stimuli (4.5°×4.5° square) were sampled from the luminance (L+M), red-green (L-M) or blue-yellow (S-(L+M)) axis in DKL color space. Stimuli were displayed against a gray background which is equal-luminant to the red-green and blue-yellow stimuli. The RMS cone contrast of the luminance, red-green and blue-yellow stimuli were 0.5, 0.09, and 0.87, respectively. With these levels of cone contrast, the overall SSVEP amplitudes are comparable for the 3 types of stimuli. However, we do observe a dynamic interaction between stimuli type and temporal frequency. Notably, first, the response to blue-yellow is most robust at low frequencies (1.5 and 3 Hz) and continues to drop at higher frequencies. Second, the response to red-green is highest at 7.5 and 15 Hz. Third, at 30 Hz, the response to luminance is relatively robust, but the response to red-green and blue-yellow is neglectable. Based on these results, we recommend future chromatic SSVEP studies to use low frequency at ~3Hz when S-cone stimuli are involved, and to use higher frequencies if only the red-green or luminance mechanism is targeted.

Modelling Visual Decision Confidence and Reaction Times

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Many decisions must be made with incomplete information. The ability to evaluate the resulting uncertainty is a key aspect of metacognition. As both confidence judgments and reaction times are expected to be closely related to sensory uncertainty, a mathematical model of human visual decision-making should be able to explain them both. Here, we propose the new two-stage dynamical evidence and visibility model, an extension of the popular drift diffusion model of decision making, to account for choices, reaction times and confidence at the same time. The decision process in a binary perceptual task is described as a Wiener process accumulating sensory evidence about the choice options bounded by two constant thresholds. To account for confidence judgments, we assume parallel accumulation of information about the reliability of the present stimulus. In addition, there is a period of post-decisional accumulation of sensory evidence to allow for changes of mind. We examined model fits in a post-masked orientation discrimination task with varying stimulus-onset-asynchrony and subsequent confidence judgments. A comparison between the two-stage evidence and visibility, two-stage dynamical signal detection theory and several versions of the race models of decision making showed that only the new two-stage evidence and visibility model produced an acceptable fit to choices, confidence, and reaction time. This finding suggests that confidence judgments may depend on parallel estimates of sensory uncertainty.

Convolutional Neural Networks Do Not Rely On Object Features Which Drive Human Overt Attention

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Deep Convolutional Neural Networks (DCNNs) are among the most accurate models of human object recognition. It has been shown that humans rely on specific segments of objects (called MIRCs) for recognition (Ullman et al., 2016). However, DCNNs did not show such sensitivity to identical MIRCs. Therefore, it remains unclear if humans and DCNNs use different mechanisms for object recognition. One potential difference can be that human recognition may involve bottom-up attentional mechanisms which make "different" parts of an image more salient for down-stream mechanisms. Such bottom-up attentional mechanisms are not explicitly incorporated in DCNNs. Computaional models of such bottom-up mechanisms use local low-level image statistics (e.g. color, orientation, contrast) to accurately predict the location of human gaze on the image (Kimura et al., 2013). To test if MIRCs are predicted by salient parts of images, we obtained MIRCs for one of the most brain-like DCNNs (VGG16) using the well-established Bubbles method (Gosselin and Schyns, 2001). We extracted MIRCs from 12 object categories (each including 16 examplars) of the ImageNet dataset (Deng et al., 2009). Results showed that the MIRCs obtained from the DCNN and the salient regions obtained from computational models of human attention were quantitatively and qualitatively different. This suggests that, rather than relying on salient low-

level image statistics which may guide human attention, DCNNs may rely on object segments which contain semantic category information critical for object categorization. We are collecting human data to quantitatively compare to the results from our DCNN and the computational models of attention. [Funded by Newton International Fellowship from The Royal Society to HKR.]

Perceptual Learning of Crowding: Binocular vs. Monocular Learning

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Visual crowding refers to the impairment of recognizing peripherally presented objects flanked by distractors. Crowding is characterized by a radial-tangential anisotropy, which describes an ellipsoid shape of the crowding area elongated along the radial target-fovea-axis. Crowding effects, exhibiting a "critical distance" between target and flankers, as well as the radial-tangential anisotropy, can be reduced by perceptual learning. In this experiment we investigated the learning-induced reduction of crowding in normally-sighted participants, who trained to detect the orientation of a Landolt-C optotype flanked by distractors over four sessions. One group (N=15) trained the task binocularly, the other group (N=15) trained the task monocularly with their dominant eye, while the other eye was patched. Preliminary results show that both groups improved significantly over four sessions, while the group, who trained the task monocularly, showed a trend to overall larger crowding effects (i.e. larger critical distances between target and flankers) (p=.059). The radial-tangential anisotropy also decreased with learning, an effect that was more pronounced in the binocular learning group. The results show that perceptual learning of a crowding task with optotypes could be a promising tool in rehabilitation programs to help improve peripheral vision e.g. in patients with central vision loss. [This research was supported by the ZSER e.V. (Support Association for Children and Adults with Rare Diseases e.V. c/o University Hospital Regensburg) funding program and the Deutsche Forschungsgemeinschaft (DFG: PL641-1/1).]

Peripheral interactions in single and dual tasks, attention and crowding

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We studied peripheral spatial interactions between Landolt C targets (1.5 deg, 40 ms, low contrast) and distractors of the same shape or full rings. Observers performed either a single task (recognition of a test at 13.2 deg eccentricity, a single distractor placed between the test and the fixation point, the standard crowding-effect layout) or a dual task (recognition of both the test and the shape of the distractor). t-test showed significantly impaired similar performance in both tasks for separations up to eccentricity of the target. Also, the psychometric functions were fitted with Weibull functions and normal distribution to obtain critical spacings which were smaller, but the extent of interaction exceeded the Bouma rule of 0.5 eccentricity (Bouma, 1970) which shows that the critical spacing depends on criteria used. Distractors identical in shape to the targets caused greater impairment than did rings. Moreover, almost at all separations recognition errors were non-random: observers tended to report the orientation of the distractors instead of the orientation of the tests. Stronger (but not significant) deterioration of performance in the dual task found at all separations provides evidence that similar spread of attention contributes to performance even in the single task. Non-random confusion errors, stronger influence of distractors having the same shape and minor changes in the size of the critical spacing in the single and dual tasks favor hypothesis by Treisman and Gelade (1980): confusion of features between tests and distractors is observed in a spatial area modulated by attention.

Audiovisual rhythmic stimulation within the beta band improves the perception of crowded stimuli

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Visual crowding represents a phenomenon in which it is difficult to recognize objects that are presented in clutter and sets an essential limit on visual perception and peripheral object recognition. An increased amplitude of endogenous beta oscillations induced by transcranial alternating current stimulation (tACS) in the parietal cortex was found to improve threshold-level performance in a crowding task. Visual and auditory rhythmic stimulations could also be used to modulate endogenous oscillatory brain activity through sensory entrainment. Here, we aimed at investigating if audiovisual rhythmic stimulation would modulate the perception of stimuli in a crowded regime, similarly to what already shown for tACS. We employed synchronized streams of sounds and flickering visual stimuli, which were presented for ~3 seconds in

the prestimulus period of a letter crowding task. Such rhythmic streams could be presented at two frequencies, one within the alpha band (10-Hz) and one within the beta band (18-Hz), with the hypothesis that 18-Hz sensory stimulation would improve the recognition of crowded stimuli. An additional control stimulation with stationary audiovisual stimuli was used to account for the general effect of timing. We found that the 18-Hz sensory stimulation, as compared to 10-Hz and control stimulations, reduced visual crowding on both visual hemifields, but only for above-threshold performance. These results confirm previous evidence of a selective effect of beta-band stimulation in improving perception within a crowding regime. Differently from parietal tACS, sensory entrainment seems to increase mainly supra-threshold performance, possibly because of the different neural networks entrained.

Contour-Configuration Competency in Visual Crowding

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Visual crowding intensity is highly contingent on grouping principles. Grouping targets and flankers by contour, orientation and spatial frequency increases crowding intensity. Nonetheless, there is no literature that demonstrates how simultaneously varying contour and configuration affects crowding strength. In this study, we demonstrate that both contour and configuration have a significant effect on crowding strength but weakly interact with each other ($p=0.06$). While they have similar effect sizes, contour manipulations can decrease crowding magnitude by more than twice compared to configuration manipulations. We used sharp-edged and curve-edged contours along with random and smooth configurations to modify identification performance. Performance was significantly better in sharp-edged trials compared to curve-edged ones. In addition, trials in random configuration were detected more accurately and fast compared to smooth configuration. The latter finding supports the notion that grouping makes target detection harder. Interestingly, global and local coherence (e.g., curved shapes presented on a curved layout) did not influence crowding strength. This study showed that both local (contour) and global (configuration) manipulation strongly influenced visual crowding intensity. This result corroborates with recurrent processing which, compared to traditional models (e.g., hierarchical and pooling models), argues that the integration of both local and global information is essential for perceptual processes. Parameters that lead to a release from crowding could be used to improve how visually impaired (e.g., macular degeneration) people experience virtual environments.

A simple saliency model accounts for complex results of crowding experiments

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According to a widely accepted view, visual crowding can be explained by a spatial integration of feature information over large receptive fields in the visual periphery. Usual radius of crowding zones is about half of the eccentricity of the target stimulus (Bouma's law). However, several studies have found that crowding zones can be very different from these predicted by Bouma's law and difficult to explain by simple pooling models. Crowding may be reduced by increasing the number of flankers within a "crowding zone", and depends heavily on identities, homogeneity/heterogeneity, and spatial configuration of flankers. In this study, I attempt to simulate these "complex" results using a simple saliency model. The main mechanism is a feature-dependent lateral inhibition. Inhibitory interactions between visual items depend on their similarity along feature dimensions (e g. color, orientation) as well as spatial proximity. I use this mechanism to calculate visual saliency of the target and flanking objects for several complex displays from published crowding experiments. Combining the saliency map with the traditional pooling model of crowding explains a large part of apparently puzzling results from previous studies.

Stimulus uniformity modulates the effect of target-flanker similarity in crowded letter recognition

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Crowding occurs when nearby items impair object perception. For example, identifying a peripheral letter is usually worse with than without flanking letters. Crowding is typically weak when target-flanker similarity is low, for instance, when the flankers are of opposite versus same contrast polarity as the target. However, recent studies showed better performance with high rather than low target-flanker similarity, suggesting benefits of uniformity in crowding. Here, we investigated how letter uniformity affected crowded letter recognition. Stimuli were letter trigrams, briefly presented at ten degrees eccentricity. We varied contrast polarity on the letter- and trigram-level. Trigram letters were uniform or horizontally bisected. Uniform letters were entirely black (white), bisected letters had a black (white) upper and white (black) lower half. Horizontally adjacent parts had the same polarity in 'uniform' trigrams, and opposite polarity in 'alternating' trigrams. Observers (n=10) reported the central trigram

letter (Experiment 1) or its randomly precued upper or lower half (Experiment 2). As expected, with uniform letters, Experiment 1 revealed superior performance for alternating compared to uniform trigrams. However, with bisected letters, performance for alternating trigrams was only marginally better than for uniform trigrams. Importantly, despite radial and tangential flanking parts of opposite polarity, performance for alternating bisected letters did not exceed performance for uniform same polarity letters. Experiment 2 revealed the same pattern of results. Our findings show that disrupted letter uniformity may counteract potential benefits of low similarity between adjacent letter parts. The typical effect of target-flanker similarity seems strongly dependent on overall stimulus uniformity. [Supported by the Swiss National Science Foundation - SNF grant PP00P1_163723 to Bilge Sayim.]

Target-flanker similarity modulates the spatial profile of errors in crowding

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Visual crowding is the inability to accurately identify target features when presented with additional flanking elements. Although flankers are known to induce systematic substitution- and averaging-style errors which vary as a function of target-flanker similarity, how this interacts with the spatial separation of flanker elements is less clear. In this experiment, we measured continuous response errors to Landolt-C targets, as a function of target-flanker similarity (orientation difference) and spatial separation. Participants (n=3) were presented with a target Landolt-C at 12.7° visual field eccentricity and were required to rotate a dial to register its perceived orientation under randomly-interleaved combinations of target-flanker separation (1.5°-5.5°) and orientation difference (0-180°). Distributions of errors in the target orientation response for unique combinations of target-flanker separation and orientation-difference were constructed for each participant and fitted with population-pooling models. Model parameters describing performance accuracy and precision were investigated as a function of target-flanker separation for each of five target-flanker orientation differences and data were fitted with a logistic function. With increased separation, the accuracy of target identification improved. This transition became systematically sharper (steeper logistic curve slope) as the target-flanker orientation difference increased. However, curve position is unaltered, such that when the maximum spatial extent of the crowding zone is taken at the midpoint of this function, zone extent is invariant to target-flanker orientation differences. Our findings also indicate that the use of larger orientation differences may provide more precise endpoints in the measurement of crowding zone extent. [Funded by The College of Optometrists.]

Does numerosity adaptation affect numerosity judgments of 3-D stimuli?

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We examined our expectation that if a process(es) for estimating the number of elements in a 2-D space and a 3-D space differs inherently (Aida et al., 2020), the difference of the process could be reflected in the adaptation effect. The 2-D adaptation effect has already been reported; adaptation to a 2-D stimulus with a relatively large (small) physical number of elements resulted in perceiving a 2-D test stimulus to contain a smaller (larger) number of elements (Ross & Burr, 2008). We used the method of constant-stimulus to measure the adaptation effects. After observing a 2-D or 3-D adaptation stimulus, observers compared the number of elements of 2-D or 3-D test and comparison stimuli and reported which stimuli had more elements. The results showed that 1) 2-D adaptation effect was similar between the 2-D and 3-D test stimuli irrespective of element number of the adaptation stimulus and 2) 3-D adaptation effect was similar between the two test stimuli for the adaptation stimulus with the large number of elements but differed for that with the small number of elements. This result suggests that processing the number of elements of 2-D stimulus is partially different from that of 3-D stimulus, being consistent with our expectation. [This work was supported by JSPS KAKENHI Grant Numbers 17K18187, 21K18027. The authors declare no conflicts of interest associated with this presentation.]

Computed Tomography Image Viewing Strategies on the Multi-Planar Volumetric Display

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Visual search is challenged due to the use of flat-panel monitors when viewing multi-slice medical images. Typically, images are viewed in a slice-by-slice manner which might lead to the increased cognitive load. Three-dimensional visualization of information on the multi-planar display is expected to facilitate visual search because the entire object can be demonstrated in a true volume of display's optical element. However, it remains unknown how multi-slice images are viewed when different

image manipulation options are available. This study aimed to gain insight into the multi-slice image viewing strategies when searching for information presented on fundamentally different displays. Participants searched for targets (engraved lines) when examining computed tomography images of animal bones on the multi-planar volumetric display and flat-panel monitor. Slice-by-slice image viewing was ensured on the flat-panel monitor. Participants could choose to view the entire three-dimensional images or adjust the amount of information to be shown on the multi-planar display. Moreover, the usability of image rotation was explored. As a result, participants mostly inspected all image slices at least once when searching for the targets on the flat-panel monitor. Despite of opportunity to view the entire three-dimensional image, participants preferred to reduce the amount of presented information if no image rotation was available. On average, less time was spent on visual search when viewing images on the volumetric display compared to the flat-panel monitor. In sum, our results highlight that additional image manipulation options may facilitate visual search when viewing three-dimensional computed tomography images. [This work was supported by LightSpace Technologies ("Evaluation of volumetric display's 3D image effect on human visual system", project No. ZD2019/20807) and the European Regional Development Fund ("Development of a compact, high-brightness laser image projection system for application in volumetric 3D displays", project No. 1.1.1.1/18/A/179).]

Developing a quantitative and consistent psychophysical test of sensory eye dominance based on the Pulfrich effect

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Clinical and psychophysical tests of sensory eye dominance (SED) show inconsistent and not reliable results, and some author questions the very concept of SED as a unitary aspect of the visual system (e.g., Garcìa-Perez & Peli, 2019; Laby & Kirschen, 2011; Mapp et al., 2003; Walls, 1951). Here we propose a rapid psychophysical measure of the SED on a continuous scale and in a comparative way that may allow disentangling the peripheral (retinal) from the central (hemispheric) components of SED. We used a dichoptic motion stimulus, that could be fused through a VR headset, and that consisted in a modified version of the paradigm described by Reynaud & Hess (2017), which produced different degrees of a 3D illusory perception strength o a rotating cylinder through the variation of retinal disparity of the two stimuli. We spatially arranged the stimuli to project them on the nasal and temporal hemiretinas. Two independent QUEST procedures allowed to measure two points of subjective equalities (PSEs), used to estimate peripheral and central eye dominance. We performed four classical tests for eyedness (motor dominance: pointing through a hole; SED: red filter and positive lens) and handedness (Edinburgh Inventory). We found that our test quantitatively predicted the dominance obtained by using an index that combined the results from the four classical tests (a procedure used by, e.g., Lopes-Ferreira et al., 2013). Our results could lead to the development of a continuous-scaled SED examination that may be used both in clinical and research contexts. [The authors have no conflicts of interest to declare.]

Depth perception is impaired in patients with cerebral stroke

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It is known that the posterior parietal cortex is encoding target location and that movements in 3D space are affected by its lesions. While bisection test in the lateral dimension is used to screen patients with cerebral stroke, the ability to estimate depth is seldom assessed, even though errors in the sagittal plane have been observed in 3D horizontal bisection tasks in stroke patients (Chino et al., 1994). The aim of our study is to evaluate any disorder of depth estimation in stroke patients. Stereopsis was assessed using both TNO. Functional testing of depth perception, providing monocular cues, was divided into two types: same distance placement and mid-distance placement (a type of in-depth bisection task). Each test was performed under three conditions of feedback: visual, proprioceptive and visuomotor. TNO, depending on binocular cues, was impaired in patients. Functional tests of depth perception were less impaired, but some of them were correlated with TNO. Patients may compensate by relying more on monocular cues. Previous studies suggest that binocular cues seem to rely on the normal functioning of the dorsal stream, while pictorial cues seem mainly processed along the ventral visual stream (Ferraina et al. 2009). Patients indicated systematic overshooting error in depth perception tests. Patients were impaired most in the proprioceptive task. Extent of visuomotor impairment was intermediate between proprioceptive and visual overshoot. The differences between these results likely rely on the availability of visual, proprioceptive and motor cues used for the task. Impaired depth perception may affect rehabilitation process.

Contour integration in 3-D space

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Contour is essential information for recognizing the shape of objects and the structure of the environment we live in. The perception of contours has been examined mainly by using visual stimuli on a 2-D field. Hess et al. (2003) showed how spatially fragmented short lines were integrated to induce the global impression of 2-D contour. In this study, we examined the characteristics of contour integration in the 3-D space, in which the visual stimuli (thin cylinders) shown through the head-mounted display induced 3-D impressions. More than 1000 cylinders were randomly studded in the 3-D virtual space. Participants were given the task to find the target, a straight-line structure made of five cylinders, embedded in this space. The orientation of the five cylinders in the target was varied to deviate from the virtual straight line. In the parallel condition, all the cylinders were parallel. In the anti-parallel condition, neighboring cylinders were pointing to opposite directions. We found that the search performance for the target in the parallel condition was better than that for the anti-parallel condition. Also, finding the target in which the orientation of straight-line structure and that of its elements (cylinders) was perpendicular was easy. These results indicate that (1) The orientation-selective units in the early visual system function to integrate fragmented 3-D elements and detect contours in a noisy environment. (2) These units are sensitive not only to real contours but also to subjective contours such as those formed by the perpendicular elements in the 3-D space. [Funding: This work was supported by JSPS KAKENHI 20H01788.]

Neurons in macaque visual areas V2, V3 and V3A solve the stereo correspondence problem more than neurons in V1

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Binocular disparity, a powerful depth cue, is initially computed by a process similar to cross-correlation computation between the left-eye and right-eye images (correlation-based representation). This process takes place in the primary visual cortex (V1). At higher processing stages of the visual pathway, this representation is refined into a match-based representation, which reflects the strength of feature matching between the left-eye and right-eye images and discards responses to falsely matched features (i.e., solving the stereo correspondence problem). Previous studies show that the disparity representation in IT and AIP is match-based (Janssen et al., 2003; Theys et al., 2012). Also, the disparity representation in V4 is more match-based than that in V1 and MT (Tanabe et al., 2004; Yoshioka et al., 2021). In order to determine to what extent processing stages before these areas solve the correspondence problem, we examined single-neuron responses to correlated and anti-correlated random dot stereograms (cRDSs and aRDSs) in areas V1, V2, V3 and V3A of macaque monkeys. The disparity representation in V2, V3 and V3A was more match-based than that in V1; many V2, V3 and V3A neurons were insensitive to disparities for aRDSs, and some neurons had weak modulation by disparities in aRDSs, whereas a vast majority of V1 neurons exhibited inverted tuning to disparities in aRDSs. Proportion of neurons with sensitivity to binocular disparity in aRDSs was larger in V2 than in V3 and V3A. Thus, the transformation of correlation-based to match-based disparity representation gradually progresses from V1 through V2 to V3 and V3A. [This work was supported by grants to I.F. from the Ministry of Education, Culture, Sports, Science and Technology of Japan (MEXT; 17022025, 23240047, 15H01437, 17H01381).]

