Abstract Book 2021

Lightning Talks

Many thanks to all contributors!

Category-orthogonal object features guide modulatory operations in recurrent neural networks trained for invariant object categorization [Room 1, 16.15]

Giacomo Aldegheri, Radboud University, Netherlands

Recurrent computations are ubiquitous in biological neural networks. The functional role of these recurrent computations has been studied recently with artificial neural networks. Artificial recurrent neural networks have shown performance advantages compared to feedforward architectures in visual object categorization, especially in challenging conditions such as in the presence of occlusion and clutter. We investigate the informational content of recurrent activations, hypothesizing that they might convey information about category-orthogonal auxiliary variables such as the location and orientation of the target object, to iteratively select information at subsequent timesteps to optimally discriminate object categories. We find that linearly decodable information about auxiliary variables increases across time in all layers, that this information is present in recurrent activations, and that altering it decreases task performance. These observations confirm the hypothesis that category-orthogonal auxiliary variable information is conveyed through recurrent connections and used for selecting information relevant for optimised category judgements.

Deep Neural Networks Rely on Distinct Semantic Features of Same-Category Exemplars Not Predicted By Low-Level Image Statistics [Room 1, 16.30]

Mohammad Hossein Niki Maleki, Faculty of Computer Science and Engineering, Shahid Beheshti University, Iran

Deep Convolutional Neural Networks (DCNNs) are among the most accurate and brain-plausible models of human object recognition. It has been shown that humans rely on specific segments of objects (called minimal recognizable configurations or MIRCs) for recognition. However, DCNNs did not show such sensitivity to identical MIRCs (Ullman et al., 2016). Therefore, it remains unclear if humans and DCNNs use different mechanisms for object recognition. Specifically, we have shown previously that while humans used relatively consistent/invariant sets of object features across variations (in-depth and in-plane rotation, size and translation), DCNNs relied on relatively inconsistent/distinct object features across the variations of the same objects (Karimi-Rouzbahani et al., 2017). This suggests that, as opposed to humans, DCNNs seem to rely on semantically distinct object features across object variations for recognition. This might be a more general mechanism suggesting that DCNNs may even use relatively more distinct object features to recognize the exemplars from the same semantic object category (e.g. different exemplars of an elephant), compared to humans. To test this hypothesis, we obtained MIRCs for one of the most brain-like DCNNs (VGG16) using the well-established Bubbles method (Gosselin and Schyns, 2001). As an advantage to previous procedures, which detected MIRCs from pre-selected discrete image parts, Bubbles sweeps the whole image using continuous masks, allowing data-driven contribution of all pixels to recognition. We extracted MIRCs from 12 semantic object categories (e.g. elephant, hammer, pot, etc., each with 16 exemplars) of the ImageNet dataset (Deng et al., 2009). Results clearly showed different MIRCs for distinct exemplars of the same object category, reflecting the exemplar-specific nature of feature selection in DCNNs. This may underlie the robust object recognition observed for DCNNs under variations in objects and examplers. To provide a mechanistic account of how feature selection might happen in DCNNs, we then asked if the MIRCs found for DCNNs could be predicted by low-level image statistics. Specifically, we wondered if the MIRCs were simply salient segments of an image as detected by computational models of saliency. These models use local low-level image statistics (e.g. color, orientation, contrast) to predict the location of human overt attention (gaze) on the image (Kimura et al., 2013), and can indicate image areas that are visually rather than semantically distinct from other areas. Alternatively, MIRCs could be object segments which potentially contain semantic information which diagnoses the category of the object. To test this hypothesis, we obtained the salient segments of all the images in our dataset using 5 of the most brain-plausible saliency-based models e.g. Itti et al., 1998. Results showed that the MIRCs obtained from the DCNN and the salient regions obtained from the saliency models were quantitatively and qualitatively different. This suggests that, rather than relying on salient low-level image statistics, DCNNs may rely on object segments which probably contain semantic category information relevant for object recognition. We are collecting human data to quantitatively compare to the results from our DCNN and the computational models of attention.

