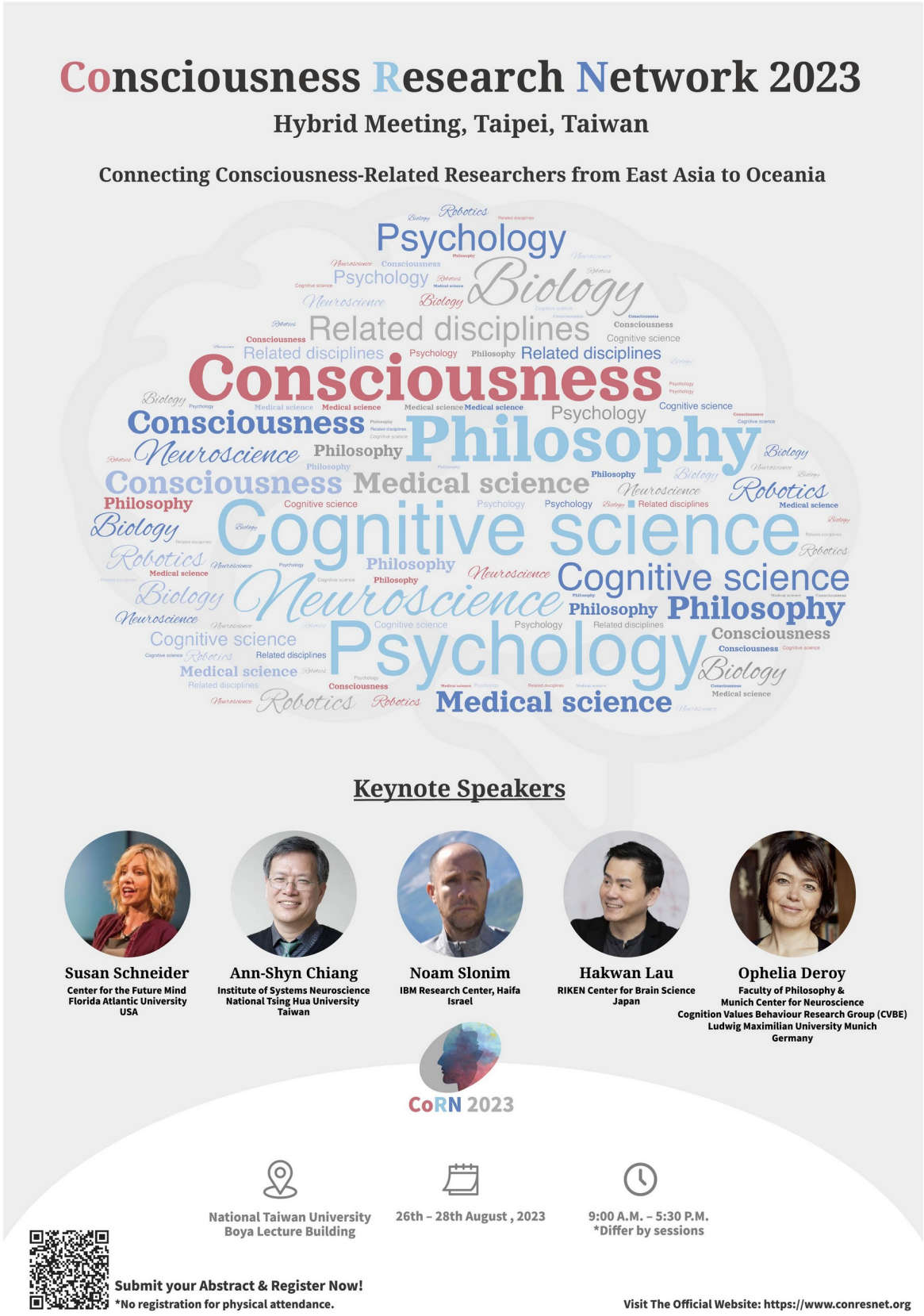
Abstract Book - CoRN 2023



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Talks

Keynotes Speakers

1) Hakwan Lau (RIKEN Center for Brain Science, Japan) - Lateral Prefrontal Mechanisms for Perception and Sentience