Mobile-based examination of stereovision in elderly

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The visual decline in the elderly is a major cause of falls and traumatic injuries. Mass screening is hardly feasible to be performed by eye professionals. In the current study, a mobile-based visual acuity (VA) and stereovision (SV) testing system (EuvisionTab®) was applied in primary care. We aimed to study the aging-related changes for VA and SV. Sixty-two elderly participants (m= 71.71 yrs) were examined with the necessary refractive correction. For monocular VA 16 Landot-C optotypes from 5 m were presented on the tablet, the VA was estimated with Best-PEST algorithm. SV testing was performed by TNO stereotest and EuvisionTab random dot stereogram (from reading distance, by using anaglyphic glasses). The fail-pass criteria for TNO was 240', for EuvisionTab stereotest 6 correct answers out of 10 randomly presented stereo-E optotypes. The decline of VA correlated with age. In the age group 80-90, there was a significant stepwise decrease in VA compared to the younger age groups. The SV measured by TNO also decreased with age (Chi-square test P=0.0473), while the performance obtained by EuvisionTab showed no significant decay. The reference value (95% CI) of VA measured by EuvisionTab is -0.26-+0.54 logMAR. In the low-risk elderly, we found a correlation

between VA and TNO-stereoacuity. Conversely, performance measures by the low-density EuvisionTab stereo tests was stable across ages. Based on our results, EuvisionTab could be a useful tool to monitor age related visual changes (i.e. VA and SV) and prevent traumatic injuries in elderly patients. [The Hungarian Brain Research Program (KTIA_13_NAP-A-I/11 and 2017-1.2.1.-NKP-2017-00002) and the Higher Education Institutional Excellence Programme of the Ministry for Innovation and Technology in Hungary.]

Selective age-related changes in orientation perception gradually emerge across lifespan

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Orientation perception is a fundamental property of the visual system for scene perception. The analysis of real-world scenes has revealed a prevalence of horizontal and vertical contours in indoor, outdoor and even naturalistic scenes, compared to oblique ones. Because of our constant exposure to such an orientation selective environment, we predict that, across the life span, our visual system gradually develops a selective decline in the discrimination of oblique but not cardinal orientations. To test our hypothesis, we presented a sequence of oriented Gabors and asked observers to adjust the orientation of a bar to match each Gabor's orientation. We tested 123 observers, ranging from 18 to 78 years, in an online experiment. For oblique gratings, orientation discrimination performance gradually deteriorated with age. For cardinal gratings, orientation discrimination performance remained unchanged across all age groups. Our results show that orientation perception selectively and gradually changes with age. We propose that these age-related changes reflect a long-term functional adaptation to the visual environment that actively shapes our perception as we age: by constantly adapting to our visual environment, the brain develops to optimally process our surroundings.

Cross-cultural asymmetries in oculomotor interference elicited by gaze distractors belonging to Asian and White faces

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A wealth of data suggests that the averted gaze of others triggers a reflexive orienting of attention in the corresponding direction. However, recent evidence has shown that the pushing of attention exerted by an averted gaze is not entirely automatic, in that it is sensitive to different social variables characterizing both the face stimulus, the participants, and their relationship. Here, we used an eye-tracking technique to investigate the role of ethnic group membership in a cross-cultural study. We adopted an oculomotor interference paradigm in which Italian and Chinese individuals were required to perform a goal-directed saccade either leftwards or rightwards according to an instruction cue. A task-irrelevant central face belonging to either Asian or White individuals was presented displaying an averted gaze either looking to the same or the opposite location as the instructed saccadic direction. Consistent with previous studies, overall results showed that participants were unable to ignore the direction of the gaze, which, in turn, elicited oculomotor interference. Moreover, for Chinese participants, White faces elicited a larger oculomotor interference than Asian faces. By contrast, Italian participants exhibited a similar oculomotor interference effect for both Asian and White faces. Hence, Chinese participants found it more difficult to suppress eye-gaze processing of White rather than Asian faces. These findings suggest that social attention can be modulated by social factors characterizing both the face stimulus and the participants and that major differences can arise depending on the socio-cultural context. [This research was supported by a DPSS-SID2019 grant (University of Padova) to Mario Dalmaso.]

The Effect of Head Orientation on the Initial Eye Movements during Face Identification

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Humans optimally land their first fixation towards the nose bridge, just below the eyes during identification of full-front faces (Peterson & Eckstein, 2012, PNAS). However, it remains to be explored the positions of initial fixations to faces rotated in depth (¾, profile views), where the facial features (eyes, nose, mouth, etc.) are shifted in relative position and changed in appearance. We recorded the eye movements of 32 observers during face-identification tasks across 13 head orientations, ranging from left profile view (–90°) to right profile view (+90°) including full-front view (0°). On each trial, observers moved fixation from the screen center to a face presented (350 or 5000 ms) randomly at one of four screen corners, followed by identifying the presented face from 10 faces. Observers were highly accurate (0°–60°: >90% correct, 90°: ~75% correct) and located their first fixations below the eyes across views. Notably, the horizontal position of the first fixation

shifted from the region between the nose bridge and the near eye for smaller rotations (0°–40°) to the featureless region between the near eye and the near ear for larger rotations (60°–90°). The first fixation's horizontal distance from the nose bridge, normalized by the horizontal distance between the near eye and the nose bridge, formed an approximately quadratic relationship with head orientation. The effects of view direction, face position, and stimulus duration were also explored. Overall, the results reflect a systematic change in initial fixation away from major facial features with rotated head views. [Acknowledgements: Supported by NTU CoHASS Start-Up Grant, Singapore MOE AcRF Tier 1 Grants 2018-T1-001-069 and 2019-T1-001-060 to CO, and NTU CoHASS Teaching Assistantship to MSA.]

The Development of the Uncanny Valley in Children

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Due to declining birthrates, children nowadays might grow up without siblings or playmates. A possible solution is for robots to accompany children throughout childhood. Since robot appearance is a crucial factor for the acceptance of robots, understanding children's preferences towards robot appearances becomes an important issue. The uncanny valley effect (UVE) refers to the phenomenon that likeability towards robots increases as robots become more humanlike, but only up to a certain point. Likeability drops drastically as robots approach a near-perfect similarity to human appearance. Our previous study showed that the UVE was only observed in younger and middle-aged adults but not in older adults, suggesting that age-related differences in the UVE exist. Here we examined whether the UVE is also applicable to children. Elementary school first graders (ages 6-7) and fourth graders (ages 9-10) viewed 12 pictures of robots and evaluated, for each robot, humanness, likeability, feeling of disgust, and intention to play with the robots. The UVE was observed in fourth grade girls in ratings of likeability and intention to play, but not in fourth grade boys and all first graders. Additionally, first graders could not judge disgust towards the robots, as disgust is a relatively late-emerging complex emotion, suggesting that likeability is a better index than disgust for evaluating the UVE in children. Together, our results showed that there are both age and gender-related differences in the UVE for children, possibly due to age and gender differences in cognitive development. [This study was supported by the Ministry of Sciences and Technology in Taiwan (MOST 110-2634-F-002-042-).]

How do children view and categorise own- and other-species facial expressions?

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Children often have contact with both own- and other-species faces (OwSF vs OtSF), such as family dogs. Given that facial expressions (FE) of emotion are crucial in social interactions both with own- and other-species, we know surprisingly little about how children learn to read OtSF. In this eye-tracking study we explored how children (N=156) viewed and categorised FE in humans and dogs by presenting naturalistic primary and secondary FE videos (happiness, fear, neutral, positive anticipation, frustration). GLMMs analysis revealed that children's viewing patterns were modulated first by facial region, followed by species and emotion category. Children looked more at dogs than humans, and more at negative than positive or neutral human emotions. Their gaze allocation to individual facial regions was modified by the viewed species and emotions. Interestingly the eyes were not always viewed most: with OwSF, the eyes were the most viewed for all emotions except positive anticipation, whilst when viewing OtSF, the mouth was viewed as much or more than the eyes for all emotions. This indicates a markedly different viewing pattern for humans versus dogs. The children's identification of naturalistic FE was generally poor, except for human and dog happiness, and human fear, for which there was better performance compared to other emotions. Children have a different gaze pattern and identification accuracy than adults, for viewing FE of humans and dogs. We suggest that for OwSF (i.e. humans) they simply need exposure, but for an OtSF (e.g. dogs) children may also need explicit training.

Gaze cueing of attention is not altered by face masks

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Social interactions with others wearing a face mask became a regular practice since the beginning of the COVID-19 pandemic. Here, we explored the impact of the face

mask on gaze cueing of attention, an essential ability allowing individuals to orient their attention towards the same spatial location gazed at by others. Individuals from both a Western (i.e., Italian) and an Asian (i.e., Chinese) country were tested, namely, two cultures in which the daily use of face masks before the COVID-19 pandemic was either extremely uncommon or frequently adopted, respectively. Both samples completed a gaze-cueing task requiring the discrimination of a peripheral target, while a task-irrelevant averted gaze face, wearing a mask or not, also appeared as a central cue. A reliable and comparable gaze cueing emerged in both samples, regardless of the mask condition. Taken together, these findings indicate that gaze cueing is conserved even when the individual perceived is wearing a face mask.

Facial Surface Property Modulates the Uncanny Valley Effect of Robot Face on Older Adults

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The Uncanny Valley Effect (UVE) refers to the low affinity towards robots that do not perfectly resemble humans (Mori, 1970). Tu, Chien, and Yeh (2020) observed no UVE for older adults using existent robot pictures; however, as existent robots were designed with diverse functions and various appearances, controlling all confounders is difficult. This study systematically controlled stimuli (morphed pictures) for potential confounders that affect the evaluation of human-likeness. We applied the "shape-morphing" method, warping pictures from human to robot and manipulating facial surface properties. Online experiments were conducted with Japanese participants of young to old age-groups with pictures of existent robots' faces (Experiment 1, N=261) and shape-morphed faces (Experiment 2, N=268). Participants rated human-likeness, likeability, and eeriness for each robot's picture. In Experiment 1, likeability of robot faces resembling humans was lower in the younger group (i.e., stronger UVE) than that of other age-groups. Cluster analysis of robot faces by participants' evaluations showed that existent robots' faces could be separated by facial surface properties, implying that surface property is a key factor in perceived human-likeness of faces. In Experiment 2, older adults showed higher likeability for human-surface faces and lower likeability for robot-surface faces compared to younger adults, which attenuated the UVE for older adults. As the degree of shape-morphing correlated with human-likeness only in human-surface faces but not robot-surface faces, this implies different mechanisms for evaluating human-likeness between android and machine-like robots. We conclude that surface property is a strong moderator for human-likeness and affinity dimensions of the UVE.

The Parthenon architecture as a collection of visual illusions

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In the architecture of the Parthenon, the upper parts of columns taper upward and the two-dimensional projections of the building have many convex horizontal and vertical lines, although the temple is perceived to be perfectly straight. We considered the architecture of the Parthenon from the point of view of the tilt and the Wundt-Hering illusions. Psychophysical experiments were carried out to estimate the values of these illusions. The obtained data were matched with the Parthenon`s architecture. We observed an illusion of repulsion in the tilt illusion with a small difference between the orientation of lines. The angle between the lines seemed to be enlarged. This illusion can arise due to the thinning of the upper part of the columns in the temple. As a consequence, it will seem that the Parthenon columns are deviated from each other at the top part similarly to a fan. To avoid the influence of the tilt illusion, the temples' columns were inclined inward. This procedure led to the genesis of the Wundt-Hering illusion (or fan illusion). We obtained our experimental data using concave, convex and straight lines in the modified Wundt-Hering illusion and showed that the curvature of these lines was distorted. The curvature corresponding to the temple's lines decreased. Thus, distortions in the perception of the curvature of lines have been compensated for in the architecture of the Parthenon. As a result, all lines in the Parthenon are perceived as straight ones. [Funded byl Research Programs of the State Academies in 2013-2020 (GP-14, Section 63).]

A Parametric Framework to Generate Visual Illusions using Python

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Visual illusions have had considerable importance in the history of psychological science, leading to important scientific breakthroughs in our understanding of perception, consciousness, and the underlying mechanisms of neuropsychiatric disorders such as schizophrenia or autism. However, despite their historical and theoretical importance as psychological stimuli, there is no dedicated software, nor consistent approach, to generate and report illusions in a systemic fashion. Illusory stimuli are often manually crafted or obtained via pre-made images, making it increasingly difficult for researchers to reproduce visual illusion paradigms and to properly measure the invoked sensitivity. In order to address replicability and reproducibility issues in illusion-based research, we present the Pyllusion package, a Python-based open-source software (freely available at https://github.com/RealityBending/Pyllusion), that implements a parametric framework to manipulate, generate, and report illusions in a systematic way. It is a flexible programming-based tool, as it can be easily incorporated with experimental software (such as PsychoPy) or pre-generated as image files (with the option of different output formats i.e., .png, .jpg, .tiff, etc.). Currently, our parametric approach accommodates several different illusions, especially classical ones such as the Ebbinghaus, Delboeuf, Ponzo, and Müller-Lyer illusions, and the addition of new illusions will be continually integrated as community needs evolve. With Pyllusion, we hope to facilitate a better understanding of critical processes underlying conscious perception and the associated underpinnings of psychopathology.

Perceived animacy is affected by consciousness and metacognition of distractor-target synchronicity

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Perceived animacy of a target dot could be induced unconsciously by the dot's moving along random trajectories; however, perceived animacy is reduced when task-irrelevant surrounding dots exhibit synchronous motion with the target (Takahashi & Watanabe, 2015). We aimed to investigate whether consciousness is required for integrating synchronicity of distractors and target in terms of their motion trajectory in order to affect perceived animacy and whether confidence of the synchronous distractor-target motion plays a role. A red moving target dot was present among other white distracting dots that either had or did not have synchronous motion with the target. The percentage of distractor dots being synchronous with the target was manipulated based on each participant's threshold for detecting synchronous motion between the target and distractors. Participants were asked to report (1) animacy ratings for the target, (2) whether or not they detected synchronous motion, and (3) confidence ratings for the detection of synchronous motion. The perceived animacy decreased only when the participants could consciously detect synchronous motion, suggesting that consciousness is required for integrating distractor-target synchronicity to reduce perceived animacy. Confidence rating increased with the degree of distractor-target synchronicity and the higher the confidence the higher the perceived animacy. The results showed that consciousness and metacognition of distractor-target synchronicity both affect perceived animacy. [This research was supported by Grants from Taiwan's Ministry of Science and Technology to SY (107-2410-H-002 -129 -MY3) and SC (109-2811-H-002 -519).]

Boundary extension under naturalistic viewing conditions

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Boundary extension (BE) is a classical memory illusion in which people remember more of a scene than was presented. BE is traditionally described as an adaptive error supporting our coherent visual experience across discontinuous visual input. Contrary to this view, a recent study showed that for ecologically representative stimulus sets BE occurs equally often as the opposite error: boundary contraction (BC). BE may therefore simply reflect one end of a generic normalization process towards a prototypical viewing distance, and interpretations of BE as referring to an anticipatory representation of scene layout based on memory may need to be discarded. Crucially, however, cameras can capture scenes in ways that are impossible for the human eye, yielding photographs that are not necessarily ecologically representative. Reanalyzing existing data and presenting new experimental evidence, we show that

photographs that are within the range of human vision overwhelmingly lead to BE.

Is it rolling, or sliding, or carried stationarily? : an experimental phenomenological study on motion perception

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Perceived meanings of motion is dependent not on a sequential succession of physical movements but on the relation between all the objects and events present in the scene. On the white screen of the display, a black circle moved diagonally downward or upward or horizontally in a straight line at a constant speed. The circle moved in contact with the side of the opaque gray surface. Then the horizontal or downward or upward motion of the circle followed. It appears to be rolling or gliding if it moves fast or moderate speed. However, when the moving speed is slow, the black circle appears to be carried by the conveyor belt, that is, the circle seems stationary on the conveyor belt even though it is physically moving. In this way, the motion is perceived as an event with various meanings, depending on the total scene. Sometimes the causal relationships are perceived between motions. That is, the meaning of the preceding motion decided in dependent on the following motion.

Proprioceptive drift by virtually split arm

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The studies of body augmentation have shown that we are able to manipulate new body parts which inherently do not exist in human. However, it is difficult to manipulate augmented body parts naturally as own actual body. In contrast, it might be easier to modify innate human body perceiving it as own body part and operate it naturally. In this study, we presented visual feedback of a virtual arm split in two using head mounted display as if there were two arms from one elbow, with/without synchronized haptic feedback by vibration of data glove. We examined whether the proprioceptive perception of the participants' own arm was modified with the virtual split arm after the training of pressing virtual buttons. We also examined whether their sense of self-ownership and self-agency were higher with haptic feedback than without it. The results showed that the perceived proprioceptive position between index finger and little finger of split hand was significantly wider than normal hand condition. These results suggest that the proprioception can be modified by visual feedback of the split arm and be used for augmented body part. However, the addition of haptic feedback did not promote proprioceptive drift toward the split arm and did not show the higher sense of self-ownership and self-agency to the split arm. These results suggest that the haptic feedback may rather make the proprioception based on the real than the virtual arm and make the split arm perceive as non-self body. [JSPS KAKENHI Grant Number JP20K03500.]

Contrasting Perceptual and Hedonic Judgments of Visual Contour

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Perceptual and hedonic judgments are fundamental aspects of cognition. Contour is a prominent structural feature that affects perceptual and hedonic judgments of visual objects, and preference for curvature seems to transcend cultural and species boundaries and stimulus kinds. However, the relationships between perceptual and hedonic judgments of stimuli varying in visual contour have not yet been systematically investigated. In this study, we generated 88 abstract contours with varying number of vertices, distance between adjacent vertices, and tension of the spline connecting adjacent vertices. Then, we examined participants' ($N = 87$) perceptual and hedonic judgments using two paradigms (continuous ratings and the method of constant stimuli) and probed the impact of individual traits on the way people use these features in their perceptual and hedonic judgments. The results suggest that perceived curvature decreased with vertices, distance, and tension, and that liking increased with vertices and distance and decreased with tension. Tension was the principal determinant of visual contour to influence perception and liking, and people tended to use it consistently in both kinds of judgments. Moreover, manipulating features that drive contour perception and liking along a continuum revealed stronger links between tension and contour and between distance and shape. Finally, higher scores in art experience, openness to experience, and need for cognition entailed enhanced general influences of the parameters on perceptual and hedonic judgments. As a whole, this study contributes empirical findings and an innovative methodological approach to the investigation of perceptual and hedonic judgments.

Dramatic transformations in the perception of 3D shape induced by the accretion and deletion of moving self-occluding contours

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There is a rich body of research documenting the role of relative motion in eliciting vivid percepts of 3D shape. However, there is currently little insight into the what or how self-occluding contours (SOCs) contribute to 3D shape perception when different portions of the surface appear and disappear in subsquent frames of motion displays (accretion and deletion) because they fail to generate corresponding features needed to compute motion signals. We assessed the role of such SOCs in 3D shape perception by generating rotating displays of shaded surfaces of convex objects where SOCs and shading provided conflicting information about 3D shape. Randomly perturbed bumpy spheres were rotated around their y-axis and compressed in depth along the depth (z-axis) in each frame. The changes in shape along the SOCs of this compressed, non-rigid rotating object are identical with the uncompressed, rigid rotating object of surfaces that are progressively being accreted and deleted, but the patterns of shading provide information consistent with the compressed 3D shape. In series of experiments we show that global 3D shape is dominated by the pattern of shading in static images. However, in motion displays, the perceived global 3D shape is dominated by the SOCs: global 3D shape is dramatically enhanced and appears uncompressed; shading only modulated the perceived local surface relief within SOCs. We discuss the theoretical implications of these results and ways to incorporate this neglected source of information into structure from motion models. [This research was supported by grants awarded (to B.L.A.) from the Australian Research Council.]

The OCTA Toolbox: A new tool to create flexible and reproducible stimuli for studying perception and appreciation

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Originally created for aesthetics research, the newly developed Order & Complexity Toolbox for Aesthetics (OCTA) allows for the creation of stimulus patterns varying qualitatively and quantitatively in order and complexity, both based on unity and variety along multiple dimensions (e.g., position, shape, size, color, orientation) of the elements in the patterns. This Python toolbox provides perception and aesthetics researchers with a free and easy way to create reproducible and parametrically manipulated stimulus sets, with a focus on multi-element displays. Elements can include geometric shapes, but also images or custom-defined vector-based shapes to increase ecological validity. The standard vector-based output is ideal for experiments on the web and the creation of dynamic interfaces and stimuli. This flexibility is evidenced further by the option to animate specific elements in the display. An additional benefit of OCTA is its accessibility: researchers with programming experience can use the available functions or specify additional functionality tailored to their own wishes, whereas researchers less familiar with programming can use the point-and-click interface that is provided. With OCTA being fast, flexible, and transparent, we strongly believe that this toolbox will facilitate reproducible stimulus construction and experimental design in research on order, complexity, and aesthetics. In addition, OCTA can be a very useful tool to study research questions concerning visual perceptual organization and visual perception in general. [This work has been supported by a PhD fellowship from the Research Foundation – Flanders (FWO) awarded to Eline Van Geert (Grant 11D3619N) and by long-term structural funding from the Flemish Government awarded to Johan Wagemans (METH/14/02).]

Shape variation in proximity grouping: An individual approach

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In 1995, Kubovy and Wagemans performed a groundbreaking study within perceptual organization, revealing that the probability of grouping elements can be quantified as a decreasing exponential function of the distance between those elements, thereby quantifying the law of proximity. This study has been the starting point for many more studies, for instance, on competing grouping principles and additivity (Kubovy & van den Berg, 2008). However, the scope of this type of research has been limited to dot lattices with no to little element variation. In this study, we added shape variation on top of proximity cues, to investigate whether alignment of any shape axis (e.g., sides of squares, base or axis of equilateral triangles) with the globally perceivable orientations in the lattices affects grouping by proximity. To create shape variation, in addition to dots, we employed the recently developed Order and Complexity Toolbox for Aesthetics (OCTA; Van Geert, Bossens & Wagemans, in preparation). Squares were tilted to create a condition in which the sides aligned with the two main perceivable orientations (horizontal and vertical) and a neutral condition with no alignment with either of the orientations. Triangles were tilted to obtain a neutral condition, and two conditions in which one side

aligned with either the horizontal or the vertical orientation. We expect to observe a proximity effect in the neutral conditions. However, for the aligned conditions, we expect to see individual differences in the relative impact of shape variation and proximity on perceptual grouping.