Arousal state affects perceptual decision-making by modulating deep hierarchical sensory processing [Room 1, 16.45]

Lynn Sörensen, University of Amsterdam, Netherlands

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 novel 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.

Testing a model of Aesthetic Value [Room 2, 16.15]

Max Berentelg, Max-Planck Institute for Biological Cybernetics, Germany

We routinely judge the aesthetic appeal of objects and experiences such as the attractiveness of a face or the taste of a meal. However, we lack a clear understanding of the processes underlying these evaluations. So far, two main families of theories try to explain aesthetic judgment. One bases them on processing fluency: the better the sensory-cognitive system suits a sensory input, the more fluent its processing, and, putatively, the more positive the aesthetic judgment. Processing fluency can explain some effects, like increasing appeal given increasing exposure, but it cannot explain others, such as boredom. A second family comprises learning theories. These quantify aesthetic value via the change in the sensory-cognitive system's ability to process expected future sensory input. Moderately surprising stimuli inspire substantial learning, and attract positive aesthetic judgments. Extremely surprising stimuli trigger limited learning, and hence low aesthetic values. Learning theories in aesthetic judgment can account for boredom, but fail to explain phenomena such as listening to the same favorite song repeatedly over long periods. Brielmann and Dayan (2021) propose a model of aesthetic value that combines these two existing families of theories and promises to explain empirical findings that neither previous account alone can encompass. Their model quantifies aesthetic value as a temporally sophisticated prediction error associated with the long run fluency of processing current and expected future sensory input. Here, we test the model with a new experimental paradigm which mimics the core features of a walk through a gallery. Our stimulus material consists of images of dogs generated by morphing with Neural Crossbreed (Park et al., 2020) so that their similarity is controlled. This allows us to make predictions about how learning progress might be influenced by images as a function of their similarity. Participants look at an image as long as they want. At each point in time, they can decide to go on to the next image (which is previewed as a thumbnail). Images ultimately recycle in a random order. After this free viewing time, participants rate how much they like each image. We record the sequence of images, their viewing times, and the liking ratings. A pure fluency account would predict that the aesthetic value of a stimulus increases with viewing time. A pure learning account would predict that the aesthetic value of a stimulus slowly decreases when it is viewed for too long. The proposed full model incorporates elements of both simpler models. By fitting it to the data, we can therefore directly compare whether elements of both simpler models are needed to account for people's aesthetic judgments and choices. Preliminary data show a substantial variability within subjects for each image in viewing times (mean sd = 2.26 s) and ratings (mean sd = 43.24; on a 0-500 scale). The variability is also substantial between subjects for each image in viewing times (mean sd = 3.42 s) and ratings (mean sd = 136.48; on a 0-500 scale).

A Neurocomputational Model of Prospective and Retrospective Timing
[Room 2, 16.30]

Joost de Jong, University of Groningen, Netherlands

Humans are marvellous theory-generating entities. We're often confident that the free-floating ideas in our minds make for good theories, especially when it comes to theories about how minds work in general. But despite our most creative efforts, we might never discover whether our theories are sound, or whether they are just a collection of half-baked thoughts. This is the beauty of computational modelling: you can find out about the viability of your theory when you build it. And that's only the start. The real fun begins when these computational models return the favor by radically changing the way we view the mind. These sudden changes of perspective are not just poetic; they have actually shaped my research on time perception. When I was studying how statistical context sculpts our sense of time, we though we had found evidence that only stimuli in working memory undergo these kinds of effects. Then we realized that a Bayesian account - in which all stimuli undergo this effect - can equally well account for the data. Only after implementing both models computationally were we able to see that our first intuitions (read: free-floating ideas) were completely mistaken. In more recent work, we've been looking at the effect that 'time flies when you're busy, but feels long when looking back'. Such an interaction effect screams 'dual-systems', and this has indeed been the dominant view in the literature: 'internal clock' for time in passing, 'memory' for looking back. But upon closer inspection, we found that such 'dual-system' accounts ignore interactions between 'clock' and 'memory' systems. More surprisingly, our computational model suggests that precisely by modelling 'clock' and 'memory' processes as esssentially the same, can we account for 'time flying by' and 'time seeming long in retrospect'.