Sentience can be defined as qualitative sensory information acquiring an ‘assertoric force’, i.e. an effective epistemic signal that such information reliably reflects the current world. A piece of sensory information can be said to be qualitative when it is presented in a format that makes (implicit) comparisons with other possible sensations inevitable. In this talk I will present new empirical findings from my lab, in order to argue that the human lateral prefrontal cortex (LPFC) contains mechanisms that are essential for sentience, as well as perception in general. Because many animals including rodents lack LPFC homologues, these findings call for some rethinking as to whether subjective experiences are common across mammalian species. I end by speculating how sentience could perhaps be engineered in future artificial neural network models that mimic human LPFC functions.

2) Ann-Shyn Chiang (National Tsing Hua University, Taiwan) - Cracking the Brain Code (破解大腦密碼)

The brain is responsible for controlling all aspects of a person's behavior, from movement and eating to sleeping, emotions, memory, consciousness, and even lifespan. Since the launch of the "Brain Initiative" by the United States in 2013, various countries, including the European Union, Japan, Canada, South Korea, and China, have also introduced their own national brain projects. These massive scientific undertakings aim to decipher the brain's code by deconstructing and reconstructing connectomes, which are the synaptic connections between all neurons in the brain, across various animals such as nematodes, fruit flies, zebrafish, mice, and monkeys. Recent advances in connectomics have led to the development of disruptive technologies and revealed many new principles of information processing in the brain network. In the coming decade, knowledge gained from structural and functional connectomics may provide us with the ability to manipulate specific brain cells, understand the mysteries of emergent properties in neural networks, treat various mental diseases, and even develop Artificial General Intelligence that mimics the brain.

During this lecture, I will share my personal journey in connectomics, including creating the transparent brain, reconstructing the *Drosophila* connectome, localizing genes and proteins in the entire brain, mapping memory engrams, and manipulating behavior. I will also discuss the potential for new industries that brain technology may bring and how we can apply new knowledge in brain science to improve learning efficiency and healthy living.

Key reference

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Short Biography

Ann-Shyn Chiang Received Ph.D. (1990) and trained as a postdoctoral fellow (1992) in Rutgers University, Ann-Shyn Chiang joined Department of Life Science, National Tsing Hua University as an associate professor (1992), promoted as professor (1997), took sabbatical to study *Drosophila* memory at Cold Spring Harbor Laboratory (2001) and became the adjunct International Faculty of Kavli Institute for Brain and Mind (KIBM) at the University of California, San Diego (since 2011). For his contribution to our understanding of memory formation using a connectomics approach, Chiang was elected as an Academician of Academia Sinica (2014) and a fellow of The World Academy of Science (2016).

Chiang invented the world-first hydrophilic tissue clearing technology, reconstructed a brain-wide wiring diagram in *Drosophila* (the New York Times reported this discovery as the first step toward mapping human brain) and published the first *Cell* (2007) paper from Taiwanese scientists. Guiding by this connectomics map, he and his colleagues discovered that long-term memory formation requires new protein synthesis only in few brain neurons and published the first full article in *Science* (2012) from Taiwanese scientists. At his Presidential Special Lecture in the Society for Neuroscience 2016 Annual Meeting, Chiang announced the era toward whole-body connectomics. He received many awards, including: Outstanding Research Award, National Science Council (2004, 2009, 2012); Outstanding Scholar Award, Foundation for the Advancement of Outstanding Scholarship (2007); Academic Award of Ministry of Education (2007); Outstanding Contributions in Science and Technology of Executive Yuan (2008); TWAS Prize in Biology (2012); and National Chair Award of Ministry of Education (2015, 2021).

Chiang is currently the Director of Brain Research Center, the Distinguished Chair Professor of National Tsing Hua University, and the International Fellow of Kavli Institute for Brain and Mind (KIBM) at the University of California, San Diego.

