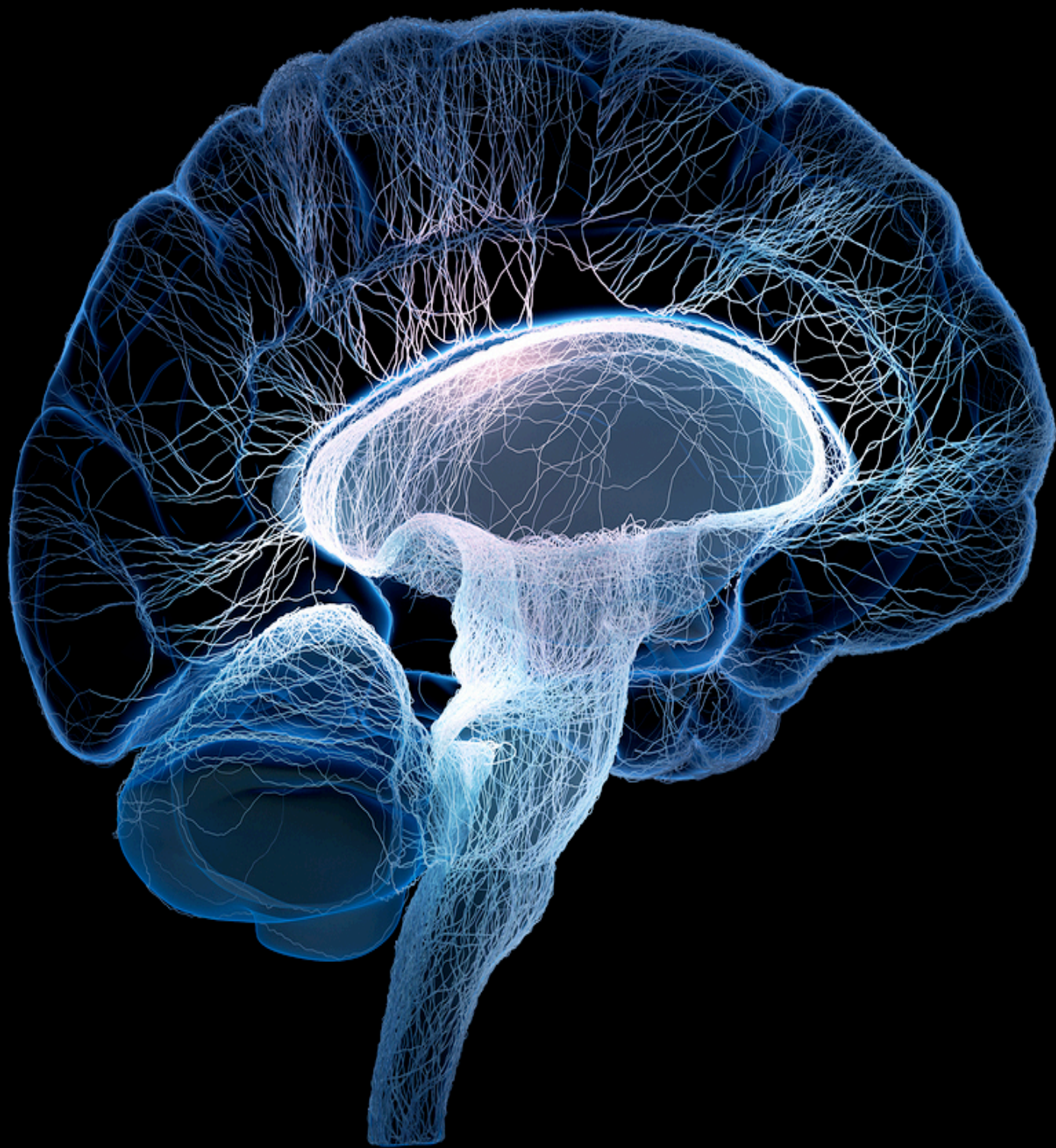


Chinese Computational & Cognitive Neuroscience 2020



中国计算与认知神经科学会议 2020

Chinese Computational and Cognitive Neuroscience Conference 2020

By constructing the mathematical models based on the facts observed in experiments, using simulation and mathematic analysis, computational neuroscience characterizes the neural activity, investigates the neural dynamics underlying the information processing during perception, learning, memorizing, decision making, reasoning, et al. The investigation on the mechanism of information processing bridges the neuroscience and artificial intelligence. The analysis and simulation of cognitive function helps people recover the mechanism underlying the psychiatric disorders.

The aim of Chinese computational and Cognitive Neuroscience (CCCN) Conference is to boost the field of computational neuroscience in China and communication between researcher in the field. CCCN 2019 has been held in Chengdu and hosted by the Key Laboratory for NeuroInformation of Ministry of Education, UESTC(<http://meeting.csn.org.cn/JSRZ/>). CCCN 2020 is hosted by School of Systems Science, State Key Laboratory for Cognitive Neuroscience and Learning, BNU. CCCN 2020 goes to virtual conference due to the Covid-19(<http://meeting.cns.org.cn/2020CCCNC/>).