Prediction Error and Memory: Insights from a Computational Model
[Room 2, 16.45]

Francesco Pupillo, Goethe University Frankfurt, Germany

Predictive processing accounts suggest that our brain constantly tries to match top-down internal representations with bottom-up incoming information from the environment. Through the extraction of regularities from the environment, prior expectations of varying strength are formed and used to make predictions. Information encountered in the environment can either match or violate these predictions, leading to varying degrees of prediction error. Theoretical and computational models assume significant, beneficial effects of prediction error on learning and memory. Nevertheless, very little is known on the effects of prediction error on memory encoding. Therefore, the aim of the present investigation is to examine how prediction error at encoding influences subsequent episodic memory. We first used a contingency-learning paradigm to establish different levels of priors for scene-object category associations, ranging from strong to weak. In the encoding phase that followed, participants were asked, for each trial, to predict the category of the object that will be presented as cued by the scene category. The objects that were then shown could either match or violate their previously learned expectations. Finally, participants were asked to complete a surprise recognition test. We fitted several reinforcement learning models to participants' data and selected a Rescorla-Wagner model as the one that best fitted the data. We then estimated best fitting learning rate and inverse temperature parameters for each participant, and used them to derive subject-specific trial-to-trial estimates of prediction error. Results showed that prediction error at encoding influenced subsequent memory as a function of the outcome of participants' predictions (correct vs incorrect). Precisely, when participants correctly predicted the object category, stronger prediction error (as an outcome of weak prior) led to enhanced memory. In contrast, when participants incorrectly predicted the object category, stronger prediction error (as an outcome of strong prior) led to impaired memory. These results suggests a computationally specific influence of prediction error on memory formation, revealing the important moderating role of prediction accuracy.

Learning to Infer Unseen Contexts in Causal Contextual Reinforcement Learning
[Room 3, 16.15]

Hamid Eghbalzadeh, Johannes Kepler University, Austria

In Contextual Reinforcement Learning (CRL), a change in the context variable can cause a change in the distribution of the states. Hence contextual agents must be able to learn adaptive policies that can change when a context changes. Furthermore, in certain scenarios agents have to deal with unseen contexts, and be able to choose suitable actions. In order to generalise onto unseen contexts, agents need to not only detect and adapt to previously observed contexts, but also reason about how a context is constructed, and what are the causal factors of context variables. In this paper, we propose a new task and environment for Causal Contextual Reinforcement Learning (CCRL), where the performance of different agents can be compared in a causal reasoning task. Furthermore, we introduce a Contextual Attention Module that allows the agent to incorporate disentangled features as the contextual factors, which results in performance improvement of the agent in unseen contexts. Finally, we demonstrate that non-causal agents fail to generalise onto unseen contexts, while the agents incorporating the proposed module can achieve better performance in unseen contexts.

Social Context Shapes Value Representation during Learning [Room 3, 16.30]