3) Ophelia Deroy (Ludwig Maximilian University, Munich, Germany) - Getting real : How the sense of reality is constructed in perception

The sense of reality plays an important role in deciding whether we are seeing or imagining a rabbit in front of us. But how can we account for cases which are decidedly perceptual, and yet don't feel real enough, for instance in derealisation? What about cases which feel too real, as may happen when we are tired or in awe? This talk addresses the challenge of explaining the sense of reality within perception, which differs from explaining the distinction between imagination and perception. It also explains why multisensory metacognition plays a central role in the conscious feeling of reality in perception, but also why it cannot be sufficient to account for it.

4) Susan Schneider (Center for the Future Mind at Florida Atlantic University) - The AI mega system problem

Abstract: TBD

5) Noam Slonim (IBM Research Center, Haifa, Israel) - Project Debater – Past, Present, and Future

Project Debater is the first AI system that was able to meaningfully debate a human opponent. The system, an IBM Grand Challenge, was designed to build coherent, convincing speeches on its own, as well as provide rebuttals to the opponent's main arguments. In 2019, Project Debater competed against Harish Natarajan, who holds the world record for most debate victories, in an event held in San Francisco that was broadcasted live world-wide. In this talk I will tell the story of Project Debater, present the results of systematic evaluation of the system performance (https://www.nature.com/articles/s41586-021-03215-w), and discuss the relation between this IBM Grand Challenge and recent developments of tools that demonstrate language creativity, such as Chat-GPT.

Short Bio: Noam Slonim is a Distinguished Engineer at IBM Research AI. He received his doctorate from the Interdisciplinary Center for Neural Computation at the Hebrew University and held a post-doc position at the Genomics Institute at Princeton University. Noam joined the IBM Israel Research Lab in 2007, and in 2011 he proposed to develop Project Debater. He has been serving as the Principal Investigator of the project since then, and more recently has been working on utilizing language models in practice, to address large scale text classification problems.

Invited Speakers

1) Lu Teng (NYU, Shanghai, China) - Does Aphantasia Support Unconscious Imagination?

Aphantasia is a condition where subjects are unable to voluntarily create mental imagery in their mind. Recent research employs both subjective and objective measures to verify the lack of such an ability in aphantasics. Intriguingly, compared to non-aphantasics, these subjects can perform mental rotation tasks with similar accuracy and response time. Does this mean that they rely on unconscious imagination? In this talk, I first examine and raise objections to some arguments for unconscious imagination. Then I draw on research on consciousness and metacognition to argue that a negative answer is actually more plausible at this point.

2) Christopher Jude McCarroll - (IPMC, National Yang Ming Chiao Tung University, Taiwan) - Experience, Episodic Memory, and the Epistemic Limits of Imagination

There is a debate about transformative experiences and the epistemic limits of imagination. This is a debate about the ways in which our imaginations might provide, or fail to provide, us with knowledge of what it would be like to have a certain experience before undergoing it. Many claim that some experiences are epistemically transformative: only by consciously experiencing them can we obtain knowledge of what they would be like. We can only gain knowledge of the phenomenal character of the experience by actually having it, and no amount of imagining will enable us to grasp it beforehand. Others think that, for many experiences, imagination might enable us to arrive at knowledge of what the experience would be like before we have had it. This debate crucially hinges on an assumption about episodic memory, however. Both sides of the debate assume that episodic memory retains knowledge of our previous experiences. Yet, this view about episodic memory has recently been

challenged. In this talk, I push back against this challenge about the nature of episodic memory. I suggest that episodic memory does indeed retain knowledge of our previous experiences. I use the debate about the role of experience in gaining new knowledge and the epistemic limits of imagination to shed light on the nature of episodic memory. I suggest that if episodic memory did not provide us experiential knowledge, then the epistemic limits of imagination would be much narrower, and the range of epistemically transformative experiences would be much broader than they in fact are.