Investigating symbolic and non-symbolic numerical representations in a joint classification task

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Previous studies have shown that symbolic numerals (digits) are spatially represented, with relatively small numbers being responded faster with a left key and large numbers being responded faster with a right key. This effect has been widely replicated and is well known as the Spatial-Numerical Association of Response Codes (SNARC). Follow up studies have also shown that non-symbolic numerals (dots) can elicit similar effects. This was demonstrated both when dots were arranged as dice patterns and when they were randomly distributed in the visual field. In the present study we aimed to investigate whether the representation of symbolic and non-symbolic numerals interacts in the SNARC effect when both sources of information are presented simultaneously. Participants were presented with dice-like patterns with digits being used instead of dots. In two separate conditions, participants had to respond either to the number of digits being present on the screen or to their numerical size, by completing a magnitude classification task. In the numerosity task, they had to judge whether the digits on the screen were more or less than three by pressing a left or right key, irrespective of the numerical value of the digits. In the other condition, participants had to judge whether the digits on the screen were numerically smaller or larger than three, irrespective of the number of digits being present. Our results suggest that numerosity and numerical values did not interact, supporting the idea of independent representations.

Categorizing Color: The Influence of Color Terms on Visual Working Memory

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Recent behavioral studies found that visual working memory (VWM) for color imposes a categorical bias on perception: observers typically remember colors as more prototypical to the category they belong to than they actually are. Here, we further examine these color category effects using pupillometry. We asked participants to remember and reproduce a color, and during the retention interval colored probes were shown. We measured pupil size in response to this probe, assuming that pupil constriction strength reflects the visual saliency of the probe. We found that the pupil constricts most strongly for new colors that do not match the content of VWM, suggesting that colors to which the participant has not adapted are more salient than memory-matching colors. Later in the pupil response, the effect shifts to the opposite direction: the recovery of the pupil to its original size is slower for memory-matching compared to non-matching colors, suggesting that later in time memory matching colors attract more attention than memory non-matching colors. We found no effects of color category on pupil size, demonstrating that at the level of pupil responses color category has no influence on the saliency of the probe. These results are important in two ways. First, they indicate that two distinguishable stages in pupil responses are present: an early stage reflecting saliency of new items and a late stage reflecting saliency of memory-matching items. Second, by showing no effects of color category on pupil size, they suggest that color category effects may be smaller than previously assumed.

Imaginary temporal distance affected the amount of a donation, but not universal

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The amount of donations is a major preoccupation for a charitable organization. What determines how much people donate? The construal level theory suggests that psychological distance (perceptual, temporal, spatial, social) in one domain also affects other domains. Depend on this theory, imagining the near future evokes local scope processing whereas imagining the far future evokes global scope processing. When global scope processing is evoked, the amount of a donation could increase because global scope processing would relate to thinking about other people. Japanese (N=60) and German (N=80) participants were randomly assigned to near future, far future or control conditions. Participants in the near or far future conditions wrote imaginary stories what they would do the next day or in ten years, respectively. Participants in the control condition engaged in a word writing task. After that, participants were asked how much they would donate money to a foreign country (Germany or Japan). For the Japanese, the amount of donations to a foreign country (Germany) in the near future condition was significantly lower than

that in the control condition, whereas there were no significant differences among the conditions for the German participants. These results indicated that the local scope processing in cognition affected social behavior such as donation. However, this effect was not universal. To clarify the relationship of the local/global scope processing among social behavior, cognition, and perception, the effect of local/global scope processing should be investigated on perception instead of cognition on social behavior, and for different nationalities.

Classifying perceived 'texturality' in natural images based on simple image statistics

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The visual system represents textural image regions as simple statistics that are useful for the rapid perception of scenes and surfaces. What images 'textures' are, however, has so far mostly been subjectively defined. The present study investigated the empirical conditions under which natural images are processed as texture. We first show that 'texturality' – i.e., whether or not an image is perceived as a texture – is strongly correlated with the perceived similarity between an original image and its Portilla-Simoncelli synthesized image. We found that both judgments are highly correlated with specific PS statistics of the image. We also demonstrate that a discriminant model based on a small set of image statistics could discriminate whether a given image was perceived as a texture with over 90% accuracy. The results provide a simple method to determine whether a given image region is represented statistically by the human visual system. [This study was supported by the Commissioned Research of NICT(1940101) and JSPS KAKENHI JP20K21803.]

Specular highlights "contaminate" the color of rendered natural materials

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When matching an object's color, humans tend to base their judgments on diffuse reflections and ignore specular highlights. However, it has recently been shown that our ability to discount specular reflections depends on the specular roughness of the stimuli. Here we investigated how much specular reflections influence the color of natural materials. We used the relatively high-parametric ABC-model to closely approximate the measured reflectance of 15 materials from the MERL database. Ten observers were asked to adjust the diffuse reflectance of a matte blob (probe) to match the color of the similarly-shaped natural materials. As a control, they also adjusted the probe to match the color of matte blobs rendered with the same diffuse-reflection parameters as each natural material. The matched diffuse-reflection parameters were highly correlated with the effect of specular reflections, approximated by the difference between the mean L^* and C^* of the natural materials and their controls (R-squared = 86% and 73% for L^* and C^*, respectively). We quantified how much observers compensated for specular reflections with an index varying from 0%, when the average change in L^* (or C^*) caused by specular reflections implies the same change in the matched probes, to 100%, when the mean L^* (or C^*) of the matched probes for materials and controls are equal, i.e. color matches only depend on diffuse reflections. Compensation was rather poor (39% for C^* and 1% for L^*), suggesting that specular reflections are more important for determining the color of real materials than previously thought.

Poster Session 8

Unconscious priming revisited: Is there evidence for superior unconscious processing with EEG?

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It is often argued that unconscious processing of a prime stimulus is preserved even when the prime is so strongly masked that participants are not aware of the prime. Typically, these claims are based on close-to-chance prime identification in a direct task while there is nevertheless a clear and significant priming effect in an indirect task. From this pattern, preserved unconscious processing in the indirect task is concluded. However, this widely used standard reasoning is problematic. Instead, researchers should compare both tasks using a sensitivity analysis (Meyen, et al., in press, Journal of Experimental Psychology: General). When applying the sensitivity analysis to RT data in the indirect task, we found no evidence for superior unconscious processing (Zerweck, et al., 2021, Attention, Perception and Psychophysics). But this has not yet been tested with EEG data, which might be more sensitive than RTs. In two EEG experiments we used masked priming with numbers (Exp. 1, N=13) and simple line stimuli (Exp. 2, N=11). Consistent with the literature, we found that the lateralized readiness potential (LRP) showed a

positive deflection in the early response locked LRP for incongruent as compared to congruent trials. However, sensitivities did not support the idea of better unconscious than conscious processing (indirect/direct sensitivities: Exp.1: d'=0.13/d'=0.8 and Exp.2: d'=0.12/d'=0.66). Although these data are preliminary (we target at a larger sample size of N=24 each), this might indicate that earlier claims about superior unconscious processing might have been premature. [This project is supported by the Deutsche Forschungsgemeinschaft (DFG,German Research Foundation) through the CRC 1233 "Robust Vision", project number 276693517.]

Blur Perception in Myopes, Emmetropes, And Post-LASIK Subjects

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Constant viewing of a clear or a blurred image creates alteration in the perception of blur or sharpness. Perception tends to incline towards the type of image they were viewing / adapting. Myopes have a defocused optical system and are more exposed to blurred environments than emmetropes. This may be the reason to have higher blur detection and discrimination thresholds in myopes. In this study, using psychophysical methods we aimed to understand the blur adaptation mechanisms in emmetropes, myopes and post LASIK subjects. The subjects were adapted to either a blurred or sharp image for 6 minutes and blur detection thresholds were measured using 2 alternative-forced choice task using an adaptive staircase. A top up adaptation was given for 6 seconds before each trial. Images were blurred or sharpened by altering the 1/f slope. We measured blur detection thresholds post adaptation in 3 emmetropes (age range: 20-35y), 3 myopes (age range: 20-35y) and 1 post LASIK subject (age: 26y). We found that myopes had reduced blur sensitivity than emmetropes, implying that myopes will appreciate a mildly blurred image to be clear. With adaptation to a blurred or sharpened image, myopes have a shift towards the type of image they were adapted to. Interestingly, for the post LASIK subject, the blur sensitivity post adaptation was like the emmetropes for blur adapted images. This suggests blur sensitivity may not be an intrinsic factor in myopes.

The effect of modeling on experience of physical attractiveness and unattractiveness

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In the present study we investigated the effect of professional modeling on the experience of both physical attractiveness and unattractiveness. We hypothesized that, according to the "lean athletic imperative", models prefer more masculine male bodies and less feminine female bodies. Six body parts were selected: shoulders, chests (male figures) or breasts (female figures), waist, hips, buttocks and legs. Each body part was presented with 5 figures ranked in size. Two groups of participants, models (n=15, 7 females) and non-models (n=23, 13 females) judged the most attractive and the least attractive sizes of six body parts of male and female figures. Analyses have shown that, compared to non-models, models prefer more masculine male figures (narrower hips which induce a higher shoulder-to-hip ratio) and some more feminine characteristics in female body (longer legs). On the other hand, models prefer some less feminine characteristics in female figures (smaller breasts and narrower hips). In the case of the least attractive figures models showed lower tolerance towards characteristics that suggest a thicker look – larger breasts and buttocks, wider hips and shorter legs in female figures. Group differences for male bodies were not significant. Only a few gender differences were obtained: female participants preferred wider shoulders of female figures. Finally, larger male buttocks are less preferred by female models. These findings are generally in line with the "lean athletic imperative". In the case of female bodies, models' preference for a slender and fit look even goes against the typical feminine appearance.

Using Virtual Reality to Recreate the Synaesthetic Experience

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Synaesthesia is a condition where people experience unusual sensory or cognitive experiences in response to apparently unrelated stimuli. Traditional methods for investigating synaesthetic experience include looking at consistency of relationship between inducing and concurrent stimuli and/or verbal descriptions. We have investigated if Virtual Reality (VR) technology can be used to recreate the synaesthetic experience. Most studies focus primarily on synaesthetic colours, with fewer using creative methodologies to investigate the full synaesthetic experience. This study aimed to build on previous research by using both a traditional colour-picker and VR to capture a more nuanced picture. A multiple case study design was used to examine a small number of participants' experiences in detail. Participants (six in total) were asked to complete an initial questionnaire to characterize their synaesthesia. Following that, data gathering took

place via video conferencing. During the initial data-gathering session, participants used a colour-picker to provide grapheme-colour associations. After this session, some of the participants' synaesthetic experiences were recreated in VR using the drawing package Tiltbrush (Google). This was achieved by participants reporting their concurrent responses to a variety of audio-visual stimuli which were then recreated by the experimenters. In follow-up sessions, participants rated the success of these recreations. Results indicated that VR is capable of capturing certain elements of synaesthesia that other methods have been unable to, such as visual texture and small degrees of movement. These fascinating data also suggest that VR-based investigation of synaesthesia is a very promising avenue for future research (see https://tinyurl.com/SynaesthesiaVR for examples).

The visual advantage of social interaction: Is it attention or perception?

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We have recently reported an advantage in the detection of dyads of bodies appearing face-to-face as if interacting (relative to non-facing dyads), in crowded scenarios (Papeo, Goupil, Soto-Faraco, 2019, Psychological Science). The phenomenon is reminiscent of a visual search asymmetry: it is easier to find a facing dyad among non-facing dyads than a non-facing dyad among facing dyads. As such, it has been taken to reveal functional aspects of visual attention, particularly an attentional bias towards social interaction. But is it really so? In the present study, we sought to understand the mechanism underlying the alleged attentional advantage for social interaction. In a series of visual search experiments, we limited deployment of attention by presenting search arrays for a short duration. Facing bodies among non-facing bodies were consistently found more accurately than non-facing bodies among facing bodies. However, this advantage was limited to a small set of locations falling in central fixation. Simultaneous eye-tracking showed that detection of facing dyads occurred without eye movements, confirming that the advantage applied to targets that were already in the focus of attention. By introducing arrays of object pairs, we found that the asymmetry in detection of facing dyads selectively applied to social (multiple-body) visual stimuli. These results suggest that the apparent bias towards facing dyads do not imply an attentional advantage for social interaction, but rather reflects an effect of enhancement of the visual representation of social entities that are already in the focus of attention.

Inhibition of return facilitates visual search as long as inhibition of return is not measured

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Inhibition of Return (IOR) has been shown to facilitate visual search by discouraging the immediate reinspection of previously inspected items. When testing for IOR during search, one of the search items is probed and participants are required to saccade to the probe. In general, saccadic responses to probes on items that have not been fixated before are faster than responses to recently inspected items, indicating the presence of IOR. However, the presentation of a probe constitutes a tremendous interruption of the natural search process. At least to our knowledge, the effect of the probe on search performance has not been investigated so far. We therefore (re-)analysed data of four different experiments in which we tested for IOR during search using probes. In each experiment, participants searched a letter display for a target letter. During most of the searches, a recently inspected or non-inspected item was probed by changing its size and color. The analysis showed that participants saccaded more likely to the probe when it was presented earlier during search, although the probe overall was ignored more than 66% of the time. Once participants saccaded to the probe, search time increased compared to when the probe was ignored or no probe was presented. Again, an early probe onset seemed to affect search time less than when the onset was later during search. Together, the findings reveal that probes presented during a search have a detrimental effect on the search process. [This work was supported by the Austrian Science Fund (FWF): P 28546 and P33074.]

Attention distribution in the field of vision: color and size vs spatial location

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Visual attention allows people to select the information that is the most relevant to ongoing behavior. In a search strategy of the different characteristics (e.g. color, size, shape) of the objects changing their spatial location, must be definite hierarchical order of characteristics that is reflected in the

recognition time for each particular parameter. The aim of our research was to ascertain the importance of three characteristics of a visual object – size, color and localization in the visual field, in attention distribution process under central and peripheral conditions of vision. In the first experiment, the subject was asked to simply fix glance on the fixable white spot projected permanently to the screen center and to press any button of the keyboard upon appearance of the stimuli, four Latin letters of different sizes and colors A, B, C, D in the visual field. At the second one, the subjects were required to read aloud the words presented in the white spot to be fixed as a running line and to react the emergence of stimulus by pressing the button. According to our data irrespective of the stimulus parameters and intensity of data traffic, these stimuli are perceived fast which are located in the upper-left corner of the scene. We suppose that an attention distribution in the visual field is due to the reading habit in accordance of which, while perceiving the scene, the eye starts to move from the upper-left corner to the right and then to the bottom.

The Effect of Task Difficulty on the Dynamics of Functional Field of View Adaptability

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The amount of visual information conveyed through the retina is limited by the size of the spatial area surrounding the fixation point. This area, called the functional field of view (FFV), prevents the visual system from being overloaded. The size of the FFV is determined by two types of factors that drive visual perception, namely, the retinotopic (physiological) and the functional (cognitive) factors. One hypothesis is that the FFV is highly adaptable and changes based on the difficulty of the given task (Young & Hulleman, 2013), shrinking in response to high task demands and expanding during the execution of easier tasks. In order to investigate the dynamics of FFV adaptability, we propose a gaze-contingent experiment that would allow us to manipulate the FFV in a controlled visual search paradigm. Participants (N=15) search for either a large (5-7°) or a small (1-3°) target among a set of same-size distractors in three difficulty conditions based on the size of the gaze-contingent aperture: a small aperture (2°) for the difficult condition, a medium-sized aperture (5°) for the average condition and a large aperture (8°) for the easy condition. We hypothesize that the results will show the analysis of response times and accuracies in each of the search conditions given both target sizes using a repeated measures ANOVA, as well as the interactions between them. [This work is partially supported by the HSE academic fund program for the scientific research lab "Vision Modelling Lab".]

Temporal saccadic dynamics in free viewing of competing naturalistic images

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When exploring natural scenes, a decision about the target of the upcoming fixation is dynamically made several times per second. Formal models of this decision process are available for isolated visual stimuli, but less is understood in contexts when multiple images compete for visual attention. To address this, we investigated how visual salience and task demands predict saccadic reaction times and exploration-exploitation behaviour when competing visual targets are available. We recorded eye movements while subjects freely explored bilaterally presented pairs of naturalistic images in a visual memory task and a task-free condition. We used a previously validated metric of global visual salience to quantify each image's effectiveness at attracting visual attention by modelling the distribution of first fixations. We then showed that saccadic reaction times decrease up to 50ms (or by about 25%) as a function of the difference in salience of the competing images. Surprisingly, we also observed a decrease of the same magnitude with the increasing sum of the salience of the two images: when stakes were high, perceptual decisions were quick and efficient. This was compensated with quick decisions being followed by quick fixations away (exploration behaviour), and low-stake decisions being marked by longer engagement (exploitation behaviour). In addition, we observed that task effects arise only late in the trial, after the effects of salience have subsided. Overall, we showed that visual salience dominates the guidance of visual attention in early saccadic decision making, and top-down task demands explain predominantly late saccadic behaviour.

Action video game players learn spatial configurations of visual information more efficiently compared to non-gamers

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Visual search is speeded, when the target item is repeatedly positioned within a fixed relative to the variable configuration of distractors since repeated context is thought to guide visual search (contextual cueing effect). Conversely, once a stable association between a target and a repeated context had been established, participants require extensive practice to re-associate an old context with a permanently changed target location in the subsequent relocation phase, as updating of learned target-context associations is rather inflexible. We asked whether individuals with enhanced attentional control functions, such as action video game players (AVGPs) show more efficient acquisition and adaptation of learned contextual regularities when compared to non-gamers (NVGPs). Two groups of AVGPs and NVGPs participants (N = 20 each) reported the orientation of a target letter T in repeated and novel displays in the initial learning and subsequent relocation phases, in which the target letter T is presented at a different location compared to the previous learning phase. AVGPs relative to NAVGPs showed a larger cueing effect in the learning phase, but not in the relocation phase. In the relocation phase, both groups showed no significant cueing effect in the relocation phase. Those results might indicate a superior performance in the acquisition of spatial long-term memories in AVGPs, but no advantage in the adaptation of long-term context memories. The role of action video games in the acquisition and adaptation of context-related memories will be discussed.

Contrast Sensitivity Changes at Different Background Brigthness Levels in Patients with Cataract

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In the clinical practice contrast vision tests are not used as primarily tests to check the progression of cataract but it can be a useful method to detect cataract development and help us to understand patient's complaints about daily life tasks like driving. Our aim was to estimate the contrast vision sensitivity for patients with cataract and control group, at different background levels. Methods: In our research participated 36 eyes with cataract and 30 control group patients. The contrast sensitivity before and two weeks after Femto laser cataract surgery was measured with alternative forced choice test design (AFC). Measurements were performed under mesopic conditions with different test background brightness levels (60 cd/m2, 85 cd/m2, 100 cd/m2) and spatial frequency's (4 cpd, 6 cpd, 12 cpd, 18 cpd). Results: Cataract-induced light distribution significantly decreases contrast sensitivity at all spatial frequencies. There are no significant differences between the Weber constants when the background lighting level change in group before cataract surgery and control group. At the lighting level of 60 cd/m2, cataract surgery provides a significant improvement at the average spatial frequencies, but at the background lighting level 85 cd/m2 and 100 cd/m2 an improvement in contrast sensitivity high and low spatial frequency. [Authors Zane Jansone-Langina, Renars Trukša have been funded from project "KC-PI-2020/10".]

Assessment of compensation and simulation filters for colour vision deficiency

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Compensation filters may improve perception in humans with colour vision deficiency (CVD) whilst simulation filters may mimic CVD in colour vision normals (CVN). This study assessed impact of EnChroma (Cx-65) filters on perception in CVN and CVD observers, and Variantor filters in CVN observers. Fourteen CVN and nine CVD (1 protanopic, 4 deuteranopic, 2 protanomalous, 2 deuteranomalous) observers completed colour discrimination and colour naming tasks. A 5° chromatic square was presented on achromatic, static, luminance-noise backgrounds (Linhares et al., 2016). Participants indicated square location (right or left) or named its colour (reporting 1 of 11 standard colour names). Discrimination threshold and colour naming tasks were repeated for 16 hues, with naming performed at three saturation levels (100, 66 and 33%). Repeated-measures and mixed-measures ANOVAs on discrimination thresholds showed: (1) Variantor vs no-filter on CVN observers: a significant effect of filter ($P < 0.001$) such that thresholds were higher with Variantor, (2) EnChroma vs no-filter on CVN and CVD groups: no significant effect of filter on discrimination thresholds and no significant interaction between filter and participant group. Colour naming errors significantly increased for CVN observers with Variantor vs no filter ($P < 0.001$) but with EnChroma vs no-filter, they did not change significantly for CVN or CVD groups. Variantor and EnChroma filter results demonstrate similarity of pattern across hue for discrimination thresholds and naming error scores. No significant improvements in colour discrimination and colour naming errors by CVD observers

were demonstrated with EnChroma filters. Variantor filters in CVN observers simulated protanopia. [This work was supported by an Evelyn Trust Grant (to SJW) and HEFCE QR (Quality Related) Funds (to Anglia Vision Research) to support a Postdoctoral Research Fellow (LA) and visits (LA and JMML) to the laboratories of Anglia Vision Research, to facilitate completion of this project. The authors thank Ashley Gray (a research assistant supported by the QR fund), Emily Mailman and Laura Douds (who were undergraduate Optometry students) for their help with data collection.]