Ham Huang, University of Pennsylvania, United States

Computational modeling is a powerful tool for understanding how people learn and make decisions on behalf of themselves and others (Suzuki & O'Doherty, 2020). Models of learning and decision-making typically share a common theoretical construct which assumes that the mind maintains some form of value representation and guides behavior that yields higher value. On one hand, reinforcement learning models describe low-level learning mechanisms through which external rewards implicitly update the values represented in the mind (Rescorla, 1972); on the other hand, social preference models describe higher-level subjective evaluation of external rewards. For example, Jenkins et al. (2018) recently adapted a social preference model to capture how inequity and social perception interact to shape the subjective value of monetary rewards to oneself and others. To what extent does the mind integrate higher-level inequity and social perception information with value representations in the lower-level learning system? When learning relationships between cues and rewards to be divided across oneself and another person, to what extent does the identity of that person influence learning? One possibility is that there is no influence; that is, the fidelity with which a person learns relationships between cues and rewards does not depend on social factors. We embody this hypothesis by a naive reinforcement learning (Naive) model that assumes the mind represents only the total, objective reward. A second possibility is that the mind represents separately the reward to self and to other, as captured by a dual-process (Dual) model (Christopoulos & King-Casas, 2015). A third possibility is that inequality and social perception dynamically shape value representations during learning; this is embodied by our social preference reinforcement learning (SPRL) model. To test these hypotheses, we recruited 94 online participants to perform a computerized instrumental learning task (modified from Collins & Frank, 2012) in which the monetary rewards obtained on each trial would ostensibly be split between themselves and another person (e.g., "Nurse"; "Lawyer"; known to be associated with preference for resource allocation). On each trial, an image appeared, along with information about how the reward would be split (e.g., you: 30%; Nurse: 70%); participants were obliged to quickly press 1 of 3 keys, which yielded either $0, $1, or $2 (before splitting). We varied the split percentage to create either disadvantageous inequality (participant gets the smaller share) or advantageous inequality on each trial. Following the task, subjects rated the warmth and competence of each partner. Mixed-effect linear regressions with subject ID as the random intercept revealed that the percentage of split, the warmth rating, and the competence rating significantly affected the total reward obtained (all ps < 10-15). Critically, we then compared our 3 computational models using Akaike and Bayesian information criterion. We found that the SPRL model outperformed both the Naive and the Dual model. Learning curves also show SPRL best validates the behavioral trend. These results suggest inequality and social perception information influence value representation during learning in a way that mirrors their effects on social behavior.

A model of moral decision-making fitted to mouse-tracking data reflecting paradigm constraints [Room 3, 16.45]

Flora Gautheron, Grenoble Alpes University, France

A multitude of factors may influence moral decisions, leading to complex dynamics that call for nuance. Yet, experimental paradigms are often restricted to two-alternative forced choice tasks, with alternatives placed in opposite corners of the screen space. It presents them as two extreme and contrasted answers and might not be representative of the decision-making mechanisms when there is the opportunity to be nuanced (especially in the case of moral judgments). In this study, we investigate if the paradigm response mode (two-alternatives or continuous scale) could influence how morality is cognitively represented and processed, either relying on continuums or categories. To this purpose, we built a computational model of (moral) decision-making based on differential equations corresponding to dynamic neural fields coupled with sensorimotor control, extending classical drift diffusion models. In this model, a 1D population of neuronal units maps a moral judgment scale (discrete or continuous). Neural fields usually operate on continuous spaces (e.g., sensorimotor), but allow the emergence of spatially localized attractors. Spatiotemporally coherent activity across the neural field reflects convergence in the decision space, while generating (mouse) trajectories aiming at on-screen response locations. Simulated data were fitted to mouse-tracking data previously collected on human participants, where the dynamics of participants' judgments on moral statements was recorded using the computer mouse. Based on paradigmatic constraints implemented in the model, it successfully produced adequate mouse trajectories in both binary and continuous response modes, possibly reflecting the impact of the response constraint in the decision-making process. Adjusting parameters in our model based on empirical data allowed us to bridge the gap between two-alternative forced choice and continuous scale paradigms, possibly giving insights into processes underlying human decision-making, and whether moral decision dynamics - and decision dynamics in general - would differ depending on response mode.

Decoding of Sequential Memory Reactivation from Wake Rest [Room 4, 16.15]

Simon Kern, Central Institute of Mental Health, Germany

Animal research suggests replay of memory traces during rest and sleep improves performance, but this research relies on highly invasive methods and only has access to simple behavior. Similarly, quantifying replay in humans has proven difficult, and up to this point, no study exists that is able to detect endogenous human memory replay during sleep. In this proof-of-principle study, we applied a recently developed method in healthy humans to record item-level human replay events and thereby uncover the processes occurring during quiet rest. In subsequent studies we hope to further develop this method to be able apply it to human sleep. In this study we attempted to detect sequential memory replay in humans during rest. In a first step, sixteen items were presented multiple times in a pseudorandom order while brain activity (MEG) was recorded in order to extract the representational brain state activity for these items. Machine learning classifiers were trained to decode the brain states belonging to each item. In a second step, the participants learned an ordering of the previously presented items. Subsequently, in a resting state condition, we were able to detect preliminary evidence for time-compressed replay of the learned items. Our analysis confirmed previous findings, that items are replayed with a time-lag of around 40-50 milliseconds between individual items