Keywords: Episodic memory; Imagination; Experience; Transformative experience; Experiential knowledge

3) Acer Chang (Department of Psychology Rikkyo University, Japan) The sense of agency as active causal inference: How We Comprehend Our Control Over the Environment using Abstract Action Plans

Several aspects of conscious experience can be understood as the results of internal inference processes. As the conscious experience of controlling one's own actions, we asked whether computation of the sense of agency could also be viewed as causal inference. In this study, participants were asked to move a computer mouse freely and determine whether a visual object is controlled by them (control judgment task) or which of three moving objects they are controlling (control detection task). The degree of control and rotation of the motion directions of the objects were manipulated. We showed that the participants formed high-level action policies (plans) to effectively infer their degree of control in the noisy environment. We utilized deep neural networks (transformer-LSTM-based autoencoders) to capture action plans which were idiosyncratic across but stable within individuals. Specifically, we trained the autoencoder with motor sequence data from the control judgment task and tested the generalisation of the trained action plan spaces to the control detection task. We found that the individual behavioural profiles in the two

tasks can be well predicted by the geometrical relationship between the intentional and the presented action plans in the action plan space. Crucially, not only the similarity but also the dynamical similarity of action plans contribute to predictability suggesting that participants assess the effects of interventions on the environment, an essential aspect of causal inference. Our findings demonstrate that the computation of the sense of agency is not simply determined by passive observational inference but involves actively inferring the causal influence of one's own actions on the environment.

4) Ying-Tung Lin - (National Yang Ming Chiao Tung University, Taiwan) - Dimensions of immersion and episodic simulation

The concept of immersion has been used to describe experiences associated with virtual reality, gaming, dreaming, memory, imagination, mind-wandering, etc. (e.g., Gorisse et al., 2017; Liao, manuscript; Schad et al., 2012; Schellenberg, 2013; Windt, 2010). For instance, episodic memory is characterized by mental time travel (Suddendorf & Corballis, 1997; Tulving, 1985) or the ability to “re-experience” past events. During remembering, an episodic simulation of the past world is constructed, and the subject is partially detached from the current environment and becomes immersed in the episodic simulation. Each episode of memory differs in terms of the depth of immersion. Individuals with post-traumatic stress disorder (PTSD) suffer from vivid involuntary intrusive memories of past traumatic events. In the flashbacks, they may lose awareness of the current environment, and the sensory impressions are experienced as if they were features of present surroundings or of what is happening right now (Hackmann et al., 2004).

Despite the widespread use of the concept, what it means remains elusive. This talk aims to examine how the concept is applied and utilized in these contexts and to propose a multi-dimensional framework for immersion.

The framework includes the dimensions of reality opacity, self-presence, cognitive integration, absorption, which jointly constitute a multi-dimensional space in which different forms of immersive experiences are located. These dimensions offer a new perspective on the conditions of immersion: They show how experiences can differ qualitatively respective to immersion. In addition, by analyzing the case of episodic simulation, I argue that there could be tradeoffs between conditions of immersion. The framework not only can be used to understand how phenomenology of memory differs from that of other kinds of experiences such as perception, but also provides us with a way to explore remembering experience as part of the whole experience of the remembering individual.

Keyword: Immersion, Virtual Reality, Episodic Simulation, Mental Time Travel

5) Soon Chun Siong - (National University of Singapore, Singapore) - Brain Signatures around Transitions between States of Consciousness

Human consciousness typically gets turned on and off at least once a day. While EEG has yielded tremendous insights into the electrophysiological structures of sleep, few studies have tried to zoom in on the exact moments when the brain transits between conscious states. In a series of microsleep studies, we combined eyetracking and self-reports to pinpoint the seconds during which the brain loses / regains consciousness, and the concomitant EEG, BOLD and physiological changes around these transitions.