Discrimination and Bias of Perceived Hues with Stimulus Uncertainty

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Noise in sensory stimuli not only results in high response variability but can also lead to perceptual biases. According to a Bayesian observer model, these biases arise through a process of statistical inference, in which a non-uniform internal prior integrates with the information from noisy measurements. Such a model is supported by studies on visual judgment of orientation and speed. For hue perception, the effects of uncertainty on discrimination or bias have been rarely investigated. We used two-alternative forced-choice discrimination tasks to measure the perceived hue of noisy hue ensembles. For isoluminant stimuli defined by azimuth angle in cone-opponent color space, discrimination thresholds followed a bimodal pattern, with lowest thresholds near a non-cardinal blue-yellow axis. Adding chromatic noise increased the discrimination thresholds while maintaining the non-uniformity. When subjects discriminated two ensembles with different levels of chromatic noise, a systematic sine-shaped perceptual bias was observed with zero crossings around the blue-yellow axis. The perceptual bias was repulsive from blue and attractive towards yellow, which indicates an asymmetry of the blue-yellow axis. Given that this axis coincides closely with the variation of natural daylights, the results suggest that a preference related to natural colors might play a role for the prior in hue perception.

Hue ensemble perception in the presence of distracting stimuli

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In natural scenes, objects' color distributions can be spatially interspersed with unrelated colors. We asked whether the visual system can selectively form an ensemble hue percept over a target hue distribution displayed among distractors. Hues were drawn from uniform distributions (range 30°) on a hue circle in CIELuv color space. A test and a comparison ensemble were presented in two 500-ms intervals, separated by 500 ms. Observers indicated whether the second ensemble appeared bluer or yellower on average than the first ensemble. The test ensemble was either red or green, and comparison hue mean was varied around the test hue mean. The ensemble stimuli in the baseline condition consisted of 18 uniformly colored circles (0.5 degrees of visual angle) located randomly in a 6-by-6 invisible grid with element separation of 1 degree. Distractor conditions included an additional distractor ensemble, filling the 18 vacant spaces in the test ensemble grid. The mean distractor hue differed by -60, +60, or +180 degrees from the mean test hue. Psychometric functions were fit to the proportion of "bluer" responses to estimate perceived test hue and discriminability. Observers were able to selectively judge the test ensemble colors, but discrimination thresholds were higher in distractor conditions, and higher with a 60-degree, compared to 180-degree, test-distractor difference. With a 60-degree test-distractor difference, perceived test hue was significantly biased towards the distractor hues, more for bluer than for yellower distractors. Color ensembles can be segmented by their distributions, but surrounding context may impair the accuracy of color estimates. [This project was supported by the Academy of Finland (Grant #319404) and Emil Aaltonen Foundation (Grant #200240 N1).]

Surface-reflectance discrimination is optimized in the presence of inter-reflections

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Surface-reflectance discriminations aid in segmenting the visual field. Surface-reflectance discrimination is highly variable, depending on the illumination, the object, the context, and the viewer. In order to stably discriminate invariant surface spectral reflectance in a changing world, the visual system must somehow discount the contributions of the light field. Contemporary artificial lights significantly differ from the natural illuminations originating from blackbody radiations under which human vision evolved. With the rapid developments in solid-state lighting technologies, artificial light spectra can be sculpted to hold arbitrary shape with the power to conceal or reveal the surface-reflectance differences. This study reports that indiscriminate metameric surfaces are less likely to exist for concave geometry due to inter-reflections. Unlike flat or convex surfaces, the incident light undergoes more than one bounces between concave surfaces. Through high-order reflections, the incident light's spectral power will be absorbed spectrally in an

exponential way. The exponential attenuation of the spectral power leads to a luminance decrease before entirely diminishing. It is less evident that higher-order light reflections' spectral shape simultaneously varies as a function of the number of bounces they went through, except for the achromatic surfaces with flat reflectance spectra. Via theoretical analysis, we found that the spectral changes are systematic shifts towards reflectance spectral peaks. Using computational simulation, we empirically demonstrated accumulated inter-reflections could induce statistical differences for the visual system to distinguish flat or convex metameric surfaces. We will next investigate how the human visual system exploits such a statistic when discriminating the surface reflectance. [Author Cehao Yu wants to acknowledge the funding received from the European Union's Horizon 2020 research and innovation programme (grant no. 765121; project "DyViTo").]

Perception of CCT in cyan spectra composed light emitting diode white source

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Modern LED technology relies on the gallium nitride properties with pronounced blue spectra at around 460 nm, which is largely present in most of LED white light sources. Light and especially blue spectrum have a proven role in the management of non-visual physiological functions, for example, in the regulation of the circadian cycle. In our approach we tend to minimize the use of blue light by replacing it with the mixture or cyan spectrum. Multichannel LED source (Red, Amber, Green, Cyan1, Cyan2, Blue1, Blue2) was developed with emphasis on blue and cyan spectral representatives. Experimental procedure was lightness (300, 600, 900 lx) and correlated colour temperature (3K, 4K, 5K,6K, 6.5K Kelvin) matching to the reference source. Results obtained on the group of young naïve subjects indicate that cyan spectra edition to the same CCT white source have no impact of the perceived lightness. However, lowering the blue spectra with addition of cyan part significantly impact the perception of CCT.

Appearance of alpha rhythm as a predictor of visual information processing in working memory

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We studied brain activity in alpha-band during retention of visual characteristics in visual working memory. The subjects (N=10, age=21.5±0.7) were presented with complex shapes like blots (8 variants), colored in different colors (9 variants), which they were asked to remember. A cue was then presented, which tasked the participant to recall the color, shape or both and remember it. After a pause of 2000 ms, a test stimulus was presented. The subject had to answer whether the retained characteristic of the remembered stimulus coincided with the test stimulus. EEG (60 channels) was recorded; Morlet wavelets were calculated in Brainstorm (Tadel, 2011). We analyzed 2000 ms after cue presentation. We found alpha-activity 700-1300 ms after cue when comparing the color of the perceived stimulus with the color in memory. When comparing the shape of the stimulus with the memorized shape, alpha-activity occurred at 1400-1600 ms after cue. Finally, in the series that required comparing both the shape and color of the stimulus and the memory image, alpha-activity occurred at 1100-1300 and 1500-1700 ms. It was shown that the number of alpha rhythm appearances coincided with the number of different characteristics of the visual stimulus in memory that the subject was required to pay attention to. Thus, we hypothesize that the appearance of alpha rhythm when the eyes are open may be evidence of a temporary disabling of visual information processing in the primary visual cortex at moments when the subject is analyzing an image in visual memory. [Funded by Russian Science Foundation (RSF), project 19-18-00474.]

Neural model for social interactions recognition from abstract and naturalistic scenes

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INTRODUCTION: Humans can interpret social interactions from schematic stimuli (Heider & Simmel, 1944). We present a simplistic neural model of the visual pathway that recognizes dynamic social interaction from naturalistic and abstracted scenes. We also present an algorithm for the generation of the controlled stimulus classes of dynamic social interactions, derived from dynamic models of human navigation (Warren, 2006). METHODS: The model consists of shape-recognition pathway, modeled by a Deep Neural Network (VGG16) for mid-level feature detection, followed by an RBF network that recognizes shape, orientation and position of moving agents. Agent position and orientation is tracked by a recurrent neural network (neural field). Combining a gain field mechanism and motion energy detectors, the (relative) positions, velocities and accelerations of the agents are computed, followed by a neural level that classifies interactive

behaviors. RESULTS: The model reproduces psychophysical results on the classification of interactions form abstract stimuli (Salatiello et al. 2021), and it recognizes interactions from real movies showing interacting animals in natural environments. CONCLUSION: The recognition of social interactions can be accounted for by simple physiologically plausible neural mechanisms, which are consistent with the architecture of the visual pathway. The model makes concrete predictions about the behavior of neurons in relevant brain areas, at the single cell as well as at the population level. [Funding: ERC 2019-SyG-RELEVANCE-856495, HFSP RGP0036/2016, BMBF FKZ 01GQ1704, NVIDIA Corporation, SSTeP-KiZ BMG: ZMWI1-2520DAT700.]

Characterizing the human cortical networks for spatio-temporal binding in vision: an MEG study

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Continuous visual input is grouped over space and time into unique and discrete objects and events. We investigated this binding process by taking advantage of two perceptual binding paradigms: two-flash fusion (TFF) and apparent motion (AM). In the case of TFF, on any given trial participants were presented two separate flashes, separated by a blank interstimulus interval (ISI), which could be perceived as either a single flash (fusion) or correctly distinguished as two separate events. When the location of the two flashes differs, as in AM trials, participants either perceive a single object moving through space or two separate flashes with no motion. We matched the ISI to create a bistable stimulus, so that MEG activity could be investigated in trials in which the bistable stimuli were temporally combined versus those in which the participant reported seeing two separate flashes. We used MVPA to decode subjective perception based on the pre-stimulus activity: the brain state at the time of stimulus presentation predicted the eventual percept as either integrated or temporally segmented. We found significant pre-stimulus decoding of TFF percept based on the phase of alpha-band activity in the right medial temporal (MT) area. Phase decoding of outcome for AM was strongest for theta-band activity, localized to a right intra-parietal sulcus (IPS) source. The two tasks also depended on different functional connectivity patterns. Overall, these findings point to the importance of at least two different binding windows for temporal perception, with our subjective experience not depending on any single binding window.

d2 – a new metric for characterising retinotopic areas

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The retino-cortical visual pathway through the thalamus up to area V4 is retinotopically organized: Neighbourhood relationships on the retina are preserved in the mapping. Local size relationships in that mapping are inversely proportional to eccentricity in the visual field. Globally, the locations in these maps are given by a logarithmic function (Fischer, 1973) if certain premises are fulfilled. An individual map can be characterised by the decrease of the cortical magnification factor (CMF) with eccentricity, or by a set of iso-eccentricity contours drawn on a flat map of the cortex. Here I propose, as a concise alternative, a new structural parameter d2 to characterize these maps; it is defined as the radial distance, in millimetres, from the retinotopic centre to where the cortical magnification factor (CMF) is halved. It is a neuroanatomical counterpart to E2, known from psychophysics, the eccentricity where the foveal scale is doubled. d2 captures the map in a single number along a radius, or a single contour on the map. It is the scaled product of the central CMF, M0, and E2, and it is more stable than either of these parameters. It can be used across studies, across radii, across individuals, and even across species. It can further help assess the retinotopic centre's CMF, M0. Typical values for d2 and M0 are given for a number of well-known mapping studies. The comparison of d2 and M0 across mapping studies shows considerable variation, and I discuss possible reasons for this.

Detection of second-order texture modulations by neural network saliency models

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In our work, it is shown that training a neural network visual saliency model makes it capable of detecting second-order visual features. To train the models, two datasets were used, which consist of pairs of images and their corresponding empirical saliency maps. The first set is Salicon, created at the National University of Singapore using a computer paradigm "to simulate the natural viewing behavior of humans" (Jiang at al., 2015). Salicon contains 10000 and 5000 image-map pairs for training and validation, respectively. The second set was formed from the results of

11 eye-tracking studies, freely available on the internet, and contains 11561 and 2863 pairs for training and validation. The model was a simple convolutional auto-encoder with only 31105 trainable parameters. Network training was aimed at obtaining the maximum similarity between the empirical saliency map and the result of encoding-decoding operations. For testing, we used pairs of modulated textures and raster-encoded two-dimensional modulation functions; there are 960 of such texture-function pairs for modulation of contrast, orientation and spatial frequency. The parameters of the textures varied randomly over a wide range. The trained saliency models have been found to be very good at decoding contrast modulations (e.g., the Kullback-Leibler metric for a model trained on oculographic data is 0.099), but they also decode orientation and spatial frequency modulations quite well. This results are further evidence of the importance of second-order visual features in the formation of a saliency map. [Supported by RFBR, project No 18-29-22001.]

Sensitivities in luminance and amplitude may not predict sensitivity to shape-from-shading

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In this study we investigated the effects of age on second-order vision and how the loss of first-order (carrier) visibility and coarse-scale second-order visibility can affect how we sensitive we are to shape-from-shading. Human vision is sensitive to first-order and second-order characteristics. Modulations in luminance are characterised as first-order stimuli whereas contrast and amplitude modulations of luminance patterns are second-order stimuli. It was proposed that first- and second-order signals combine to provide depth information, aiding the observer to discriminate changes in illuminance vs texture (Schofield, Hesse, Rock, & Georgeson, 2006). These visual cues can be replicated by modulating a high spatial frequency carrier with low-frequency amplitude and luminance modulations. To investigate this, observers (18-25 and 60+) completed a 2afc orientation discrimination task with a sinusoidal plaid composed of one in-phase LM+AM grating and one out-of-phase LM-AM grating. Observers' sensitivities were also estimated for noise carriers and course scale amplitude modulations in detection tasks (4, 8 and 12 cpd). We found that performance in the carrier sensitivity and amplitude modulation task did not significantly predict performance in the shape-from-shading orientation discrimination task. In conclusion, we find that older observers' performance in detecting shape-from-shading cannot be explained by reduced sensitivities to coarse-scale luminance and amplitude modulations. [Economic and Social Research Council.]

Bounded Human Ability for Stereopsis

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Stereopsis is believed to be perceivable when two different 2D images of an object, lying on Binocular Horopter, fall on corresponding retinal locations with same eccentricity in both the eyes. As the blind-spot region of our retina is devoid of photo-receptors, it cannot receive any visual information. In binocular vision, the corresponding higher visual area of one eye compensates the other's non-reception area. Hence, our brain receives only one image which physically contributes in constructing the actual view of an object. Yet, our ability to circumvent the 2D-3D spatial transitional crisis around the blind-spot indicates that the brain aids in this adaptation. To verify if this is the sole mystery regarding 3D reconstruction across our Field of View (FoV), we first placed the depth cue dependent "Ponzo illusion" stimulus at different visual eccentricities. Participants fixated at the center of the monitor and responded about their perception of the illusion at different eccentricities. Area-of-Interest metrics, heat-maps and gaze-plots from an eye-tracker were utilized for checking proper gazing fixation and saccadic movements of the participants. In a second experiment, participants tried to align their index fingers at different positions in front of a chart paper-made Horopter. Our findings manifest that we cannot perceive stereopsis beyond 10 degree in both the visual halves centering around fovea, although spatial continuum experiences indicate that the brain somehow compensates the 2D-3D transitional gap which would otherwise highly impact the multitude of real life activities. [This work was funded by CSRI of DST (SR/CSRI/307/2016), Govt. of India and TAC-DCSW funding (2018-21) of ISI. The authors are thankful to Dr. Bijay Bal and all the colleagues in the Laboratory for Cognitive Systems and Cybernetics Research at the Center for Soft Computing Research of ISI, Kolkata. The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.]

Looking while loaded: Differences in oculo-motor tendencies during three common visual tasks might be based on varying degrees of cognitive load

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In the study of eye movements, three visual tasks are often used: free-viewing, exploration followed by a question, and visual search. We noticed in previous experiments that fixation

and saccade features differed strongly between tasks and part of the reported viewing tendencies could be related to the task rather than the type of stimulus. Surprisingly, few studies have directly compared these tasks within the same experiment, making comparisons difficult due to variations in the type of stimulus material and data processing between studies. Therefore, we set out to explore oculo-motor differences of participants each performing the three different visual tasks, using pictures of indoor and outdoor scenes. We hypothesized that dissimilarities arise because of differences in top-down task requirements rooted in different degrees of cognitive load. To test this, we measured reaction times to an auditory distractor as well as pupil dilations. Our results showed that saccade amplitudes were longest during free-viewing trials. We observed that average saccade amplitudes decreased over time following trial onset during exploration with question and visual search trials, whereas they increased during free-viewing. Additionally, observers needed less time to react to an auditory stimulus when it was presented during free-viewing trials. Further, pupil dilation was on average at its highest during visual search and lowest during free-viewing trials. This study, once again demonstrates the impact of a visual task on oculo-motor tendencies. Importantly, we suggest that the differences that have been reported across tasks might be largely explained by effects of cognitive load. [This study was supported by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation), project number 222641018 SFB/TRR 135 TP C7 granted to MLHV.]

Instantaneous drift velocities measurement

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To investigate the processing of visual information, accurate data on the distribution of instantaneous velocities of fixational eye movements are required. While the velocities of microsaccades are well studied, drift velocities have been examined by only a few researchers. Eye movement recordings are noisy and estimating instantaneous velocity is not trivial. This study aimed to obtain histograms of the distribution of instantaneous velocities and to test the hypothesis put forward by Murakami (2004, 2010) that the histogram is well fitted with a Gaussian distribution. Twelve participants fixated the central target for 1000, 2200, or 5000 ms in 82 trials each. The observer's eye movements were recorded with SMI HiSpeed 1250 binocularly (500 Hz frequency). Blinks and saccades have been removed from the raw data. Only fixation intervals longer than 150 ms were analyzed. To estimate the instantaneous velocity, a 15-point second-order Savitsky-Golay filter was used. For each subject, the two-dimensional (horizontal and ·vertical) histograms of instantaneous drift velocities were obtained for all records. The resulting histograms are not well approximated by the Gaussian distribution. The standard deviation estimates range from 1.4 to 4.0 deg/s for different observers. [Supported by RFBR grant № 19-013-00784.]

Gaze parameters in visual search on the volumetric display

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Various image parameters, such as screen type (three-dimensional (3D) or flat screen) and stimulus eccentricity, can affect eye movements. Eye-tracking can be used to analyze the effect of image parameters on perception, as well as to assess the user experience for the novel displays. This study first described how the location of visual elements on volumetric multi-plane display affects the way images are viewed. All participants (n=10, 21-24 years) performed a visual search task on a volumetric multi-plane screen with elements in four field eccentricities (2, 4, 6, and 8 degrees). In target-present trials, the task was to determine which of the four circles was displayed closer to the observer. In target-absent trials, the individuals were instructed to report that images were two-dimensional. As a result, the correct response rates were higher when the stimuli were closer to each other (2 and 4 degrees) and differed significantly when comparing target-present and target-absent trials. Moreover, the analysis of eye movements revealed that gaze was more often directed to the target in closer field eccentricities. However, as the field eccentricity increased, a similar amount of time was devoted to viewing each element on the display. To conclude, the study showed that it was easier to distinguish three-dimensional images than two-dimensional images on the volumetric multi-plane display. Moreover, as the field eccentricity of the elements increased, the distribution of fixations changed indicating that it was more difficult to evaluate the relative depth of elements in the optical element of the volumetric multi-plane display. [This work is a part of the research project "Evaluation of volumetric display's 3D image effect on human visual system", No. ZD2019/20807. It was supported by the European Regional Development Fund ("Development of a compact, high-brightness laser image projection system for application in volumetric 3D displays", project No. 1.1.1.1/18/A/179).]

The systematic strategy in solving Raven's Progressive Matrices: comparing eye movements of programmers and psychologists

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Raven's Progressive Matrices is a test designed to differentiate subjects according to their level of intellectual development. Two strategies are known for executing Raven's Progressive Matrices. The systematic strategy consists in the fact that the subject analyzes the structure of the matrix and, based on the mental operations (search for a relationship, analogy, progressive changes in the figures of the matrix; rearrangement of the figures of the matrix; decomposition of the figures of the matrix into elements) formulates the answer and proceeds to his search among the proposed options. The toggling strategy checks each answer option by substitution in the matrix, so solution is performed by the method of selection or elimination. The purpose of this study was to study the features of the strategy of executing Raven's Progressive Matrices by programmers using eye tracking method. Programmers make 3.2 times more fixations on the matrix than on the answers (for comparison, the control group of psychology students makes 2.2 times more fixations on the matrix than on the answers). With an increase in the complexity of tasks, this coefficient increases The programmers are characterized by fewer switches between matrix and answer options compared to the control group. The time before the first glance of attention to the answer options is higher for them than for the control group. Based on the results obtained, we can assume that programmers are characterized by using a systematic strategy of executing Raven's Progressive Matrices.

Enhancing the contrast within a face influences on the attractiveness and attention

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The enhancing the contrast between the eyes, lips and the surrounding skin influences the perception for femininity and attractiveness of faces. However, it is not clear whether the contrast-enhancing manipulation within the faces gives rise to the same effect in the faces with emotional expressions. Generally, high-contrast stimuli are more likely to capture exogenous attention than low-contrast stimuli. However, the effect of contrast on attention might be different depending on the emotional valence of the stimulus. In the present study, we conducted two experiments by varying the contrast of three facial expressions: happy, angry, and neutral expressions. In Experiment 1, we tested the evaluation of attractiveness and femininity by changing the contrast and expressions. In Experiment 2, we used a dot-probe task to examine differences in attention capture between conditions in which both valence of facial expressions and contrast of images were manipulated. The results showed that attractiveness and femininity were higher in high-contrast images of happy and neutral faces, but the effect of contrast manipulation was not observed in angry faces. The results of the dot-probe task showed that attention was captured with natural contrast images of emotional faces, but not with the contrast-manipulated images. These results suggest that the effects of contrast manipulation might be differed which depending on the emotional valence of facial expressions. Negative facial expression tends to decrease attractiveness, femininity even in high contrast condition. Also, enhancing face contrast may reduce attention to emotional faces. [This work was supported by JSPS KAKENHI Grant Number17K04492.]

Emotional intelligence and perception of facial attractiveness

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Perception of attractiveness is known to be associated with facial expressions: positive expressions increase perceived attractiveness, while negative expressions decrease it. It was also shown that neutral faces are often perceived as emotional, as different facial morphotypes vaguely resemble facial expressions. In the present study we examined the influence of emotional intelligence (EI) on perception of facial attractiveness. Photographs of neutral faces were presented separately for 2 seconds for each participant (N = 49). After each photograph was presented, participants had to rate its attractiveness on a scale from 1 to 9. The level of EI was measured by using the Test of emotional intelligence (Russian adaptation of MSCEIT v. 2.0). We found significant negative correlation between the ability to identify emotions and the attractiveness ratings. According to the parameter of the ability to identify emotions, the subjects were divided into two extreme groups. The group with the high ability to identify emotions rated faces as significantly less attractive than the group with the low level of ability. No significant differences were found in the average fixation duration, saccade amplitude, as well as in dwell time spent in the areas of eyes, nose, nose bridge and lips between two extreme groups. Both the general EI and the other trees of ability were not associated with attractiveness ratings. [Funded by RFBR, project №19-29-07392.]