Sensory versus cultural expectations in the neural processing of music
[Room 4, 16.30]

David Quiroga-Martinez, Aarhus University, Denmark

When listening to music, we constantly attempt to predict the sounds that will follow. For example, quite often we end up humming, singing along or tapping our foot to the beat, and find pleasure in listening to pieces we know very well. However, the nature and brain basis of musical predictions or expectations remain poorly understood. Concretely, we do not know the extent to which these expectations arise from adaptation to the sensory properties of sounds or from a more cognitive and culturally shaped learning of the statistics of musical pieces and styles. Here, we employed computational modelling and MEG data to investigate the neural correlates of melodic expectations. We compared the performance of a cognitive model of music statistical learning (IDyOM) and pitch distance (a simpler measure of sensory similarity between tones) in predicting neural responses to sounds in listeners with different cultural background and musical expertise. For this, an encoding model based on regularized linear regression was used. Our results show that, across listening conditions, datasets and types of listeners, the pitch distance model outperforms statistical learning models. Furthermore, in exploratory analysis, a Gaussian predictive coding model reproduced the relationship between pitch distance and neural activity, thereby pointing to a potential neurophysiological mechanism. Our work suggests that sensory expectations play a prominent role in shaping neural responses to musical sounds.

Dynamic computation and frontal-parietal circuit implementations of multisensory causal inference in Macaque monkeys [Room 4, 16.45]

Guangyao Qi, Center for Excellence in Brain Science and Intelligence Technology, Institute of Neuroscience, Chinese Academy of Sciences, China

Natural perception relies inherently on inferring causal structure in the environment. However, the neural mechanisms and functional circuits that are essential for representing and updating the hidden causal structure during multisensory processing are unknown. To address this, monkeys were trained to infer the probability of a potential common source from visual and proprioceptive signals on the basis of their spatial disparity in a virtual reality system. The proprioceptive drift reported by monkeys demonstrated that they combined historical information and current multisensory signals to estimate the hidden common source and subsequently updated both the causal structure and sensory representation. Single-unit recordings in premotor and parietal cortices revealed that neural activity in the premotor cortex represents the core computation of causal inference, characterizing the estimation and update of the likelihood of integrating multiple sensory inputs at a trial-by-trial level. In response to signals from the premotor cortex, neural activity in the parietal cortex also represents the causal structure and further dynamically updates the sensory representation to maintain consistency with the causal inference environment. Thus, our results indicate how the premotor cortex integrates historical information and sensory inputs to infer hidden variables and selectively updates sensory representations in the parietal cortex to support behavior. This dynamic loop of frontal-parietal interactions in the causal inference framework may provide the neural mechanism to answer long-standing questions regarding how neural circuits represent hidden structures for body awareness and agency.

Role of pupillary tonic and phasic activity in cognitive flexibility and stability
[Room 5, 16.15]

Anna Jos, McGill University, Canada

The impact of locus coeruleus (LC) activity on task performance, and the concordance between LC firing modes and pupil diameter changes are well established. However, the direct influence of tonic-phasic pupillary activity, on cognitive control has not been systematically investigated. We examined these associations, specifically focusing on cognitive flexibility and cognitive stability. Participants completed a stability-flexibility task, with pupil recording. We measured flexibility based on response times on task-switch trials, and preference to switch tasks on ambiguous trials. Stability was measured by performance on repeat and distractor inhibition trials. These measures were modeled based on phasic-tonic pupil dilation, using multilevel models and bayesian analyses. We find a lower preference to voluntarily switch in individuals with higher tonic activity. This aligns with three findings indicating a negative relationship between higher phasic modulation of performance and lower preference to voluntarily switch. Additionally, higher average tonic pupil predicted quicker errors and not accuracy on trials measuring cognitive stability. Higher tonic was also observed post lapses in task performance (errors). These findings provide pupillary and behavioral evidence that refines the hypothesized relationship between cognitive control and LC activity.