6) Yoshida Masatoshi - (Center for Human Nature, Artificial Intelligence, and Neuroscience (CHAIN), Hokkaido University, Sapporo, Japan) - Aberrant processing of visual salience in schizophrenia

Patients with schizophrenia show a variety of eye movement abnormalities, such as shortened scan paths during free-viewing of natural images. To understand the pathology of schizophrenia, it is necessary to find a link between these behavioral markers and theories about how the symptoms develop. Here, we investigated the relevance of exploratory eye movements as a behavioral marker and the aberrant salience hypothesis of psychosis. Specifically, we examined whether abnormalities in eye movements during free-viewing reflect aberrant processing of visual salience. Analysis of eye movements in 82 participants with schizophrenia and 252 healthy controls showed that the gaze of the participants with schizophrenia was attracted to positions of high visual salience in the image. These results suggest aberrant processing of visual salience in schizophrenia, thereby connecting the dots between abnormalities in early visual processing and the aberrant salience hypothesis of psychosis.

To understand the brain mechanisms of aberrant salience, animal models of schizophrenia need to be established. To this end, subanesthetic doses of ketamine were injected intramuscularly to the common marmosets, New World monkeys, and their eye movements were recorded during free-viewing. Ketamine injection significantly reduced scan paths, reproducing the symptoms seen in schizophrenic subjects. We concluded that ketamine administration is a promising pharmacological model of schizophrenia in the common marmosets. Ongoing studies have shown that ketamine also affects brain activity in the posterior parietal cortex as measured by Ca imaging. This work was funded by AMED (JP19dm0207069) and KAKENHI JP22H02936.

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Keyword: Salience, Schizophrenia, Saccades, Vision, Ketamine

7) Niall Duncan (Taipei Medical University, Taiwan) Thinking about the role of GABA in disorders of consciousness

GABA is the primary inhibitory neurotransmitter in humans and is found across the whole brain. Different lines of evidence suggest that this transmitter system plays a role in the production of consciousness. We might therefore expect to see alterations to GABAergic transmission in patients with disorders of consciousness. In my talk, I will introduce empirical evidence that this is indeed the case. I will also discuss what mechanisms may lie behind an association between GABAergic activity and disruption to consciousness.

8) Hyeong Dong Park - (Taipei Medical University, Taiwan) - Brain-body interactions in perception and action

Do interactions between the brain and body (e.g., heart and lung) play a functional role in human cognition, in particular conscious experiences? This is the central question of my research career. In this talk I will introduce my previous research suggesting that 1) neural responses to heartbeats (i.e., heartbeat-evoked brain potentials) could predict conscious visual perception, using MEG (Park et al. Nature Neuroscience. 2014); 2) experimentally induced changes in self-consciousness are associated with heartbeat evoked brain potentials, using virtual reality technology combined with scalp EEG (Park et al. Journal of Neuroscience. 2016); 3) voluntary action and cortical readiness potentials are coupled with the breathing system (Park et al. Nature Communications. 2020). Then, general implications and potential future projects will be discussed.

Keywords: Brain-body interaction, Heartbeat Evoked Potential, Perceptual Awareness, Bodily Self-Consciousness, Voluntary Action

9) Yee Joon Kim (Center for Cognition and Sociality, Institute for Basic Science (IBS), Daejeon, South Korea) - The influence of subjective visibility on conscious perception: An EEG study

Coauthors - Jisub Bae and Oliver James

Previous attentional blink study demonstrated perceptual integration without conscious access. However, it is unclear how systematically illusory contour perception can occur independently of subjective visibility. We investigated this by generating five types of stimuli consisting of an image with four pacman-shaped inducers: four illusory conditions with inducers configuring isosceles right triangles and a control condition with random inducer orientation, but neither forming triangles nor a square. To influence consciousness, we only manipulated the ISI between target and backward mask with their contrast level fixed. At the end of each trial, participants were instructed to report one of five possible target shapes and then rate its subjective visibility. We recorded participants' 128-channel EEG and divided EEG trials into high-visibility(HV) and low-visibility(LV) groups according to visibility ratings and behavioral performance accuracy. Preliminary Kanizsa vs. control EEG classification analysis showed that perceptual integration emerged transiently around 150ms post-target onset, subsided quickly, and reappeared during a late period from 300 to 800ms post-target onset for HV trials whereas perceptual integration occurred very briefly around 450ms post-target onset for LV trials. The subjective visibility-dependent differential perceptual integration dynamics of the same physical target suggest that brief perceptual integration can still occur through long-range integration during a late period even though masking interferes with local recurrence-based perceptual integration during an early period.