The motion-induced size illusion is driven by motion that follows the test probe

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When a random-dot background is repeatedly expanded and contracted, dramatic changes in size are seen for squares that are flashed at the motion reversal points (Anstis & Cavanagh, 2017). Here we examine how different parts of the motion sequence contribute to the size change. In the experiment, two textured backgrounds were presented side-by-side, expanding and contracting in synchrony. On one side, a square was flashed at the end of expansion while on the other side the square was flashed at the end of contraction. The two squares had identical physical size. Participants reproduced the perceived sizes of the two squares and the size difference was taken as the illusion magnitude. We manipulated the duration over which the texture was present before and after each flash. When only motion after the flash was present, the illusion was almost as strong as it was when the motion was present throughout the whole cycle. Motion before the flash produced little or no illusion. These results suggest that motion occurring after a flashed probe is dominant in producing the motion-induced size illusion.

Illusory decrease of element size with entire expansion depends on information of distance decrease to the elements

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The perceived size of elements, which form a circular arrangement, illusorily decreased with the expansion of the entire arrangement (Uechi & Ichikawa, ECVP2018). One may consider this illusory decrease of element size would be caused by the "size-distance invariance hypothesis"; the expansion of entire arrangement, which might inform the visual system of distance reduction, would cause the perceptual reduction of element size because its size was constant on the display despite the information of distance reduction. In this study, we examined how the information of distance to the elements is involved in the illusory decrease of the element size with the expansion of the entire arrangement. We manipulated the information of distance to elements in terms of various factors; background (image of natural scene with rich distance cues, or uniform gray plane), relative height (high, or low), size of the entire arrangement (0, 2.57, 5.14, or 10.26 arc deg in diameter), and size of element circles (0.514, or 1.028 arc deg). Participants selected one circle from a chart of 21 circles with various diameters, which perceptually corresponds to the element circles, and estimated distance to those circles. We found that the perceived distance to elements varied with manipulation of any factors, and that the perceived size of the elements decreased with the decrease of distance determined by any factors. These results suggest that the illusory decrease of the element size with the expansion of the entire arrangement is caused by information of decrease of distance to the elements.

What can explain the difference between the Giovannelli illusion and the gravity-lens illusion?

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The perception of the relative position of two dots can be affected by other stimuli while properties of the effects vary with them. The positions of the dots can appear to shift toward or away from the center of the superimposed large circles. In this study, we examined factors that determined the direction in which the perceptual position of a dot was shifted. We manipulated the distance between two figures consisting of a dot and a superimposed circle. The observers judged the angle of the subjective line connected by the two dots. We found that the dots were perceived to be repelled from the center of the circle when the two figures were close to each other, while the dots were perceived to be attracted to the center of the circle when they were far from each other. The repulsion corresponds to the Giovannelli illusion and the attraction to the gravity-lens illusion. When we manipulated the size of the circles, the distance between the figures where the repulsion switched to the attraction changed. These results suggest that the relative distance between the figures to their size determines the direction of the perceptual shift of the dot, with switching from the Giovannelli illusion to the gravity-lens illusion as the relative distance increases.

Simultaneous Lightness Contrast as a Temporal Illusion

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In the classic simultaneous lightness contrast (SLC) illusion, two identical gray squares placed on adjacent black and white backgrounds appear different in lightness, with the former appearing lighter than the latter. In the present study, we introduced a temporal component to the classic illusion by moving a single gray square smoothly back-and-forth between end positions on the black and white backgrounds. On each trial, the square began to move either from the centre of the white or black background (counterbalanced), completed several full cycles,

and then vanished at one of three stopping points: black background, white background or across the middle border. Naive observers were asked to track the moving target, remember its lightness at the stopping point and adjust a probe to match the target. Our first goal, to investigate whether the SLC illusion still persists when a single target is judged against two backgrounds, was confirmed by the data. Furthermore, our preliminary data also indicate that prior history rather than motion anticipation, affects its perceived reflectance. That is, the middle target appeared lighter coming from the black than the white background even though its position and the immediate context were physically identical. These results suggest that the traditional spatial SLC illusion can be turned into a novel temporal illusion.

The impact of visual function on neuropsychological profile in children with Cerebral Visual Impairment

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Cerebral Visual Impairment (CVI) has become the leading cause of visual impairment in children in developed countries. Since it has been shown that CVI may negatively impact on neuropsychological profile, its early diagnosis and characterization are fundamental to tailor re-habilitation based on children's cognitive and functional profile. To date, there is a lack of standardized diagnostic methods to assess CVI in children, and the role of visual functions in cognitive development in children with CVI has been poorly investigated. In the present study, we aimed to unravel a possible correlation between neuropsychological and visual functions in children with CVI, thus providing insights on functional vision during development. Fifty-one children diagnosed with CVI were included in this retrospective study, with Verbal IQ >70 on Wechsler Scales as an inclusion criterion. For each child, we reported the neuropsychological assessment using standardized tests based on the age, exploring: i) the cognitive domain (i.e., by using WPPSI-III, WISC-IV, and WAIS-III); ii) visual perception and visual-motor integration (i.e., by using DTPV, VMI). We also collected data on visual functions, particularly perception and oculomotor abilities. Results showed a significant impact of visual acuity at far distance and oculomotor abilities on the neuropsychological abilities of children, suggesting that cognitive and visuo-cognitive abilities can be influenced by visual functions. Our findings might pave the way for novel early re-habilitation strategies aiming at improving visual function and, consequently, sustaining functional vision and neuropsychological development.

Guessing strategies in visual working memory account for resource-like behavioural data with a slot-like model

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There are two dominant hypotheses on the general nature of visual working memory storage, often referred to as slot and resource models. Slot models assume that a small number K of items can be retained over a memory delay, whereas resource models assume that the fidelity of encoded memoranda decreases with more items, with no limit K. These hypotheses make different predictions for continuous report tasks, where participants view the items (e.g. coloured squares around a circle) before reporting a feature value corresponding to a probe (e.g. the location corresponding to a colour). For display sizes S above K, slot models assume that if the probe is not in memory, participants guess, drawing from a uniform distribution (e.g. from all possible locations). In contrast, resource models assume lower coding fidelity with higher S, manifest as a broader distribution of reports (monotonic imprecision). Resource models therefore account for experimental data showing monotonic imprecision, and it is typically assumed that slot models cannot account for these data. This assumption ignores the possibility that participants guess strategically, rather than uniformly, by leveraging the information in the stimulus display. We show that a slot model can account for monotonic imprecision when guesses are preceded by a chunking strategy (clustering the items along a feature dimension). There is abundant evidence for chunking, so our study makes the case for re-evaluating slot and resource models in relation to strategies for working memory performance.

Similarity to internal models determines the efficiency of scene perception

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Natural scenes are perceived incredibly quickly and efficiently. Schema theory proposes a possible explanation: the visual system matches observed scenes to internal models representing typically structured scenes, where a higher similarity between the input and model leads to better processing. Here, we aimed to predict scene perception from descriptors of individual participants' internal models. Participants took part in a drawing task where they sketched their most typical versions of kitchens and lounges, as stand-in descriptors for their internal models. These drawings were converted into 3d renders, which

were then shown in a scene categorisation task. We observed better categorisation for renders based on participants' own drawings compared to renders based on others' drawings. Further, using a deep neural network (DNN) trained on scene categorization, we investigated whether graded similarity to participants' own drawings predicted categorisation performance. We found that behavioural categorisation was better when the DNN's response to a scene was more similar to the DNN's response to the participant's typical scene of the same category – and more dissimilar to the response to the typical scene of the other category. This effect was specifically observed at late DNN layers, suggesting that perceptual efficiency is determined by high-level visual similarity to the internal model. Together, these results highlight that perception operates more efficiently in environments that adhere to our personal internal models of the world. By further describing these internal models through unconstrained methods like drawing, we may come closer to accurately predicting individual perception in real-life situations. [This research was funded by the German Research Foundation (DFG).]

Evolutionary and Deep Learning Approaches to Accessing Mental Representations

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The childhood game of searching for shapes, objects and faces in clouds is a famous example of pareidolia, our tendency to spuriously detect signals in noise. Previous research has cleverly attempted to exploit this phenomenon to access mental representations of objects through reverse correlation (Gosselin & Schyns, 2003). In typical reverse correlation experiments, participants report whether they see a signal—e.g. the letter "s"—in noise images. Similarly to how some clouds happen to resemble known shapes, some noise samples will resemble the signal the participant has in mind. Averaging over all noise images in which a participant spuriously detected the signal yields a "classification image" — a visualisation of their representation of the letter. Averaging over pixel noise however has major drawbacks: the method requires thousands of trials and can only reconstruct blurred impressions of mental images. We address these issues using an evolutionary algorithm approach. We generate image populations by cross-breeding noise and show these to participants. Across generations, only those images in which participants detect a signal are kept for further breeding. This method converges faster (N=21, $p<0.001$) and produces sharper reconstructions (N=20, $p<0.001$) than standard reverse correlation, and can even recover competing internal representations (N=20, $p<0.001$). By coupling this evolutionary approach with deep neural network image classifiers we were able to "mind-read" which numerical digits participants (N=17) were thinking of by decoding them from reconstructed classification images. These tools thus provide highly promising and efficient strategies to access complex mental representations. [This research was supported by the DFG (IRTG-1901: 'The Brain in Action', SFB-TRR-135: 'Cardinal Mechanisms of Perception'), and an ERC Consolidator Award (ERC-2015-CoG-682859: 'SHAPE'). Author KRS was supported by an Alexander von Humboldt fellowship.]

Radial motion anisotropies depend on visual field location

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Background: Motion discriminability varies with motion direction. For example, sensitivity is greater for radial motion compared to tangential motion. Motion discriminability also depends on the visual field location of the stimulus, with greater sensitivity in the lower compared to the upper visual field. This study investigates whether and how these directional and location anisotropies interact. Methods: In a 2AFC task, observers reported motion direction relative to an internal reference. Each trial included 1 Gabor drifting either slightly clockwise or counterclockwise relative to the reference. The stimulus appeared within an aperture at 7 degrees eccentricity and was presented in 1 of 8 locations around the visual field (4 cardinal, 4 intercardinal). Throughout the experiment, 2 conditions were tested per location; radial motion (collinear with a vector connecting the stimulus to the gaze position), and tangential motion (orthogonal to the radial vector). Results: First, we found a main effect of location: all participants discriminated motion direction better in the cardinal than intercardinal locations. Second, we found an interaction of location and direction: radial motion discriminability was much better than tangential motion discriminability at the lower vertical meridian, but was approximately matched at other locations. Conclusions: Overall, these findings demonstrate that for drifting gratings, motion direction discriminability is greater in cardinal than intercardinal locations. Additionally, we find that greater sensitivity for radial motion direction interacts with polar angle location and is specific to the lower vertical meridian. These results suggest that this motion direction anisotropy is a local rather than global effect.

[Funded by US National Institutes of Health (NIH) National Eye Institute RO1-EY027401 to MC and JW.]

Non-linear interactions of perceived behaviours in collective flow

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In everyday life our visual system is continuously exposed to a wide range of motion flow patterns. Our knowledge of low-level motion processing is substantial, while higher-level processes such as future state prediction, motion constancy, and behavioural property estimation remain poorly understood. Here, we concentrate on behavioural cues of collective flow. Collective flow exists of a body of individual agents that show both collective and individual behaviours following a coordinated set of rules. In nature there are many occurrences of collective flow on various scales, various levels of complexity, across both animate and inanimate systems (e.g., swarms of insects, cars on highways). Using a real-time browser-based simulator of a relatively simple six-dimensional parametric model we displayed a range of collective behaviours. In a variety of experiments with free naming, name selection, similarity judgements, and rating tasks we started exploring the parametric space and its perceived behavioural dimensions. We find that observers can name a wide range of behaviours despite the abstraction of the simulations. Observers found the words expressing the spacing between agents to be the most descriptive. However, in the rating experiment it was found to be a challenge to differentiate between more distinct definitions of this spacing such as grouping or dispersal. Moreover, the six-dimensional parametric space contained multiple instances of the same perceived behaviour, making direct mappings between the parametric space and perceptual space even more complex. The challenge will be to clearly tease apart the perceived behaviours with their non-linear interactions across the explored parametric space. [This work was supported by a Marie-Skłodowska-Curie Actions Individual Fellowship (H2020-MSCA-IF-2019-FLOW, Project ID: 896434) and a Marie-Skłodowska-Curie Actions Innovative Training Network (MSCA-ITN-ETN, grant number 765121, 2017) DyViTo.]

Neural correlates of perceptual ambiguity over time

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The perception of an ambiguous motion stimulus, enabling a local and global percept, is characterized by a 'shift to global' over time: the more often observers see the stimulus, the more they perceive the global percept (Boeykens et al., 2019). This implies that when observers are presented with a stimulus that is initially maximally ambiguous (i.e., the local and global percept are equally likely), the ambiguity diminishes over time as the global percept becomes more dominant. We sought to examine the neural correlates of the perception of this ambiguous motion stimulus, as well as the decrease in ambiguity over time. Previous EEG research has found that perception of a wide variety of ambiguous stimuli is robustly characterized by a smaller positive wave in evoked potentials compared to the perception of their disambiguated stimulus variants (Kornmeier et al., 2016). In the current study we aimed to confirm this effect for ambiguous motion stimuli, as well as to trace the change of this effect over time, potentially corresponding to the 'shift to global'. EEG was recorded in 20 observers while they perceived six rotating dot pairs intermittently and reported any change in their (local or global) percept. We found the ambiguity-related positivity, similar to one reported before. In addition, we found that this positivity increases over time. Interestingly, this increase in positivity over time occurs not only for ambiguous stimuli, which may be disambiguated over time due to the 'shift to global', but for disambiguated stimuli as well.

Cortical responses to symmetry: source localisation of the sustained-posterior negativity

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Visual regularity activates a network of brain regions in the extrastriate cortex. Previous EEG studies have found that this response scales parametrically with proportion of symmetry in symmetry + noise displays. The parametric symmetry response happens in multiple tasks, but it is enhanced when the task requires active regularity discrimination. However, the origins and time course of this selective enhancement remain unclear. Here we answered remaining questions with new source dipole analysis in a reanalysis of the data originally reported by Makin et al. (2020). As assumed, the parametric symmetry response found at the sensor level was generated by a pair of dipoles in the left and right extrastriate cortex, a finding consistent with previous fMRI research. This bilateral activity was itself enhanced during regularity discrimination, in accordance with original findings. However, we identified a third, and later, symmetry response in the posterior cingulate during regularity discrimination. The spatial distribution of this component was characterised by a strong positive potential

over the vertex of the scalp at approximately 580 ms. Unlike the extrastriate response, this previously unknown activation only indexes strong, task relevant regularity signals. This clarifies the neural circuits which mediate the perceptual and cognitive aspects of symmetry discrimination.

Are actions characterised by canonical points in a sequence of movements?

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Across two online experiments using Psychopy/Pavlovia we explored the idea that actions are characterised by a 'peak' or 'canonical' point in a sequence of movements. In both experiments participants (125 in Experiment 1, 146 in Experiment 2) viewed 50 short video clips depicting human actions, 10 video clips from each of 5 categories (Transitive-Social, Transitive-Non-Social, Non-Transitive Social, Non-Transitive Non-Social, Communicative Actions) where social actions involved two people, non-social involved one person, transitive actions involved the use of an object, and communicative actions included gestures such as pointing, signing, shrugging, winking etc. After viewing each clip participants were asked to choose which of 12 still images from the sequence 'best represented' the action by scrolling through the sequence of stills (Experiment 1) or via a 2AFC task (Experiment 2). Statistical analyses showed the frequency distributions of participants' choices to have high similarity across the two methods and this held for all 5 categories of actions. The distributions of choices were largely unimodal, except for action sequences of a repetitive nature. These findings are discussed with reference to an emerging literature on action observation in the study of high-level vision and they highlight the utility of online experiments in perception research.

Visual scene recognition: As soon as you know there are two people, you know their relationship

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Identifying a social interaction requires –at least– recognizing 1) the social entities involved in it (e.g., two human bodies), 2) their relative spatial relation, and 3) the relationship between their body postures/movements, in order to understand whether and how they interact. The present study seeks to determine the relationship between the above processing stages involved in the identification of social interactions. In three different experiments, participants (N=60) were presented with visual images featuring two human bodies or two chairs either face-to-face or back-to-back. Images were shown for 17, 33, 50, 67, or 167-ms. Participants had to decide whether: a) each stimulus featured bodies or chairs (task1), b) the two objects were face-to-face or back-to-back (task2); and c) the two bodies were fighting or dancing with each other (task3). Results showed that, in all three tasks, accuracy was at chance with 17-ms of exposure duration, but significantly above chance with 33-ms of exposure duration. Accuracy in tasks1 and 2 was comparable at each exposure duration and reached a performance plateau already with 50-ms of exposure. In task3, accuracy kept increasing until 167-ms of exposure. Moreover, we found a consistent advantage in the processing of face-to-face (vs. back-to-back) bodies across the three tasks. These results suggest a similar amount of information intake and a similar time course for the detection and recognition of bodies and their relative spatial positioning in a visual scene, with an advantage for bodies (but not chairs) presented face-to-face, throughout the process of identification of social interaction. [This work was supported by the European Research Council (Horizon2020, Project THEMPO, Starting Grant 758473).]

Perception of social interaction from body motion in 10-year-old children and the potential effect of art-based interventions

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Social perception includes several aspects. Here we studied the ability to perceive social interaction between two people presented as point-light figures. These stimuli have been developed and used by Centelles and co-workers (e.g. Centelles, Assaiante, Nazarian, Anton & Schmitz, 2011). We adopted them to study social perception in 10-year-old children (n=59). We compared their performance with that of adults (n=9), and also investigated the effect of three art-based interventions on their social perception. In the social interaction test, the participants were shown 94 videos of two point-light human figures, either interacting with each other or moving separately, in random order. After each video, they responded yes or no as to whether the people interacted. Performance was expressed as discriminability d'. Children performed the test more poorly than adults. After the first test, the children were divided into four groups. One group participated in a music,

movement or music-movement intervention each, for 15 minutes three times a week during one school year. The fourth group was a control group. The test was repeated after the interventions, and there was a trend for improvement in the intervention groups. These findings indicate that the social interaction test was suitable for children, who were not yet mature in their perception of social interaction. The test was also promising in assessing the effect of interventions aiming to foster art-based group activity on social perception. [Funded by Academy of Finland's Strategic Research Council ArtsEqual project number 314223/2017.]

Tolerance of observers vision during misusing of light protective goggles

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Inexpensive easy build-up and methodically instructive learning device is developed for students to understand operation principles of light protective goggles and application of the device in student experimental praxis. Liquid crystal light shutters (LCLS) are originally intended for protection against infrared welding radiation. Cheap device (20$) consists of sandwich – IR-filter, pair of visible range polarizers, and LC layer between polarizing sheets. Two active built-in IR photodiodes (one replaced by us to visible photodiode) measure illumination and add together square-wave voltages delivered to LC element from two portion of device, both of which generate AC voltages either in-phase or opposite-phase depending on the device ON vs OFF state. Dual-channel generator (80$) controls two light fluxes: of dazzling visible LED flashlight, and of IR lightdiode that allows the offset of LCLS blocking function according to pulse of dazzling light, thus varying time window that determines dazzling. During tests, LCLS with IR-filter removed and separate photodiode control is used for a standard observer and for a cataract observer, to observe increasing of determining errors of optotype orientation for cataract observer, displayed shortly after dazzling on the computer screen, and to determinate dependencies of visual recovery relative to the time reference starting point, and of the dazzle strength and window timing. [Support by CAMART2 , SPIE grant and Latvian Ministry of Education Mikrotīkls 2257.]

Friday August 27th

Poster Session 9

Perceived speed slows during self-controlled head movement: Testing a Bayesian analysis of motion in both vision and hearing

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A hallmark of standard Bayesian models is that prior information increasingly dominates perceptual biases as sensory signals become less precise. Thus, in motion perception, a slow-motion prior explains why targets moving in the dark appear slower when pursued: the extra-retinal signal is known to be less precise than the visual signal present during fixation. We investigated whether the same perceptual slowing occurs during self-controlled head movement, using both visual and auditory stimuli. Alongside, we tested the Bayesian explanation by developing a method for measuring the precision of the underlying head-movement signal, made difficult because head movements are under participant control. Participants sat at the centre of an LED/speaker ring. In a 'head-movement' condition, they judged whether a head-fixed target (I.e., moving 'with the nose') moved more during self-controlled head rotation (interval 1) than when the head was stationary (interval 2). Motion in interval 2 was based on a scaled version of head-movement recordings in interval 1. In a 'head-always-stationary' condition, similar scaled versions of these recordings were used, again in a two-interval task, to determine the precision of visual and auditory. We then estimated the precision of the head-movement signal by combining the two conditions using signal-detection theory. For both visual and auditory targets, we found perceived speed slowed by around 30% with the head moving. However, preliminary data suggests that the precision of the head-movement signal is very similar to the precision of visual or auditory signals, a finding difficult to explain within a standard Bayesian framework. [Funded by the Leverhulme Trust.]