Geometric Ocular Behaviour; Exploring The Visual System And Short Term Working Memory: Through Eye Movement Behaviour [Room 5, 16.30]

Michelle Morelli, Ulster University, United Kingdom

Eye tracking equipment serves as a tool to explore the workings of the visual system. Hence it has proven to be a very effective technology within experimental psychology. This technology has provided evidence for numerous contrasting theories as to how the fovea (main visual perception) links to the left and right hemispheres in the brain to view stimuli in the environment. This is key to bringing about a better understanding of how humans use eye movements in cognitive strategy tasks. For instance Gesellschaft, (2011) considered if differences between individuals in the anatomy of the corpus callosum (fibres joining the two hemispheres in the brain) would show if observers perceived a visual stimulus. Gesellschaft, (2011) established that callosal fibre tracts are linked to the personal knowledge of individuals. Therefore concluded that both hemispheres influence even the very basic sensory processes. The question beckons as to; what is eye movement behaviour; and how is human cognitive behaviour impacted by the visual system; and why is this important? (Holmqvist, Nyström, Andersson, Dewhurst, Jarodzka., & Van de Weijer, 2011). The importance of these connections can bring us closer to the inner workings of the mind's eye. It is postulated that the visual system and the human mind seek to find the easiest solutions to problems within visual working memory tasks. This is theorised in Baddeley's (1974) working memory model, which is the most popular and studied theory among cognitive psychology for exploring cognitive tasks. It hypothesises which techniques are best used in problem solving (e.g., applying various geometry patterns or shapes for retracing location of placed objects) during recall on visual working memory tasks. From a cognitive psychologist perspective finding solutions to cognitive deficits by exploring cognitive tasks is very beneficial for many e.g. individuals with learning disabilities, head injuries and children's development to name a few. Hence the importance of discovering more knowledge of eye movement behaviour. Interestingly eye movement behaviour involves patterning recognition, this has been of debate from both an evolutionary and developmental perspective. For example, evolutionary psychologists such as Michael Shermer argue that humans have always had innate abilities in pattern recognition. However, child developmental psychologists such as Allen., & Kelly, (2015, p. 4) explicitly state "Infants and toddlers derive implicit theories to explain the actions of objects" (Allen., & Kelly, 2015, p. 4). These theories form the foundation for causal learning and more sophisticated understanding of the physical world and patterning is solely dependent from early learning experiences of patterning recognition. All of the above guided this particular experimental eye tracking study. (Clay, Viviane., & König, Peter., & Koenig, Sabine, 2019). To understand cognitive tasks with geometric eye movement behaviour, Baddeley's working memory model outlines the cognitive processes involved. This study explored working memory and automatic processing during problem solving (patterns-geometric) for cognitive processes to remember the objects location). The eye tracking images did show some evidence of geometric behaviour when participants recalled the spatial block tasks.

Exploring the species-specific differences in saccadic suppression [Room 5, 16.45]

Ibrahim Alperen Tunc, Centre for Integrative Neuroscience (CIN) Tübingen, Germany