10) Christopher L. Asplund - (Yale-NUS College, National University of Singapore, Singapore) - Somatosensory surprise and the conscious experience of vibration, heat, and pain

Relatively novel or unexpected events can capture attention, often disrupting ongoing tasks. Such disruptions can be profound, with otherwise obvious stimuli failing to be seen or heard. In this talk, I describe my lab's work extending these findings into the somatosensory domain. In a series of experiments, we showed that relatively rare vibrotactile stimuli (termed "surprise" stimuli) could disrupt the discrimination of vibrotactile targets presented 300-600 ms later. Such disruptions occurred even when both vibrations were presented to the same skin location, and they were little affected by low-level features such as stimulus energy. Furthermore, surprise did not cause confusion between similar target options, suggesting that their conscious representations were severely degraded or completely absent. Finally, surprise effects habituated across repeated presentations of the disrupting stimuli. In a follow-up experiment using thermal surprise stimuli, participants rated their subjective surprise for common and rare stimuli. The former were consistently rated as being low in surprise, whereas the latter's initially high ratings habituated across each session. There was an important exception: For rare thermal stimuli that were painful, the subjective surprise ratings did not habituate. Overall, the effects of somatosensory surprise on conscious experience, including the habituation of these effects, are similar to those observed in other sensory modalities. The lack of habituation with painful stimuli, however, may reflect unique features of pain's experience and behavioral relevance.

Keywords: Temporal Attention, Surprise, Capture, Somatosensation, Pain

11) Chuan-Chin Chiao (Department of Life Science, National Tsing Hua University, Taiwan) - Predatory behavior and decision-making in cuttlefish?

Cephalopods including cuttlefish, squids, and octopuses evolved with teleost fishes some 200 million years ago, and they have the most complex brain in invertebrates. Cuttlefish are predatory animals. They constantly search for food

or ambush for prey. Cognitive ability is essential for their preying behavior. In this talk, I will present evidence showing that cuttlefish can count number and their choice of prey depends not only on the quantity but also on the quality. Similar to human economic behavior, cuttlefish's decision-making also involves risk assessment and is dependent on their metabolic states. When they choose between two options, cuttlefish are not always based on the absolute values of the options, but can also depend on their relative values. Furthermore, cuttlefish's foraging strategies are influenced by the previously surprised event and their internal states. They also exhibit a speed-accuracy tradeoff in difficult and ambiguous situations when foraging for prey. All these findings demonstrate that cuttlefish are highly cognitive animals, and there are more to be learned in the future.

12) Vishal Kapoor - (International Center for Primate Brain Research, Center for Excellence in Brain Science and Intelligence Technology, Chinese Academy of Sciences, Shanghai, China) - Conscious perception and the primate prefrontal cortex

The functional role of the prefrontal cortex has been a central debate in the field of consciousness. The focus of this discussion has been, if this region is involved in conscious perception or if prefrontal activity associated with paradigms investigating conscious perception is instead conflated by task-related or post-perceptual cognitive processes associated with reporting perceptual content, e.g. decision-making, motor action. This talk shall present results obtained from experiments, wherein we probed the neurophysiological underpinnings of conscious perception in the prefrontal cortex of non-human primates, while they were engaged in paradigms of conscious perception. We found prefrontal neuronal activity correlated with both exogenously induced and endogenously generated transitions in conscious perception. Moreover, conscious content could be reliably decoded from the activity of prefrontal ensembles in the absence of volitional reports. Interestingly, the neurons displaying activity correlated with conscious content were functionally

segregated from a simultaneously recorded population which displayed trial phase-related activity. Further, the fluctuations in prefrontal state as indicated by the local field potential, are associated with spontaneous changes in conscious perception. Taken together, these results suggest that the dynamics of prefrontal activity reflect perceptual content and transitions of conscious perception.