Proprioceptive localization of the own moving finger is dissociated from perceived movement direction

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We might largely misperceive the trajectory of a peripherally moving stimulus but our saccadic eye movements target its physical trajectory, suggesting a dissociation between action and perception. Here we investigated whether proprioceptive localization of a moving finger is dissociated from the perception of its movement. Our participants were instructed to actively move the right index finger on a grating, straight ahead away from their body. In a second experiment the finger was passively pulled straight ahead. The ridges of the grating were either orthogonal to the straight ahead direction or rotated away from it (-30°, 30°). When the grating's ridges are rotated, an illusory deviation is perceived and when moving actively participants correct for it, which leads to an actual deviation in the opposite direction. At different time points during the movement, we asked participants to reach with the left index finger to the current position of the right index finger. Afterwards, we assessed the perceived moving direction with a left vs right two-alternatives forced-choice task. When the grating was rotated, participants perceived their movement straight altought they deviated to correct for the illusion. However, reaching endpoints were significantly correlated with the actual movement direction on a trial-by-trial basis. In the passive condition, the right finger actually moved straight ahead, but as expected participants perceived a deviation. Here, reaching points were biased to the perceived movement direction. These results indicate that proprioceptive localization of the moving finger is dissociated from the perceived movement direction, if efference copy information is available. [This work was supported by Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) – project number 222641018 – SFB/TRR 135, A5 & A4.]

On the relation between visual working memory and potential action planning

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Working memory allows us to hold onto visual information from our environment to prepare for and guide future action. In this way, working memory serves as a bridge between perception and potential actions. Previous research on visual working memory has mainly focused on the mechanisms of visual retention, largely without also considering action planning. More recently, studies focusing on working memory of a single visual item have demonstrated that action planning of the required response starts during the memory delay. Here we ask whether this still holds when encoding and retaining more than one visual item, while simultaneously planning multiple potential actions. To investigate this, we used a visual working memory task with a memory load manipulation, and a delayed orientation reproduction report. We measured scalp EEG, and tracked beta (15-25Hz) activity in central electrodes contralateral to the required response hand. We show an attenuation of beta activity after encoding and during retention of two (compared to four) visual items in working memory. This occurs regardless of whether the potentially required actions of the two visual items are similar or dissimilar. Moreover, we show that the degree of beta attenuation after encoding and during retention of two visual items is predictive of the speed of action implementation after either item is probed for action. These results indicate that potential action planning co-occurs with visual retention in working memory. They also reinforce the idea that working memory – even of simple visual features – is fundamentally action-oriented. [This research was supported by a Marie Skłodowska-Curie Fellowship from the European Commission (ACCESS2WM) and an ERC Starting Grant from the European Research Council (MEMTICIPATION, 850636) to FvE.]

Number-Time Interaction: Search for a Generalized Magnitude System in a Cross-Modal Setting

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Over the last two decades, numerous studies have advanced our knowledge of how humans utilize perceptual information to estimate magnitudes such as space, time, and number. One of the most popular theories of magnitude processing, a theory of magnitude (ATOM), suggests that a generalized magnitude system processes information related to space, time, and numbers. Previous studies have provided support to ATOM theory. However, our current understanding of cross-dimensional magnitude interactions is limited to unimodal settings, predominantly in the visual domain. It is still unclear whether the ATOM framework can be generalized for cross-modal magnitude interaction as well. Thus, we used number and duration as two different magnitudes to examine the cross-modal magnitude interaction. We conducted three experiments using a temporal bisection task. We presented the numerical magnitude information in the visual domain and the temporal information in the auditory either simultaneously with duration judgment task (Experiment-1), before duration judgment task (Experiment-2), and before duration judgment task but with numerical magnitude also being task-relevant (Experiment-3). Our experimental results

suggest the visual number affects temporal processing of the tone only when the numerical magnitudes were task-relevant and available while making a temporal judgment (Experiments-3). However, numerical information did not interfere with temporal information when presented simultaneously or temporally separated from the duration information (Experiments-1 & 2). The overall findings indicate that visual numbers on temporal processing in cross-modal settings may not arise from the common magnitude system but instead from general cognitive mechanisms like attention and memory.

Assessing collision avoidance behaviour using an online version of the interactive Multiple Object Tracking (iMOT) task

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Studies of multiple object tracking (MOT) suggest that only 4 or 5 items can be accurately tracked for extended periods (Pylyshyn & Storm, 1988). In a previous iPad study, we introduced an "interactive" task variant where participants controlled objects to prevent them colliding (iMOT; Thornton, Bülthoff, Horowitz, Rynning & Lee, 2014). With relatively modest speeds (1°/sec), we found that displays with up to 8 items could be maintained without collision. The purpose of the current work was to introduce and validate a web-based version of iMOT that can provide a freely accessible and rapid assessment of collision avoidance behaviour. The long-term aim is to collect data from large online samples to begin looking at individual differences. An initial sample of 48 participants (24 female) completed a 5 min version of iMOT and also answered a brief series of demographic questions. The original iPad findings were replicated, both in terms of average number of items controlled (M_iPad = 8.4, SE = 0.1; M_online = 7.7, SE = 0.2) and the average maximum items controlled (Max_iPad = 10.4, SE = 0.2; Max_online = 9.5, SE = 0.2). There was a significant gender difference in terms of maximum items controlled (Max_female = 9.0, SE = 0.3; Max_male = 10.2, SE = 0.3, $p < .05$). Male participants reported significantly more experience playing games online and were more confident in their predictions as to how they would perform, compared to female participants. However, neither of these factors correlated with actual performance. [This work was supported by research funds from the University of Malta.]

Multivariate decoding of EEG data reveals similar mechanisms mediate perceptual adaptation and spontaneous perceptual reversals

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The cause of spontaneous perceptual reversals of visually ambiguous stimuli (e.g., Rubin's faces-vase) has been attributed to several different mechanisms. One hypothesis suggests that adaptation, or "neural fatigue", builds up while one interpretation is dominant and eventually triggers a reversal in perception. Although there is behavioural evidence that adaptation to an unambiguous stimulus (i.e., adaptor) can bias subsequent perception of an ambiguous one, it is unclear whether adaptation plays a role in spontaneous reversals (i.e., no adaptor). We used multivariate pattern analysis of human EEG data to test whether adaptation is involved in spontaneous perceptual reversals. We presented two block types: adaptation and ambiguous. In adaptation blocks, perceptual reversal was induced by adapting to an unambiguous motion stimulus before presentation of an ambiguous stimulus. During ambiguous blocks, only ambiguous stimuli were presented, and any reversals occurred spontaneously. We trained a classifier on the pattern of EEG scalp voltage during adaptation-induced reversals. We then tested this classifier on spontaneous reversal data and found above-chance decoding and similar activity patterns. These results suggest that similar brain mechanisms mediate perceptual adaptation and spontaneous perceptual reversals. This provides support for the "neural fatigue hypothesis" of multi-stable perception.

Visual search asymmetry for angular figures

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The well-described phenomenon of preference for curved shapes could be explained by the fluency hypothesis, which states that curvature enables their fluent processing in the visual field. According to this hypothesis, curved figures should be faster recognized among angular, while the opposite would not be the case. In order to test the fluency hypothesis, we used a classical visual search task, with two types of the target (curved and angular), three set sizes (1, 6, 12 elements), and two set types (positive and negative). In addition, we made three experimental designs: (1) classical, where the complexity of curved and angular figures was not controlled, (2) matched, where curved and angular figures were matched by the number of changes in shape, and (3) symmetrical, consisting curved and angular figures balanced by participants' subjective ratings of complexity. Reaction time was recorded. 31 participants took part in the experiment. The results of Generalized estimating equations analysis revealed search asymmetry for curved stimulus in classical design (Wald $\chi2(1)=14.96$; $p<.001$), while the angular figure is faster recognized in both matched (Wald $\chi2(1)=9.54$; $p<.01$) and symmetrical design (Wald $\chi2(1)$

=86.66; p<.001). This difference was particularly noticeable in negative and large sets. Our results indicate that the hypothesis of fluency could be rejected when curved and angular stimuli are equally complex, and that angularity should be considered as a basic stimuli feature which pops out in the visual field. [This research was supported by Ministry of Education, Science and Technological Development of Republic of Serbia, Grant No. 179033.]

Visual experience of installation art in the gallery and aesthetic preference towards artwork variations

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In empirical aesthetics, mobile eye-tracking allows researchers to observe aesthetic experience with genuine artworks outside the laboratory settings, and online experiments can provide a supplementary research context. Here, we investigated eye movements of gallery visitors whilst they were engaging with a room-scale installation by Lothar Goetz, consisting of diagonal colour patches of parallelograms, entitled Salon Diagonale, exhibited in Compton Verney Art Gallery. Initial gaze data visualisation showed substantial individual differences, and analysis on aggregated gaze data using absolute and area-normalized dwell time yielded significant trends, such as preference on edges and vertices between colour patterns, and a horizontal central tendency. In a second, online experiment, we investigated participants' aesthetic judgments on six modified variations of the artwork presented as rendered videos and their reasoning behind the judgments. Although ratings showed high variance, most participants depreciated the version with the Gaussian-blur introduced edges, slightly more preferred a monochrome version over the original artwork unbeknownst to them, and provided vastly different justifications. In a follow-up and mainly an explorative experiment, using webcam-based eye-tracking, we identified a promising potential of online eye-tracking research, and further report a lack of linear relation between liking ratings and gaze count.

Relationship between the complexity, beauty, and file size of compressed images of Japanese Zen gardens

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Daniel Berlyne theorized an inverted U-shaped relationship between complexity and beauty in various types of artworks. In this context, several studies have shown that the file size of compressed images (e.g., JPEG) is a useful measure of the complexity of paintings and photographs. In the present study, I applied this measure to Japanese Zen gardens to examine the validity of Berlyne's theory. Typical Zen gardens are designed by arranging rocks, plants, and white sand with the emphasis on distinctive simplicity. I sampled 23 gardens and photographed them using a digital camera equipped with a circular fish-eye lens. The photographs were recorded in a JPEG format of fixed image quality. In the experiment, the photographs were presented on a 27-inch monitor using a virtual-reality technique called VR panorama. This technique enables an observer to explore the photographed environment while changing the view direction through keyboard input. Twenty-three participants rated each garden's complexity and beauty after freely observing it. I then analyzed the relationship between the complexity, beauty, and file size of the photographs. As a result, the complexity and beauty showed a statistically significant correlation ($r = .63$), which partially supports Berlyne's theory because the relationship corresponds to the left part of an inverted U-shaped curve. The file size was significantly correlated with the complexity ($r = .47$), but not with the beauty. This result suggests that the measure did not have enough ability to predict the subjective complexity, and thereby validate Berlyne's theory, at least under this experimental setting. [This work was supported by JSPS KAKENHI Grant Number 17K06701.]

Mondrian's travel into space: grand aesthetic vision or artistic imagination?

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Piet Mondrian, founder of the avantgarde arts movement 'De Stijl' in the early 20th century, is known for his iconic abstract paintings, his pictorial language being confined to black vertical and horizontal lines outlining a set of rectangles filled with a small palette of colours (red, blue, yellow, black, white, grey). This composition style reflected the 'universal' aesthetic ideal of purity, simplicity, and balance, as outlined in the 1918 'Neoplasticism' manifesto, reaching out to other artforms, such as poetry and music, and most notably architecture. Whilst discussing extensively with designers and architects, Mondrian himself rarely worked on spatial designs – with the most prominent exemption being his sketch for the interior of I. Bienert's salon in Dresden, where all 6 surfaces of the cubic space were covered in his idiosyncratic style. Why has this design never been realised during Mondrian's lifetime? We previously suggested that diagonal lines and triangular intersections appearing in the retinal projection of the cubic space could have violated his own dogma about cardinal orientations and orthogonal intersections. Making use of a recent reconstruction of the salon and a VR model of this space, and recording eye movements of visitors exploring these real and virtual spaces, we examined

how they experience the 3D composition. Fixation patterns – commonly regarded as tokens of liking – are very similar in both environments, and do not indicate bias towards cardinal line orientations and orthogonal intersections – which challenges Mondrian's dogma of universal aesthetic preference of cardinal orientation indicating ideal balance.

A sense of style; stylistic features as perceived by non-experts

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Depictions of objects exhibit appearance differences. If two painters paint the same object, the appearance difference can be called style. To give their work a unique signature artists use color, shading, brushstroke etc., i.e. the 'visual data'. Yet, style is often associated with a period, school or particular artist, i.e. the 'metadata'. Here we study the contribution of these to the perception of style. We chose 48 fragments of oil paintings in the European tradition as stimuli. All fragments showed apples. The creation years of the original paintings varied from 15th to 21st century, and their location of production varied from southern Spain to the northern Netherlands. 415 unique participants completed the first experiment (triplet similarity task). The multidimensional scaling (MDS) reached a 2D solution. To interpret the result, we had 300 unique participants completed Experiment II (30 for each ten sub-group). Each participant was asked to rate one of ten attributes (glossiness, three-dimensionality, convincingness, brush coarseness, etc.) of the 48 depicted apple fragments. We performed property vector fitting on the ten attributes and then fitted vectors into the MDS configuration from Experiment I. Dimension 1 was primarily explained by visual data (with brush coarseness being dominant) while for dimension 2, the meta data of creation year was needed to explain the variance. This outcome shows that both visual and metadata can be used to model style. However, metadata itself cannot explain visual style, which means there is potential visual data to be found that complements our current set.

The Anisotropic Western Alliance – Aesthetic Features of Propaganda Posters

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Posters have been an important medium for propaganda purposes throughout modern history, employing images created by artists to convey a political message. Besides the semantic content (written slogans and depicted objects), the form (i.e., the way of depiction) seems to be crucial for the function of these visual stimuli. Statistical image properties provide an objective measure for form, with different subsets of visual stimuli such as artworks or advertisements characterized by specific values for these properties. Here, we collected a large set of digitized wartime posters from online archives, focusing on German and Western Allied works from World War II to create a comprehensive database. In addition to a detailed set of descriptive classifiers for image content, posters were categorized by ideology, country and assumed purpose. Then, we analyzed the images for their objective properties, focusing on measures commonly used in aesthetics research. Compared with other aesthetic stimuli, propaganda posters share a similar degree of self- similarity with images of artworks and advertisements, but objective complexity and anisotropy are higher. Contrasting Allied with German posters revealed similar values for self-similarity and complexity. However, Western Allied posters are, on average, more anisotropic than Western Allied posters and also exhibit higher values for edge density. Ultimately, we show that Allied propaganda posters differ from German posters in objective measures.

Attention to multiple colours: Effects of hue and lightness

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A recent study of feature-based attention to multiple colours (Martinovic et al., 2018) indicated that hue acts as a single dimension for attentional purposes, with co-selection of targets improving with proximity in colour space. We investigated the effect of manipulating lightness and hue in feature-based attention to multiple colours to determine similarities and differences between selection based on these two perceptual dimensions. Four overlapping random dot kinematograms (RDKs) of different colour with distances equal in CIE Lab space were presented in two contexts: in one, all colours represented basic colour categories (yellow, brown, purple and pink) differing in lightness and hue, while in the other, only two basic colour categories were represented (green and blue, either light or dark). Participants attended two colours on each trial and detected brief 50% coherent motion events amid otherwise random motion. We compared attention to the same hue (e.g. light green and dark green), same lightness (e.g. light green and light blue) and when attending across both (e.g. light green and dark blue). There was no effect of colour category. This means that attentional control during sustained selection does not depend on the ease of labelling of colours, but merely on their distance in colour space. However, despite matched colour distances, co-selection by lightness was much more effective than selection by hue and selection

across both was the poorest. This implies that while CIE Lab may be perceptually uniform, it is not attentionally uniform across the two tested dimensions.

Using the P300 to create an objective and reliable tool for visual acuity measurements resistant to malingering

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Low visual acuity is an important criterion in several contexts, for instance the classification of athletes in vision impaired sports. Standard acuity testing relies on the honest cooperation of the testee, which is not always given. The P300 of the event-related potential has been suggested as an objective marker of visual performance; it has several advantages over visual evoked potentials. However, it was unclear whether P300-based measures would be sufficiently resistant against attempts of malingering, as the P300 is known to be susceptible to attention diversion. We used an oddball paradigm with Landolt Cs as infrequent stimuli (ratio 1:7) to record the P300 in two experiments with 14 and 20 participants. Optotype sizes were chosen to bracket the individual threshold size. The stimuli were presented for either 500 or 100ms and malingering resistance was tested through attention deviation (mentally or with an additional stimulus on the screen). Each participant completed the task under several conditions (honest, malingering, different presentation times and visual degradation). The difference between the responses to the smallest sub-threshold optotype (no P300 expected) and the largest super-threshold optotype (P300 expected) was taken as index of test performance. For malingering detection, sensitivity and specificity were 95%. This was reduced to 75% and 77%, respectively, when attention was diverted. The presentation duration and the visual degradation had no sizable effects. In summary, while the resistance against malingering is not perfect, the P300 is a promising tool to assist the identification of individuals who misrepresent their visual acuity. [Funded by the Bundesinstitut für Sportwissenschaft.]

The effect of target and distractor predictability on attentional capture

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A previous study by Gaspelin et al. (2015) has shown that it is possible to proactively suppress attentional capture by a singleton distractor in a visual search task. However, Wang and Theeuwes (2020) demonstrated that this suppression disappears in larger set size conditions. One explanation for these findings is that the singleton has higher local feature contrast in the larger set size conditions, which increases its physical saliency and makes suppression impossible. However, increasing the number of items also affects target and singleton distractor location predictability and the number of possible display configurations, which might provide an alternative explanation for these findings in a predictive processing framework. We performed a visual search task experiment, where occasional probe trials tested the perception of letters at each location in the search display. We manipulated the predictability of the target and singleton by limiting the location of these items to 4 locations within an 8-item search display. We compared letter recall in this condition to performance in normal 4-item and 8-item display conditions. Additionally, we tested participants on an 8-item version of the task in which the number of display configurations matched the 4-item condition. Initial results show that attention is directed towards potential target locations, as demonstrated by increased recall of letters at those locations compared to the set size 8 control. However, attention is still captured by the singleton distractor. This suggests that changes in target and distractor predictability have distinct effects on attentional capture in visual search.

Evaluating Artificial Vision in AI Systems: The Case of Autonomous Driving

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We develop a cognitive evaluation schema for analysing the diversity and nuances of visuospatial complexity and multimodal interactions encountered in naturalistic everyday driving conditions. The proposed schema is based on a fine-grained empirical analysis of real-world everyday driving situations involving stakeholders such as drivers, pedestrians, cyclists. Our method involves a semantic analysis of egocentric POVs of stakeholders, focusing on the sequence and duration of events (e.g. velocity or direction change), the combination of modalities used (e.g., gestures, gaze, head-movements), audio, quantity and variety of moving and static objects in the scene e.g., (cars, signs), behavioural metrics from the stakeholders (e.g. gaze allocation, steering), etc. The proposed cognitive evaluation schema consists of three key aspects: (1) Scene characteristics consisting of a combination of quantitative (e.g., clutter, size), structural (e.g. symmetry), and dynamic attributes (e.g. motion), (2) Multimodal interactions consisting of the mode and method of interaction, as well as the level of

joint attention achieved, (3) Recipient effects characterising subject's behaviour and driving performance through physiological measurements (e.g. eye-tracking, head rotation) in a series of virtual reality (VR) environments replicating a number of naturalistic scenarios (and variations therefrom). Driven by behavioural methods in visual perception, we aim to open-up an interdisciplinary frontier for the human-centred design, evaluation / testing of artificial vision modules within AI-technologies for autonomous driving, cognitive robotics etc., where embodied, multimodal human-machine interaction is of the essence. We also demonstrate the practical application of basic visual perception research towards technology-centric settings of social significance.

The Investigation of Explicit and Implicit Stimulation of Visual Stimuli in Evaluation Process Using Simultaneous Pupil Dilation and Galvanic Skin Response

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Various cognitive paradigms had been used to explore the effect of predictive information in human decision-making, but not many research studied about the influence of predictive information in evaluation processing. In this research, evaluative decision-making paradigm with naturalistic food images as stimuli is designed for observing influences of predictive cues towards evaluation process with simultaneous eye-tracking and galvanic skin response (GSR) measurement. The predictive cues are used to produce the expectation towards target food images: cue shapes indicate the valence of the upcoming image (either appetitive or aversive), while the cue's reliability has been explicitly stated under the cue (either 100% or 50% reliability). After exposure by predictive cues, the pupillary response showed more constriction when stimulated by negative cues in comparison to positive cues regardless of the cue reliability level. Similarly, skin conductance gradually increases overtime after exposure to positive cue regardless of cue reliability level while slightly decrease from baseline after exposure to negative cue. In contrast, pupil dilation and skin conductance response with stimuli valence in the opposite direction; appetitive food images induced more pupil constriction in comparison to aversive food images, while skin conductance rose after expose to appetitive food image but slightly declined after expose to aversive food images. This study show potential use of simultaneous GSR and eye-tracking measurement for identifying the implicit arousal level of expectation induce by predictive cues. Further analysis has to be done for unveiling the opposite direction of skin conductance and pupillary response inducing by expectation and visual targets. [This research was supported by Research Strengthening Project of Faculty of Engineering, KMUTT to KO and the KMUTT's Frontier Research Unit Grant for Neuroscience Center for Research and Innovation to KO. The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.]

Categorical target similarity prevails over perceptual similarity in subsequent search misses

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Subsequent search misses (SSM) are errors of visual search that illustrate the decrease in accuracy for detecting additional targets after finding the first one. One explanation for this phenomenon involves the perceptual set hypothesis. The features of the initially identified target create a bias towards perceptually similar targets. Thus, SSM are more likely to occur for dissimilar targets. However, it is not clear how categorical similarity is involved. This research was focused on revealing the roles of both perceptual and categorical target similarity in SSM. Two separate experiments were conducted in a visual search paradigm. The task of the participants (N = 40; 50 respectively) was to find 1 or 2 targets or report their absence among the distractors. In the first experiment letters of the Russian alphabet were used, while simplified images of natural objects were used in the second experiment. Categorical and perceptual identities of targets were separated to reveal their individual impact on SSM. The results of both experiments illustrate the significant effect of categorical similarity factor, while perceptual similarity plays only a secondary role. Targets from the same category were identified more accurately and significantly faster. At the same time, SSM were revealed for trials with perceptually and not categorically similar targets. Thus, perceptual resemblance did not hinder the SSM emergence. The findings suggest that the original perceptual set assumption might be in need of reconsideration due to the additional relevance of categorical factors.