Visual sensitivity to many stimuli drops considerably during saccades. This phenomenon, known as saccadic suppression, has been studied extensively from a perceptual perspective, and various subcortical and cortical brain regions along the magnocellular pathway of the visual stream, including the superior colliculus in the midbrain, have been proposed as likely neural correlates in primates. Experimental findings suggest a major role of corollary discharge in saccadic suppression, while there is also evidence for purely visual mechanisms. The exact neuronal mechanisms underlying the saccadic suppression are still a matter of debate. We investigate saccadic suppression in zebrafish, where a homolog of the superior colliculus, the optic tectum, is the major visual center, and which does not possess a cortex. The much smaller brain of larval zebrafish (just 100,000 neurons) can help to identify essential properties of saccadic suppression and to test existing computational models by feeding them with quantified parameters from distant vertebrate species. A recent study by Crevecoeur and Kording modeled saccadic suppression using a closed loop controller, assuming that the brain uses shared neural resources for visual perception and motor control of the eye plant. The main premise of the model is the motor commands for saccadic eye movements are determined jointly by the eye position estimates of corollary discharge and sensory extrapolation, both of which are subject to noise. During saccades, the sensory signal of retinal image shift is delayed relative to the underlying corollary discharge, causing the sensory extrapolation in predicting the next eye state to be unreliable. As a result, sensory extrapolation is weighted less during saccades in eye state estimation, which manifests as saccadic suppression of sensory responses. We are currently measuring and estimating the sensory and motor noise parameters for macaques and zebrafish in order to test the predictions for saccadic suppression according to the two species' noise regimes in the Crevecoeur model. For estimating sensory noise, we devised a basic linear stimulus shift decoder and tested the decoder performance with receptive field properties of zebrafish tectal neurons and macaque collicular neurons taken from the literature. For measuring motor noise, we analyzed zebrafish and macaque eye traces with and without saccades. Both sensory and motor noise estimates showed species-specific differences. Particularly, estimates of motor noise parameters were 20-80 times smaller for macaque than for zebrafish. In the species-specific simulations, decoding error showed a reduction with an increase in the model neuron number, which was stronger for zebrafish than for macaque. Considering the far less number of neurons in the zebrafish optic tectum relative to the macaque superior colliculus, sensory noise was quantified approximately 20 times smaller for macaque than for zebrafish. Overall, our work provides an estimate of the Crevecoeur model noise parameters for zebrafish and macaque, so that the model can be used to generate testable predictions about saccadic suppression under different stimulus conditions and for different species. Our work will hopefully help to identify mechanisms of saccadic suppression in vertebrates.

Biological Motion Perception Away From Selective Attention: Bottom-up Processing of Biological Motion under Attentional Load [Room 6, 16.15]

Hilal Nizamoglu, Bilkent University, Turkey

Perceiving biological motion has significant importance for the social adaptation and survival of not only human beings but also other animals. Even with a simple stimulus known as point-light displays (PLD), one can determine whether the perceived "person" is a friend, a mate, or a foe. Perception of biological motion (BM) under selective attention is supported by a network of regions in the occipito-temporal cortex including motion sensitive visual regions and posterior superior temporal sulcus (pSTS), in addition to the premotor cortex. However, bottom-up processing of biological motion when it is away from attentional focus 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. This finding shows that biological motion stimulus was processed incidentally. In other words, even when one does not selectively attend to the BM stimulus, it was nonetheless processed unintentionally. Based on this finding, in this study, we have examined whether BM would be processed by the occipito-temporal and premotor cortices when it was shown away from the focus of attention (i.e. at the periphery) in an attentional load experiment. In attentional load paradigms, an irrelevant stimulus is presented at the periphery, while participants are enrolled in a visual detection task that demands either high or low attentional load at fovea. Considering that there is a limit to perceptual capacity, the processing of each element within the field of view cannot be processed in the same manner. Attention, in that sense, works as a regulatory mechanism based on task demands. Accordingly, the activation related with the unattended stimuli is stronger in low attentional load conditions, while it is decreased or diminished in high load conditions. To date, flickering checkerboards, optic flow of lines, and colorful patches have been used as irrelevant distractors with these paradigms, and processing of these stimuli has been found to be modulated by attentional load at early visual cortex areas (V1-V4), motion sensitive middle temporal (MT) cortex, and color responsive area V4, respectively. However, no high-level and socially meaningful stimulus has been used as a distractor in such studies. Therefore, the modulation of attentional load on the visual processing of a meaningful stimulus remains unknown. In this study, we have used a socially meaningful stimulus (i.e. point light displays of BM) as an irrelevant distractor shown at the periphery and examined whether BM would be processed when it is away from attention, and if so, whether this processing would be modulated by attentional load. Both univariate variance analysis and multivariate pattern analysis results showed that when it was away from the focus of attention, BM was processed and could be decoded at the motion sensitive regions of occipito-temporal cortex. This processing has been found to be stronger in the low load compared to high attentional load conditions. Thus, it can be concluded that BM perception occurs unintentionally and this processing is modulated by the attentional load.