Keywords: Conscious perception, Prefrontal cortex, Binocular rivalry, Electrophysiology, Decoding

Speakers Based on Accepted Abstract

1) YenTung Lee - (Rotman Institute of Philosophy, Western University, Canada) - Virtual Veridicalism, Cognitive Orientation, and Fregean Representationalism

This paper assesses Chalmers's (2017) defense of virtual veridicalism, the view that many perceptual experiences in virtual reality (VR experiences) are veridical. Chalmers argues that, whereas naïve VR users illusorily perceive virtual things as non-virtual, sophisticated users veridically perceive virtual things as having virtual colors, locations, and shapes because of cognitive orientation: Their knowledge of being in VR orients their perceptual content to represent things as virtual.

First, I argue that cognitive orientation is ambiguous. It can be interpreted as either cognitive penetration (Macpherson, 2012; Siegel, 2012) or perceptual learning (cf. Connolly, 2017, 2019). I argue that both interpretations fail to defend virtual veridicalism: If cognitive orientation is cognitive penetration, users' VR experience cannot be penetrated as Chalmers suggests. If cognitive orientation is perceptual learning, it fails to ground the veridicality of VR experiences, since it at best explains the content's etiology. An independent theory of content that underpins perceptual veridicality is needed.

Second, I argue that Fregean representationalism is the best extant candidate for the underpinning theory of content. Fregean representationalism claims that phenomenal content picks out as extension whatever external property normally causes that content under certain perceptual conditions (Chalmers, 2004, 2006; Thompson, 2009). This allows VR experiences to pick out virtual colors, locations, and shapes as extension. Hence, a VR experience is veridical iff the subject perceives these virtual properties as virtual.

Finally, I argue that Fregean representationalism is insufficient to support virtual veridicalism. While experiences can be systematically veridical in the isolated VR (e.g., the Matrix) under Fregean framework, the veridicality does not hold in the mixed reality, where a particular content may simultaneously

pick out both virtual and non-virtual properties as extension. I conclude that the limitation of Fregean solution is fatal to Chalmers's defense of virtual veridicalism.

2) Yuwei Sun - (The University of Tokyo/RIKEN AIP/Araya, Japan) - Sparse Associative Memory-Enabled Artificial Neural Networks Through the Lens of Global Workspace Theory

Common sense is not just facts but a collection of world models. The global workspace theory demonstrated that in the human brain, multiple neural network models cooperate and compete in solving problems via a shared feature space for common knowledge sharing. Within such a learning framework, using different kinds of metadata about individual modules, as in meta-learning of AI research, shows the potential to learn, select, or combine different learning algorithms to solve a new task efficiently. The problem of uncertainty in the predictions of SOTA artificial neural networks shows that the world is only partially predictable, and a learned model cannot generalize to its ever-changing surrounding environments. We aim to provide a fundamental understanding of learning to learn in the contents of Decentralized and Modular artificial neural networks, and we believe this is one of the most critical questions and prerequisites to building an autonomous intelligence machine. To this end, we shall demonstrate several pieces of evidence for tackling the problems above by incorporating several critical elements, i.e., sparsity, discretization, and attention. We borrow inspiration from neuroscience studies and aim to develop intelligent systems with great generality to uncertainty in real-world tasks based on 1) the implementation of Global Workspaces (GWs) with diverse dimensionalities to balance storage capacity efficiency and obtain rich feature space construction for patterns, 2) Mixture of Experts in the GWs leverage the sparse selection of expert modules and the reuse of their learned patterns, and 3) feature discretization with associative memory using continuous Hopfield networks to associate perturbed memories with attractor states of learned patterns. Our hypothesis is that these constraints would serve

as critical inductive biases to build general intelligence systems in the future. Notably, the sparse architecture would be differentiable, enabling end-to-end training using SOTA deep learning practices such as backpropagation.