Simulating the effect of asynchronous phosphene stimulation on artificial vision

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Visual prostheses are aimed to restore sight to those who lost their vision due to disease or dysfunction of the eye. Prosthetic devices translate physical images into electrical signals which are then projected to a selected area along the visual pathway, bypassing the impaired site. Each electrical signal evokes the perception of a spot of light, called a phosphene. Multiple phosphenes can be elicited through multielectrode arrays to form images. The quality of artificial percepts depends on both the temporal and spatial characteristics of the electrical pulses and the phosphenes they generate. Here, we describe an experiment to explore the temporal relationships between individual phosphenes and the impact of the electrical pattern on object binding and perception, hypothesizing that object perception will be enhanced with synchronously presented phosphenes, and reduced with asynchronously presented ones. Non-invasive, virtual reality technology will be used to simulate artificial vision in sighted subjects. We will assess the effect of temporal desynchronization of phosphene presentation on performance in the MNREAD reading task. Subjects will attempt to read simple sentences out loud at varying font sizes under varying levels of phosphene temporal noise and will be scored by reading accuracy and reading speed. We expect to find that reading performance is highly sensitive to desynchronization. The results of this study will be fundamental to the creation of a visual prosthesis by predicting performance under real-world post-implant usage and providing a potential tool to the prosthesis designer to enhance figure-ground separation. [William M. Wood Foundation.]

The effect of photoreceptor stimulations on steady-state pupil diameter

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In this study, we investigated how the signals from retinal photoreceptors contribute to the steady-state pupil response. It has been shown that the melanopsin cells contribute to the pupil response and to the photoentrainment in circadian rhythm. Since the melanopsin cells receive signals from all photoreceptor classes it is important to clarify how signals from these photoreceptors are integrated in the brain to drive the pupil diameter. We used the multi-primary illumination system which enables us to stimulate melanopsin alone whereas the other photoreceptors were kept silent. Nine test stimuli were used which increased or decreased the stimulation of 4 types of photoreceptors, melanopsin cells, L-cone, M-cone, and S-cone cells. For example, the stimulus in which only the amount of stimulation to melanopsin cells was increased from the control (Mel+), and similarly the amount of stimulation to melanopsin cells was decreased (Mel-). These melanopsin stimuli are metameric stimuli with the same luminance and the color as the control stimuli. The observer's right eye was exposed to full-field light stimulation and the steady-state pupil diameter of the left eye was measured using an infrared camera. Observers had an initial adaption of 5 minutes before starting the measurement. The results showed that the steady-state pupil diameter varied according to the change in stimulations of melanopsin and the other photoreceptors. [Supported by Grant-in-Aid for Scientific Research (A) 20H00614 from the Ministry of Education, Culture, Sports, Science and Technology and Mitsui Chemicals, Inc..]

Achromatic contrast sensitivity varies depending on melanopsin stimulation of the background

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Previous studies have shown that melanopsin cells in the retina influence photoentrainment of circadian rhythm and brightness perception. In this study, we examined how melanopsin cells contribute to achromatic contrast sensitivity in humans. Contrast sensitivity is one of the most important function in vision. It varies depending on luminance and color of the background adaptation level. It is still unclear how melanopsin cells contribute to achromatic contrast sensitivity. To this end we have developed the multi-primary illumination system which can stimulate melanopsin cells independently from the other photoreceptors. We used 3 test stimuli which had a different stimulation of melanopsin cells. The stimulus Mel+ had a 20% larger melanopsin stimulation than that of white control stimulus. Similarly, the stimulus Mel- had a 20% smaller melanopsin stimulation. They had the same luminance and color as the white control stimulus. The detection threshold was measured using a test stimulus in which the luminance was modulated at 5 Hz. It was found that the Mel+ stimuli had higher achromatic contrast sensitivity than that the Mel- stimuli. These results showed that the achromatic contrast sensitivity varied depending on the amount of stimulation to melanopsin cell. [Supported by Grant-in-Aid for Scientific Research (A) 20H00614 from the Ministry of Education, Culture, Sports, Science and Technology and Mitsui Chemicals, Inc..]

Multi-alternative magnitude-sensitive perceptual decision making: evidence and implications

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The result of "magnitude sensitivity" in binary perceptual decision making is well established. For example, if asked to choose the brighter between two alternatives, participants are faster when identical stimuli have high brightness compared to when identical stimuli have low brightness. This result challenges dominant descriptive and normative models of decision making that are insensitive to absolute input values (i.e., they are magnitude insensitive), and only process difference in evidence between alternatives. Here, we extend the empirical study of magnitude sensitivity to the multi-alternative case. We do so by presenting experimental evidence from a large-scale psychophysics study (N=117) conducted online. In our experiment, participants were requested to decide as fast and accurately as possible which of three stimuli was brighter. Unknown to participants, conditions of interest were trials for which the stimuli had equal brightness; the overall brightness (i. e., the magnitude) of equal alternatives could vary across trials. Our results show, for the first time, strong magnitude-sensitive reaction times in multi-alternative perceptual decision making, given that choices for equal alternatives of higher magnitude were made faster. We discuss the implications of our findings, and present results from simulations that compare competing mechanisms that implement magnitude sensitivity in multi-alternative decision making.

Effects of spatial location in training-induced changes on crowding task

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Previous studies have shown that the radial-tangential anisotropy feature of visual crowding can be altered through training. Malania et al. (2020) have demonstrated a significant shrinkage of the crowding zone and reduction of anisotropy as a result of practice. These changes in behavioral performance were mirrored in fMRI blood oxygenation level-dependent (BOLD) responses within the retinotopic region that corresponded to the location of stimuli in the visual field, the so-called trained area. The goal of this study was to examine if the effect of perceptual learning is limited to the trained brain area or can be generalized and modify the neural activity of other cortical regions as well. Additionally, we were interested to test the involvement of higher visual areas, like V4 and lateral occipital complex (LOC), in crowding. Seventeen healthy volunteers were trained over 3-4 consecutive days on the crowding task and pre- and post-training fMRI images were acquired using a 3-Tesla MRI scanner (Prisma, Siemens). Before training, visual crowding led to a reduction in the BOLD response especially for the radial flanker configuration in V1/V2. After training, this reduction in BOLD response was less pronounced. Examination of retinotopic ROIs in V4 and LOC did not reveal this effect of training on the BOLD response in these areas. The effect of visual perceptual learning thus appears to be specific for the early visual cortex (areas V1/V2) and does not generalize to higher visual areas (areas V4 and LOC) for the stimuli used in our study.

A deep learning saliency model for exploring viewers' dwell-time distributions over Areas Of Interest on webcam-based eye-tracking data

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Visual saliency is a common computational method to detect attention-drawing regions in images, abiding by top-down and bottom-up processes of visual attention. Computer vision algorithms generate saliency maps, which often undergo a validation step in eye-tracking sessions with human participants in controlled labs. However, due to the covid-19 pandemic, experimental sessions have been difficult to roll out. Thus, new webcam-based tools, powered by the developments in machine learning, come into play to help track down onscreen eye movements. Claimed error rates of recent webcam eye trackers can be as low as 1.05°, comparable to sophisticated infrared-based eye-trackers, opening new paths to explore. Using webcams allows reaching a broader participant pool and collecting data over different experiments (e.g., free viewing or task-driven). In our work, we collect webcam eye-tracking data over a collection of images with 2-4 salient objects against a homogenous background. Objects within the images represent our AOIs (areas of interest). We have two main goals: a) Check how eye movements vary on AOIs across all spatial permutations of the same AOI in a given image; b) Extract correlations for a given image containing N

objects between viewers' eye movement dwell times over the N AOIs and the corresponding AOIs saliency maps. We will show relationships between viewers' dwell time over each AOI throughout all factorial N spatial permutations and variance of AOIs' salient pixels. Based on this relationship, eventually, object-oriented saliency models can be used to predict dwell-time distributions over AOIs for a given image.

Uncanny valley hypothesis and hierarchy of facial features in the human likeness continua: An eye-tracking approach

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The uncanny valley hypothesis refers to a subjective experience of eeriness to highly human-like objects (e.g., realistic avatars). There is evidence that objects at the human-avatar category boundary along the dimension of human likeness (DHL) are more likely to evoke the uncanny valley effect. Literature has focused on the affective domain of the phenomenon and studies on the cognitive demands are few. Here we investigate whether perceptual ambiguity could affect the hierarchical processing of facial features. Our study investigated categorical perception of female and male faces along the DHL. Participants performed a real vs. artificial categorization task and behavioral measures (categorization threshold and response time) were calculated to determine avatar, boundary, and human face conditions. An analysis on the hierarchy of gaze dwell time in regions of interest (eyes, nose, and mouth) showed greater dwell time for the nose area of boundary faces compared to the nose area of avatar and human faces. Results showed that perceptual discrimination difficulty changed the allocation of attentional resources in boundary faces. Such output may contribute on how we process artificial faces and might improve users' experiences from highly realistic characters.

Representation comparisons between human brain and hierarchical deep convolutional neural network in face perception reveal a fatigue mechanism of repetition suppression

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Repetition suppression (RS) for faces have long been studied, yet, the underlying neural mechanisms of RS remains debated, for example, fatigue or sharpening of neuronal activities. The present study used a hierarchical deep convolutional neural network (DCNN), which achieve the performance of face recognition at human level, as a tool to simulate the neural mechanism of facial repetition suppression as fatigue or sharpening of neurons. First, pre-trained but not randomly-weighted DCNN achieved discrimination between faces at human level in the output layer. Afterwards we conducted cross-modal representational similarity analysis (RSA) comparisons between dynamic processing in human EEG signals and layers in modified DCNNs. Our results indicated that representations of human brains were more similar to those in fatigue-modified DCNN, compared with sharpening modified DCNN. Therefore, the current study supports the fatigue mechanism as a more plausible neural mechanism of facial RS. The comparison between representations in the human brain and hierarchical DCNN provides a promising tool to simulate and infer the brain mechanism underlying human behaviors.

Effect of personal information-related priming on the identification processes of personally known and famous faces

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Can visual priming associated with personal information (field of activity, interests, hobbies, etc.), preceding the presentation of a highly familiar or famous face, affect the efficiency and speed of facial processing? 126 students of the Faculty of Psychology were presented with black-and-white photographs of 21 unfamiliar, 21 famous (actors, politicians, athletes) and 21 personally familiar (university teachers who delivered classes to the study participants) faces each for 200 ms. 7 photos from each category of familiar faces were presented with relevant individual priming, 7 with random priming (landscapes etc.) and 7 without priming. 63 participants had to rapidly answer, whether the face is familiar or not, by choosing the appropriate key. 63 participants had to immediately provide a name if the face is familiar. GEE analysis results have demonstrated that in the absence of priming there are no differences in the efficiency and time of recognition of familiarity of famous persons and teachers, but names of teachers are recalled significantly faster ($p<0.0005$). A significant effect of relevant priming on the number of names recalled was revealed (Chi-square=10.354(2), $p=0.006$). However, this effect only applies to the naming of teachers, not famous persons ($p=0.011$). Another trend identified is the influence of the

type of priming on the number of hits in assessing familiarity (Chi-square=3.987(1), p=0.046). Meanwhile, relevant priming did not affect the response time in any of the tasks. Thus, the priming associated with personal information affects the efficiency of recalling the name of personally familiar persons.

Perceiving Emotional and Semantic Similarity between Facial Expressions of Emotions

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Facial expressions of emotion have been assumed to be innate, discrete, and universal across cultures. Recent studies challenge this idea and propose that facial and vocal expressions of emotions are blended, gradient and sensitive to cultural contexts. Studies of facial emotion often use an emotion categorization task, which may conceal the nature of facial emotion perception and its sensitivity to cultural context. In the present study, Asian and European participants firstly rated how much a facial expression is in agreement with a set of emotion categories or semantic concepts (i.e., an emotion- and a semantic-profiling task), and then they made judgments about the similarity between pairs of facial expressions of emotions. We found that the perceptual similarity between facial expressions of emotion can be predicted by the profiling responses to individual facial expressions and by stimulus-based similarity. This result suggests we may use both physical and conceptual properties of facial emotions to determine their similarity. European and Asian participants showed a similar pattern of perceptual similarity between facial expressions of emotion, nonetheless, their responses to the emotional and semantic profiling tasks were different. These results favour a blended representation of facial emotion, demonstrating that the same facial configuration conveys information about multiple categories of emotion and links to a set of interconnected semantic concepts. How we perceive these emotional and semantic aspects of facial expression is affected by both culture-general and culture-specific processes. [This study was supported by a Royal Society Research Grant (RGS\R2\202066) to MZ and a grant from National Natural Science Foundation of China (32071048) to GZ.]

How successful are children in emotion recognition task?

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Previous studies have shown that recognition of the facial expression of emotions (FEE) varies depending on the stimulus complexity and the type of emotion. In particular, some emotions are better recognized on emoticons, and others on more complex stimuli. The aim of our study was to examine the differences in the accuracy of recognizing FEE of happiness, anger and sadness in preschool children, because there are few studies in which the respondents are children. We created the stimulus material using round and sharp shapes to make the stimuli more similar or different from the actual representations of human faces (just as we can see in cartoons). We created a total of 6 emoticons (3 emotions x 2 shapes). 20 respondents (7 boys), aged 57-88 months, participated in the research. The task of the respondents was to select one of the three simultaneously displayed emoticons, which was previously named. The position of the target stimuli was randomized. The analysis showed a significant interaction of factors, type of the emotion and type of the shape. Additional analyzes indicate that happiness is more accurately recognized compared to the emotion of sadness; that boys less accurately recognized emotions when emotions are presented in a sharp form compared to a round. More precisely, boys recognize sadness worse compared to happiness and anger when they are presented in a sharp form. We can conclude that emotions are more accurately recognized when they are presented on stimuli that correspond to the appearance of human faces (round shape).

fMRI studies of facial expression recognition in threshold observation conditions

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The purpose-to study the features of recognition of facial expressions of joy and sadness in threshold conditions of observation using fMRI (Siemens 1.5T). The first step was to establish objective thresholds for recognizing expressions of sadness and joy one person's face generated in the FaceGen (Singular Inversions). The next step was to align each graded intensities of joy and sadness expression so that the recognition thresholds and number of changed pixels (by brightness parameter) in images with different facial expressions coincide. Four fMRI stimulation phases were used. A phase with presentation of neutral facial expression (uncertainty conditions), a phase with presentation of facial expressions of joy and sadness in threshold conditions, and two phases with presentation of facial expressions of joy / sadness in suprathreshold conditions of observation. The results showed that in the threshold condition (5% change in brightness of image pixels) in

comparison with the suprathreshold conditions there is a significant increase in the number of activated voxels (Wilcoxon signed rank test, p <0.001). In particular in the areas of the premotor (BA6), the frontal (BA8, BA9, BA10, BA13), and in the areas of the limbic cortex (BA24) of the human brain a significant increase in the number of activated voxels was shown (Wilcoxon test, p <0.05). Our results are consistent with previous observations that large-scale neural networks of the human brain are rearranged under threshold conditions of observation. The most important role in this neural network is assigned to the areas of the frontal and limbic cortex. [Funded by I. P. Pavlov Institute of Physiology, Russian Academy of Sciences.]

Motion aftereffects to illusionary motion

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The present report describes motion aftereffect (MAE) induced by illusory motion. By the phenomenon designated as MAE, after viewing a stimulus moving in one direction (adaptation stimulus) for dozens of seconds to minutes, an observer perceives a stationary stimulus (test stimulus) as moving in the opposite direction to that of the adaptation stimulus. Many studies have examined MAE and have elucidated various factors affecting this phenomenon, such as stimulus features (e.g., size, velocity, and contrast) and motion types (e.g., translation, rotation, and global/local motion). This study investigated MAE to illusory global motion induced by drifting Gabors that are in fact stationary. In an experiment, participants viewed an adaptation stimulus consisting of vertically or horizontally drifting Gabor patches arranged on an imaginary square. The patches produced illusory perception of a rotating square, although no patch rotated. After the presentation of adaptation stimulus for 30 s, a test stimulus, i.e., a stationary filled square, was presented. The participants indicated whether the test stimulus was perceived as moving by pressing and holding a key corresponding to the direction of rotation: clockwise or counterclockwise. The result indicated MAE in the direction opposite to that of illusory rotational motion of the adaptation stimulus. No difference was found in MAE durations between the directions of adaptation stimulus motion. Results indicate that MAE derives from adaptation to the illusory motion. [Aichi Shukutoku University Grant for Special Research (20TT04).]

3D CSF models in peripheral vision using Bezier functions

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Human contrast sensitivity function (CSF) has been measured in various viewing conditions. However, most measurements are restricted to the central vision less than 30 degrees in eccentricity. Mathematical models of CSF, which cover whole visual field, should be based on the central and peripheral CSF data. We measured achromatic CSFs in peripheral vision up to 84 degrees in the temporal visual field for four subjects. Gabor stimuli of 5/3-degree σ were presented on a calibrated LCD. The stimulus mean luminance was 31 cd/m^2. We conducted experiments in a room, inside of which was covered by a rounded white wall of the mean luminance. We fitted 3D parametric surfaces to the present data, using the least square method, in the 3D space whose axes are spatial frequency, eccentricity, and contrast sensitivity. The surfaces adopted here are functions defined as Bezier patches of 2x3 to 5x5 degrees and a function in which the constants of the CSF model [Mannos et al.1974] are replaced with Bezier functions of eccentricity. We confirmed the fittings were acceptable by comparing the result of the original CSF model by Mannos et al. fitted and evaluated only in 0 degrees in eccentricity and the adopted surfaces fitted and evaluated in all eccentricities in terms of means and standard deviations of the errors. The models derived in the present study show that contrast sensitivity decreases with eccentricity not linearly but with a plateau at the middle range of eccentricities. This tendency was not predicted by previous CSF models.

The time course of serial dependence: an interplay between perceptual decisions and task relevant representations

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In serial dependence (SD), features of a present stimulus are judged as similar to previously presented ones. This bias is often explained by a continuity field (CF) in perception, combining similar stimuli in an extended region of space (~ 15°) and time (~15 seconds) to support non-retinotopic stabilisation across eye movements. We here question the existence of a CF in vision by focusing on its temporal properties. We investigated: 1) whether combining stimuli within the CF is mandatory and 2) whether SD is defined by the CF or by the number of previous stimuli. We presented sequences of low contrast Gabors in each trial and observers performed an orientation adjustment task. A sequence contained either 2, 3 or 4 Gabors separated by 12, 6 or 4 seconds, respectively. Participants were asked to reproduce the orientation of the last Gabor. Despite all the non-reported stimuli fell within the temporal window of the CF, we found only repulsive biases, i.e., the opposite of SD. Hence, the combination of visual features within the CF is not mandatory. Interestingly, we observed positive SD for the orientations

reported one trial in the past, despite the interval could extend to the hypothetical limits of the CF (>15 seconds). Rather than supporting the existence of a CF, our results suggest that SD depends on the interplay between decisions and task-relevant representations. [This research was supported by funding from the Swiss National Science Foundation (grant no. 415 PZ00P1_179988 to DP). The funders had no role in the study design, data collection and analysis.]

Perceptual learning bridges independent processing channels as revealed by orientation-color conjunction learning

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Visual objects are often defined by feature conjunctions, e.g., a red grating tilted to the left. Studies in visual perceptual learning have so far almost exclusively focused on single feature learning. Conjunction learning can either be achieved by sharpening each feature detector separately or by co-tuning the two detectors to provide relevant information to the task. Here, we examine whether, how, and where in the visual hierarchy information is integrated following extensive practice on color-orientation conjunction discrimination task. We trained 20 participants to discriminate orientation-color conjunctions of a set of chromatic gratings (conjunction training), 15 to discriminate orientation while ignoring color (single training), and 13 to discriminate orientation or color depending on post-stimulus cue (parallel training). To determine how specific learning was to the stimulus location, we also measured discrimination accuracy in an untrained location. Learning was specific to the trained location which suggests it resides in earlier stages of the visual hierarchy where neurons have small receptive fields. Conjunction training held a significant advantage over single and parallel training as reflected by the learning rates. Analysis of reaction times indicates that conjunction but not parallel training led to the emergence of integration of color and orientation processing. Taken together, this suggests that visual system plasticity can optimize the integration of basic visual features depending on tasks demands. This study has revealed hitherto unexplored effects of feature conjunction learning and provides important insight into the cortical mechanisms underlying this form of learning. [This project has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement No 802482).]

Processing of Russian multimodal advertising posters with lexical ambiguity

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Playing with lexical ambiguity, when several meanings of an ambiguous word collide in one advertising poster, is a frequently used technique when creating print advertising. Theoretical studies say that people prefer ads with ambiguous slogans since such slogans are often short and succinct and require from recipients some cognitive effort to solve ambiguity, and successful disambiguation gives the recipient pleasure. However, it remains unclear exactly what processes determine this better attitude towards ambiguous advertising. By comparing high-level processes of advertising posters perception (understanding, memorization) to the low-level processes (the nature of eye movements when reading posters), this study attempts to clarify the features of the functioning of lexical ambiguity in multimodal advertising discourse. In this study, 3 experiments were conducted to investigate what exactly makes ambiguous advertising posters so attractive. In the first scaling experiment, where 109 participants rated posters with and without ambiguity on several parameters, it was found that ambiguous posters are perceived by participants as more attractive, original, and effective compared to unambiguous posters. In the second experiment, the recall task, 71 participants recalled whether they had seen such posters in the first experiment. The results showed that ambiguous posters are recalled significantly better than unambiguous posters. In the third experiment, the eye-tracker study, 39 people looked at the posters, also rating them for their attractiveness and originality. The results have not been analyzed yet; they will be presented at the conference. We expect significant differences in oculomotor activity when reading unambiguous and ambiguous posters. [Research was supported by the grant No. 75288744 from Saint Petersburg State University.]