Gender Differences in Visual Perception on Selected Images of Virtual Building Models [Room 6, 16.30]

Samabth RD`, Indian Institute of Technology Roorkee, India

The current study focuses on the perceptual experiences of Indian males and females on structurally significant buildings. The study aims to understand the importance of socio-psychological factors while choosing any experimental stimuli. Moreover, the literature suggests that across gender, there is a difference in perception of socio-psychological factors. However, only a few studies explore the socio-psychological factors which reflect male & female perception of the virtual models. Hence, in this exploratory study, we have asked five socio-psychological questions which reflect male & female perception of the virtual building models to select structurally significant and non-significant virtual models. A total of 99 healthy volunteers were chosen, and each volunteer received images of 17 different building models. Participants answered five questions related to identifiability, comfort, male-centric, environment space, and place sociability of the structurally significant buildings. The results show that 3D-model perception differs significantly between men and women. Further, the findings indicate the efficacy of sex difference with regard to social, cultural, and gender preferences in the selection of virtual models.

Disassociating conformity-driven and self-interest-driven dishonest behaviors and their effects on COVID-19 pandemic. [Room 7, 16.15]

Liqin Huang, Sun Yat-sen University, China

Dishonesty is prevalent in decision makings in human society when self-interest comes into compromise. Prior studies propose the contagion of dishonesty, which might be driven by discrepant motivations, however is rarely dissociated previously. Currently, we proposed a comprehensive model comprising the processes of conformity-driven and self-interest-driven dishonesty when dishonesty emerged. With the agent-based evolutionary simulation and empirical experiments, we found a determinant effect of self-interest-driven dishonesty propensity on dishonesty when one was in pursuit of self-interest, while the effect of dishonesty conformity was depended on both the self and environmental dishonesty propensity. In addition, we found that the self-interest driven dishonesty propensity was related to individuals' preference for value allocation, while dishonesty conformity was related to interpersonal trust and could be manipulated by environmental predictability. In the background of the COVID-19 pandemic, we found that these two processes of dishonesty exerted distinct effects on regulation violation and impacted the local prevalence of pathogens differently. Our current findings validate the processes of conformity-driven and self-interest-driven dishonesty when dishonest behaviors emerge and uncover how these two processes influence the progression of a real-life emergent event.

Joint action in VR: A framework for studying low-level social interaction in a multiplayer virtual setup [Room 7, 16.30]

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Social interactions, especially joint actions, are one of the most central aspects of human life. However, due to their interactive nature, they are difficult to be grasped experimentally. So far, contemporary studies mostly employ simplistic, static stimuli under strictly supervised laboratory conditions to gain control over experimental variables. Therefore, these studies are often not able to capture the complexity and multitude of sensory cues which occur during real-world interactions. A promising solution to these issues could be virtual reality (VR) because it enables participants' perceptive immersion into virtual surroundings. Moreover, VR allows for real-time interaction in a more ecologically valid environment while maintaining experimental control. Given its advantages, it seems curious why there is such an absence of low-level joint action paradigms in VR. A possible reason might be technical limitations due to multiplayer networking. Since the majority of available networking solutions are designed for consumer applications such as online gaming, they often lack low-level control of the networking variables and other essential modification options. Therefore, a networking solution specialized to the requirements and needs of experimental paradigm implementations in VR is needed. To solve this need, we propose a new networking solution called "LightNet" that is particularly designed to implement joint action experiments in VR. More specifically, LightNet allows for customizable real-time interaction between test subjects. Additionally, our framework provides complete control over sent and received data, therefore improving performance and frame rate of the experiment implementation. To test the practicality of LightNet and provide a framework for basic joint action paradigms, we implemented two experiments in VR that are based on classical joint action paradigms originally designed for 2D desktop environments. The first experiment focuses on networking auditory feedback in an anticipatory control task. The second experiment implements a networking solution for a shared gaze task while networking complex stimuli information. Overall, our VR recreation of joint action studies demonstrates the usability of LightNet and serves as a proof of concept for our networking framework in joint action studies. As Lightnet's code is freely available, we enable possible modification and redistribution while also giving further insights into how to use LightNet. As a result, the presented networking solution and experimental framework make VR more accessible for the scientific landscape of joint action research.