The effect of reward on preconscious visual processing

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Reward not only exerts a profound influence on observable behaviour but can also effectively bias sensory processing and improve perceptual performance. Despite extensive research on the role of reward value on sensory processing, it is still largely unclear whether reward already has an effect on early, preconscious stages or only on later

stages of sensory information processing. To probe early influences of reward on visual processing, we combined two different spatial orientations of a grating stimulus each with either a high or a low probability of monetary reward. These stimuli were initially suppressed from awareness by breaking continuous flash suppression (bCFS), a variant of binocular rivalry. Participants indicated the location of the grating stimulus as fast and accurately as possible, upon which they either received a rewarding or neutral outcome. In this context, response times represent the time that a stimulus requires to overcome suppression and access awareness. Differences in response times between the two stimulus orientations would thus indicate an influence of reward value on early, preconscious processing. Response times were not modulated by the stimulus-specific reward association. However, we observed an effect of reward value on participants' responses between trials: Responses were faster when a reward was obtained in the previous trial compared to trials, where no reward was delivered previously. Thus, although preconscious sensory processing was not influenced by the specific stimulus reward association, rewarding outcomes generally boosted subsequent stimuli into awareness, possibly due to heightened alertness after the receipt of a reward. [This work was funded by the German Research Foundation (STE 1430/9-1).]

Two Misconceptions Concerning the Eye-of-Origin (EOO) Information in Visual Consciousness

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The first misconception is the following inference: Because we are normally not aware of EOO in our visual consciousness, the neural substrate for visual consciousness must be at a binocular stage. This inference was in fact used by Crick and Koch in 1995 when they were arguing for their postulate that we are not aware of the neural activity in primary visual cortex (V1). However, this inference is invalid because the information for the content of visual consciousness and the EOO information can be completely independent. The second misconception concerns human observers' blindness to the change of EOO (hereafter, COEOO). An example of our blindness to COEOO is as follows: In a binocular rivalry setting, when a naïve observer receives different visual stimuli in her two eyes, she can be aware of the recurring changes between the two percepts but be totally unaware of the fact that such changes are due to dichoptic stimulation. Currently on Wikipedia, under the subject matter "neural correlates of consciousness", there is the following inference: "Logothetis and colleagues switched the images between eyes during the percept of one of the images. Surprisingly the percept stayed stable. This means that the conscious percept stayed stable and at the same time the primary input to layer 4, which is the input layer, in the visual cortex changed. Therefore layer 4 cannot be a part of the neural correlate of consciousness." This inference is incorrect because it fails to take consideration of the observer's blindness to COEOO. [No any conflict of interest.]

Measuring the strength of the interaction between fine and coarse scales on motion discrimination under monocular and binocular viewing

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Psychophysical research has shown that two inhibitory mechanisms can explain impairments in motion discrimination: the interaction between motion sensors tuned to fine and coarse scales and surround suppression (Serrano-Pedraza et al.,2013). Motion discrimination of high spatial-frequency stimulus is impaired when a static low spatial-frequency component is added to it (Derrington & Henning,1987). Moreover, motion discrimination is impaired when stimulus contrast and size increases, indicating surround suppression (Tadin et al.,2003). Previous research has shown that motion surround suppression decreases under monocular viewing (Arranz-Paraiso et al.,2018). Here we test whether inhibition between moving fine and coarse scales is affected by monocular viewing. Using a motion discrimination task, we measured duration thresholds using Bayesian staircases under monocular (left and right eye) and binocular viewing conditions. Ten volunteers took part in the experiment. We used vertical Gabor patches of frequencies 1 and 3c/deg, 46% contrast, 4deg diameter, drifting at 2deg/sec. We tested four conditions: 1c/deg moving, 3c/deg moving, 1 static added to a 3c/deg moving (1s+3m), and 1c/deg moving added to a 3c/deg static (1m+3s). An interaction index was calculated by subtracting the duration thresholds in logarithmic units of the complex minus the simple stimulus. Results show that motion discrimination is strongly impaired (i.e.higher duration thresholds) in the 1s+3m condition. We also found that the interaction index for 1s+3m condition was significantly larger for binocular than monocular viewing. Similar to surround suppression results, our results suggest that monocular viewing decreases the inhibition produced by the interaction between different motion scales. [Supported by grant PGC2018-093406-B-I00 from Ministerio de Ciencia, Innovación y Universidades (Spain) to ISP. SAP is supported by the fellowship FPU16/02683 from Ministerio de Educación (Spain).]

Stimuli decreasing in size at a high rate show the offset Fröhlich effect

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As is known, the Fröhlich effect, as a predictive spatial shift of the perceptual onset position produced and modulated by focal attention, takes place for a one-way motion stimulus. The shift of the offset position of the stopping or disappearing stimulus is usually much less in size. With that, this effect also works for stimuli that change in size. For example, it is usually not possible for a contour object with a speed of resizing up to 15 deg/s to see exactly the start of its resizing process, while the final position of the object can be observed better regardless of the direction of resizing. The studied model of sequential formation of temporal relations between the results of centrally symmetrical relations indicated the possibility of the appearance of the opposite Fröhlich effect when the initial position of the decreasing stimulus is seen better than its final position since smaller objects can be processed by the visual system earlier than larger objects. The results of the experiments for stimuli decreasing in size (7–3 deg) at high speeds of 15, 30, and 60 deg/s showed that for a speed of 15 deg/s, the percentage of subjects with the offset Fröhlich effect was 8%, for a speed of 30 deg/s - 22%, and a speed of 60 deg/s – more than 65 %. Thus, for the last speed, there was a significant number of tests with the offset Fröhlich effect, which was predicted by the model. This result needs further verification.

Weak interaction between motion sensors tuned to high and low spatial frequencies at long durations under dichoptic presentation

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At short durations, the direction discrimination of a moving high-spatial frequency pattern is impaired if a static low-spatial frequency pattern is added to it. At long durations this interaction between spatial frequencies is also very strong if the low-spatial frequency component is flickering (Serrano-Pedraza & Derrington, 2010). The strength of the impairment at short durations is unaffected by dichoptic presentation (Derrington et al, 1993) suggesting that the interaction happens after binocular combination. However, this aspect has not been tested at long durations (>200 msec). Here we measure the strength of the interaction at long durations changing the contrast of one component of the flickering low-spatial frequency pattern in binocular, monocular, and dichoptic presentations. We used complex stimuli composed of a 1 c/deg Gabor patch grating flickering at 4 Hz added to a 3 c/deg patch drifting either leftwards or rightwards at 4 deg/sec at two durations 200 and 400 msec. The contrast of the high frequency grating was fixed at 40%. The flickering grating was composed of two opposite-moving gratings, one with a fixed contrast of 20% and the other with a contrast that changed in each trial depending on the subject's performance. The task was to indicate the drifting direction of the low-frequency component. The strength of the interaction was measured by the contrast needed to cancel direction discrimination. Results revealed the strongest interaction for the binocular condition, followed by the monocular condition and then by the dichoptic condition, which only yielded a weak interaction. [Supported by grant PGC2018-093406-B-I00 from Ministerio de Ciencia, Innovación y Universidades (Spain) to ISP.]

Temporal characteristics of global form perception in translational and circular Glass patterns

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The human visual system is continuously exposed to a natural environment with static and moving objects that the visual system needs to continuously integrate and process. Glass patterns (GPs) are a class of visual stimuli widely used to study how the human visual system processes and integrates form and motion signals. GPs are made of pairs of dots that elicit a strong percept of global form. A rapid succession of unique frames originates dynamic GPs. Previous psychophysical studies showed that dynamic translational GPs are easier to detect than the static counterpart because of the spatial summation across the unique frames composing the pattern. However, it is not clear whether the same mechanism is involved in dynamic circular GPs. We investigated the role of temporal and spatial summation in the perception of both translational and circular GPs. Specifically, we manipulated the number of unique frames in dynamic GPs and the update rate (i.e., the temporal frequency of the pattern) through nine conditions. Participants performed a two intervals force choice task, indicating in which temporal interval was presented the most coherent pattern. The two types of GPs (i.e.,

translational, and circular) were presented in different days. The results suggest that spatial and temporal summation across unique frames takes place for both translational and circular GPs; the number of unique frames and the pattern update rate equally influence the discrimination thresholds of translational and circular GPs. These results show that form and motion integration is likely to be processed similarly for translational and circular GPs. [Acknowledgements: This work was carried out within the scope of the project "Use-inspired basic research", for which the Department of General Psychology of the University of Padova has been recognized as "Dipartimento di Eccellenza" by the Ministry of University and Research. This study was supported by the University of Padova, Department of Psychology and by the Human Inspired Centre. Jorge Almeida is supported by a European Research Council (ERC) Starting Grant under the European Union's Horizon 2020 research and innovation programme (Grant# 802553 - ContentMAP). The authors thank Proaction Laboratory and University of the Coimbra for the support in carrying out the present research and Dr Adriano Contillo for his helpful suggestions on the fitting procedure for data analysis.]

Vection depends on the average luminance, luminance contrast, and the spatial frequency of the stimulus

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The size, speed, and even the perceived material properties, of global visual motion stimuli are all known to affect the intensity of vection (i.e., visually induced illusions of self-motion). To date, there has been not been a systematic study of the effects of luminance contrast, averaged luminance and stimulus spatial frequency on vection. This study therefore examined the vection induced by downward drifting grating stimuli with six different levels of luminance contrast (from 0.046 to 0.999), four different levels of averaged luminance (from 1.59 to 17.035 cd/m^2) and four different spatial frequencies (from 0.02 to 5 cpd). The first three experiments demonstrated that vection intensity is altered by manipulating each of these visual stimulus properties – specifically they showed that vection increased with either the grating's luminance contrast, its averaged luminance, or its spatial frequency. The results from a fourth experiment showed that there are also complex interactions between the effects of these three factors. While motion energy modelling suggested that these behavioural vection data could arise during low level visual processing, higher level effects on perceptions (e.g., of stimulus visibility, brightness or stimulus speed) could also have contributed these effects. [The authors declare that this research have no conflict of interest. And this study have no funding information.]

The effect of contrast on perceived speed in a road-crossing scenario

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It is well known in the psychophysical literature that visual contrast affects speed perception. This effect can have important consequences for traffic safety when navigating under low visibility due to adverse weather conditions (e.g. fog) or visual impairments. So far, research on traffic safety has focused on the perception of self-motion during driving when evaluating the effects of contrast. Drivers underestimate their own driving speed when contrast is reduced globally, but overestimate speed when contrast is distance-dependent providing a more naturalistic simulation of fog. It remains unclear whether pedestrians are subject to similar biases when estimating the speed of approaching traffic. Using a 2IFC discrimination task, we investigated the effects of a global contrast reduction (e.g., experienced by people with cataract) and distance-dependent reduction (e.g., experienced in fog) on the perceived vehicle speed in a simulated road-crossing scenario. Preliminary results point towards similar effects: Speed was underestimated when contrast was reduced globally and overestimated under simulated fog. While the effect of fog has previously been explained by drivers relying on peripheral visual cues when the visibility of central optic flow cues is reduced, this cannot account for the effects observed in pedestrians. We discuss the findings considering apparent acceleration cues.

Perceiving a 3D rectangular corner from a 2D contour-drawing

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Recovering the 3D shape of an object from its 2D retinal image is an ill-posed problem. The human visual system uses regularities of the shape as a priori constraints to recover the 3D shape: e.g. mirror-symmetry, compactness and minimal surface. These constraints can bias the perception of the 3D shape to better satisfy the constraints. A rectangular corner of an object is one of regularities that the visual system can use as a constraint for perceiving an object's 3D shape. Perkins found that a rectangular corner can be perceived in an image only

when the rectangular corner is in a theoretically possible 3D interpretation of the image. Note that a rectangular corner is not always perceived in an image even when such an interpretation is theoretically possible. In this study, we (1) measured statistical properties of the relationship between a rectangular corner and its 2D images by using computer simulations and (2) by testing in a psychophysical experiment, the perception of a rectangular corner in a 2D image. The simulations showed that some images of the rectangular corner appeared substantially more frequently than some other images when the corner was seen from random directions. We had hypothesized that the bias for perceiving the rectangular corner would be stronger with more frequent images than with less-frequent images, but our psychophysical results showed no effect of the frequency of the images on the bias. Based on these results, we will discuss how rectangularity affects the perception of an object's 3D shape. [The study was prepared within the framework of the Academic Fund Program at the National Research University Higher School of Economics (HSE University) in 2019 (grant No 19-04-006) and by the Russian Academic Excellence Project «5-100».]

The constancy of shape constancy bias over stimulus duration

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Numerous studies following Thouless (1931) have demonstrated a "regression towards object" or constancy bias in tasks involving matching to the apparent or perspectival shape of a real or depicted 3D object. It remains unclear whether the bias is entirely one of conscious vision, due to strategies of selective attention. It is possible, as has been argued (e.g., Rock, 1983; Cohen & Jones, 2008), that for a short period after the stimulus onset, a percept that preserves the perspectivity of the stimulus is consciously accessible, but overridden later by an object constancy bias. It is also possible that a response to a sub-threshold stimulus is more likely to conform to the perspectivity of the stimulus. To test these hypotheses, we used an experimental procedure similar to Hammad et al. (2008) that compares the accuracy of match to a shape presented as the top face of a cube in various slanted viewing angles with that to the same shape presented alone. Crucially, the stimulus duration was varied across blocks of trials and the stimulus was masked at its offset. A constancy bias in perceiving the rhombus towards the square shape is found as strong at the shortest stimulus duration of 150ms as it is at 500ms and 1500ms. Assuming it takes about 200ms for a visual stimulus to be consciously registered (Rutiku, Aru, & Bachmann, 2016), the more unconscious and/or automatic perceptual mechanisms may not be less biased towards shape constancy.

Continual Learning for Object Classification: Consolidation and Reconsolidation

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To achieve "consolidation", short-term memory's conversion to long-term memory requires the passage of time. This consolidation can occur at many organizational levels in the brain, e.g., simplifying, when two neurons repeatedly fire at the same time, they become more likely to fire together in the future. Eventually, these two neurons will become sensitized to one another. The brain progressively creates more of these connections when new information or experiences are presented. However, just because a memory has been consolidated it does not mean that it cannot be lost. Literature shows that memories often need to be reconsolidated once they have been recalled. In deep artificial neural networks, there is the tendency to forget previously learned information completely and abruptly upon learning new information, usually called catastrophic forgetting. We propose a Deep Modular Dynamic Neural Network (MDNN) based on "consolidation" and "reconsolidation" principles, capable of learning new information and mitigating the catastrophic forgetting issue. MDNN is divided in two blocks: (a) the feature extraction block, based on a ResNet50, and (b) the modular dynamic classification block, made up of modular sub-networks that progressively grow in a tree shape and re-arranges themselves as they continuously learn. Once one of these branches learn an object then it is "consolidated". If a new object is assigned to a branch that already as consolidated objects, then all the existing objects in that branch are "reconsolidated", this process occurs on the fly. The network presents state of the art results on CORE50 dataset. [LARSyS - FCT Project UIDB/50009/2020.]

Pandora: A new database of young and old computer generated faces

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Embodied cognition has been a field of increasing interest by scientists in the last years. Considering the importance of avatar characteristics in inducing the complete full-body illusion, it is essential to control some psychological measures in both using and creating avatars. Aim of the current study was to reach a first step validation of an extensive young and old avatar database, by adapting with Character Creator 3 (a software to customize and easily create new realistic avatar) photos selected from the Chicago Face Database. 28 bodies

(young and old female and male bodies) and 54 3D caucasian faces were rated for many psychological measures (i.e. attractiveness, realism, trustworthiness and ownership) by Italian young and old volunteers (61 and 42 raters, respectively). A second study aimed to validate the procedure of Head Shot Plug-In in creating a virtual avatar as similar as possible to the real one. Results showed a general positive attitude toward young avatars compared to the older ones. Moreover, all avatars were perceived similar to the original photo, suggesting the potentialities of this procedure in the creation of custom avatars. The database, as well as the creation process, can be applied in virtual reality research and in the field of embodied cognition.

Task dependent interaction between stimulus numerosity and duration

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The ATOM Theory suggests that space, time and numerosity might be encoded by a common neural mechanism to promote the interplay between perception and action (Walsh, 2003). In line with that, Xian et al. (2007) demonstrated via a discrimination task that larger or more numerous stimuli are judged to last longer than smaller/less numerous stimuli of the same physical duration. However, Yates et al. (2012) reported that the interaction between stimuli duration and size is intrinsically task dependent: the duration of larger stimuli was over-estimated in comparative judgments (which stimulus lasts longer?) but the opposite occurred during equality judgments (are the stimuli matched for duration?). Here we investigated whether a task dependent interaction also occurs for estimates of the duration of stimuli with different numerosities. Participants judged the duration of a variable test stimulus (duration: 400 -1600 ms; numerosity: 12 or 48; tested in separate sessions) against the duration of a reference (duration: 800 ms; numerosity: 24) in a discrimination and a same/different task. Numerosity strongly affected perceived duration in the discrimination task, with more numerous stimuli being perceived as lasting longer, but no significant interaction was found for the same/different task. On top of this, duration estimates for stimuli of different numerosity turned out in being rather identical also in a duration reproduction task. Taken together our results suggest that the interactions between magnitudes might not be the automatic outcome of a shared perceptual mechanism, but the result of a perceptual/cognitive strategy employed in the behavioral task. [This research was supported by the Italian Ministry of Education, University, and Research under the PRIN2017 program (Grant number 2017XBJN4F—'EnvironMag') and the European Union (EU) and Horizon 2020 – Grant Agreement No 832813 - ERC Advanced "Spatio-temporal mechanisms of generative perception — GenPercept".]

The Value of Visual Acuity as a Predictor of Ametropia in School-Age Children Vision Screening

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At present, there is no common approach in describing the threshold value of distance visual acuity screening that would define the need of a full vision examination. The aim of the study was to determine the threshold value of distance visual acuity in the developed computerized vision screening protocol for school-age children. We looked for the value that have a high sensitivity and specificity in selecting children with clinically significant ametropia. In the first part of the study, we analyzed the results of computerized vision screening performed in 2011-2013. We tested 696 children (age 6-19 years). A full vision examination was used to detect the types and size of ametropia in children with reduced visual acuity at a distance (1392 eyes). Results depicted that uncorrected myopia (-1.00±0.65 D) and uncorrected simple myopic astigmatism (-0.66±0.12 D) significantly decrease visual acuity at distance ($p < 0.001$). Visual acuity at distance is not statistically dependent on uncorrected hyperopia or simple hyperopic astigmatism ($p = 0.47$). In the second part of the study, we evaluated the sensitivity and specificity of our improved computerized distance visual acuity test. The results showed that the optimal visual acuity threshold for computerized visual screening is logMAR 0.1; it is capable to detect myopia and simple myopic astigmatism. A special hyperopia test should be used to detect uncorrected hyperopia during vision screening. Children with uncorrected hyperopic astigmatism can be selected in other near vision function screening tests. Our results demonstrate the applicability of screening tests in school-age children. [Acknowledgements: The study is based on project No. KC-PI-2020/10 " Development of vision screening and training device".]

The influence of peripheral vision during scene categorization

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The spatial resolution of the human visual field decreases considerably from the center to the periphery. However, several studies have highlighted the importance of peripheral vision for rapid scene categorization. Critically, low resolution of peripheral vision could trigger predictive mechanisms that would then guide the highly detailed central vision. In Experiment 1, we investigated if peripheral vision could influence the categorization of scenes in central vision, and vice-and-versa. We used large photographs of indoor and outdoor scenes from which we extracted a central disk and a peripheral ring. Stimuli were composed of a central disk and a peripheral ring that could be either semantically congruent or incongruent. Participants had to categorize the central disk while ignoring the peripheral ring or the peripheral ring while ignoring the central disk. Results revealed a semantic interference of peripheral vision on central vision, as strong as the interference of central vision on peripheral vision. In Experiment 2, we investigated the nature of the physical signal in peripheral vision that influence central vision processing. We used either an intact peripheral ring, or a peripheral ring whose amplitude spectrum was preserved (phase-scrambling), or a peripheral ring whose phase spectrum was preserved (amplitude-scrambling). Participants had to categorize the central disk while ignoring the peripheral ring. Results showed that only phase-preserved peripheral rings elicited a semantic interference effect as strong as the one observed with intact peripheral rings. Information contained in the phase spectrum, conveying the spatial configuration of the scene, may be critical to trigger peripheral predictions.

The computer, a choreographer? Aesthetic responses to computer-generated dance choreography

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Scientists striving to push machines toward human levels of intelligence are tackling endeavours often regarded as uniquely human, including art creation. But are creative productions like dance choreography valued if produced by a machine or artificial intelligence (AI)? Do those who produce art themselves (expert artists) show similar aesthetic responses toward computer-generated dance choreography as non-experts? Answers to these questions have key implications for the future of artistic artificial intelligence (AI). Across three experiments (N=180), we show that dance experts show a bias against computer-generated choreography (higher ratings of beauty and liking for human-generated choreography). This bias exists implicitly and explicitly i.e., when they are unaware (Experiment 1) and aware (Experiment 2) that the choreographies are human or computer-generated. This bias is enhanced in experts and also observed in non-experts when participants themselves categorise choreographies as computer or human-generated. The bias further persists in both experts and non-experts when a belief manipulation is introduced - they show reduced ratings of beauty and liking when they believe that a choreography is computer-generated when it is generated by a human (Experiment 3). Taken together with qualitative data, these findings reveal both an implicit and explicit bias against computer-generated art, modulated by expertise and beliefs about the art's origin. As advancements in AI continue to change and challenge how art is generated and appreciated, a challenge for scientists and artists will be to understand observer prejudices against computer-generated art, and the impact of pre-conceived beliefs on the origin of artistic creation.

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