Organizing Committee

Chair: Xiao-Jing Wang (New York University)

Member: Si Wu (Peking University)

Guoqiang Bi (University of Science and Technology of China)

Douglas Zhou (Shanghai Jiao Tong University)

Doris Tsao (Caltech)

Chengcheng Huang (University of Pittsburgh)

DaHui Wang (Beijing Normal University)

Schedule:

Session	Beijing	Sydney	California	New York	London
I	June 29: 9:00-11:25	June 29: 11:00-13:25	June 28: 18:00-20:25	June 28: 21:00-23:25	June 29: 2:00-4:25
II	June 29: 20:00-23:00	June 29: 22:00-1:00	June 29: 5:00-8:00	June 29: 8:00-11:00	June 29: 13:00-16:00
III	June 30: 9:00-11:30	June 30: 11:00-13:30	June 29: 18:00-20:30	June 29: 21:00-23:30	June 29: 2:00-4:30
IV	June 30: 20:00-23:00	June 30: 22:00-1:00	June 30: 5:00-8:00	June 30: 8:00-11:00	June 30: 13:00-16:00

Session I (Beijing time June 29 AM):

Chair: Douglas Zhou

9:00-9:10:	XiaoJing Wang	Opening speech
9:10-9:55:	Nikolaus Kriegeskorte	Testing deep neural network models of human vision with brain and behavioral data
9:55-10:40	Pulin Gong	Propagating activity patterns in cortical circuits: dynamical properties and computational roles
10:40-11:25	Guoqiang Bi	Multi-scale analyses of neurons: from synaptic proteins to brain-wide circuits

Session II (Beijing time June 29 PM):

Chair: Si Wu

20:00-20:45:	Anna Wang Roe(王菁)	Roadmap to a columnar visual cortical prosthesis
20:45-21:30	MinMin Luo	Reward processing by the Dorsal Raphe
21:30-21:40	Break	
21:40-22:00	WenHao Zhang	A normative theory of how neural circuits perform causal inference in cue integration
22:00-22:20	YunZhe Liu	Prioritizing Replay for Model-based Learning
22:20-23:00	XiaoJing Wang Henry Kennedy GuoQiang Bi Anna Wang Roe(王菁) YuHan Chen	Discussion on large scale brain network

Session III (Beijing time June 30 AM):

Chair: Chengcheng Huang

9:00-9:45:	Keren Haroush	Social representations in the primate brain
9:45-10:30:	Wu Li	Learning-induced changes in visual cortical processing
10:30-10:50	Liang Liang	Organization and modulation of distinct information lines in mouse visual thalamus

10:50-11:10	YuHan Chen	Predicting large-scale primate brain networks and revealing a benefit-risk balancing mechanism in the human brain
11:10-11:30	PengCheng Zhou	Fusing electron microscopy data and calcium imaging data to achieve functional connectomics

Session IV (Beijing time June 30 PM):

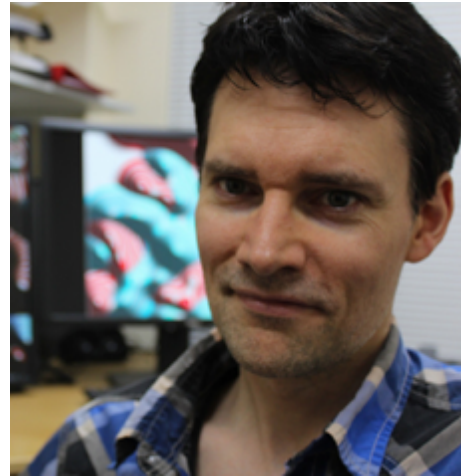
Chair: DaHui Wang

20:00-20:45:	XiaoQin Wang	Computational principles of auditory cortex
20:45-21:30	Brent Doiron	Dimensions of variability in circuit models of cortex
21:30-21:40	Break	
21:40-22:00	Robert Yang	Machine evolution of olfactory systems
22:00-22:20	Yang Zhou	Decision-making across parietal and frontal cortices
22:20-23:00	Nikolaus Kriegeskorte Si Wu Dan Yamins Robert Yang Brent Doiron Chengcheng Huang	Discussion on brain and AI

Abstracts

Prof. Nikolaus Kriegeskorte

Title: Testing deep neural network models of human vision with brain and behavioral data



Abstract: To learn how cognition is implemented in the brain, we must build computational models that can perform cognitive tasks, and test such models with brain and behavioral experiments [1]. Neural network models have enabled major strides in computer vision and other artificial intelligence applications. This brain-inspired technology provides the basis for tomorrow's computational neuroscience [1, 2]. Deep convolutional neural nets trained for visual object recognition have internal representational spaces remarkably similar to those of the human and monkey ventral visual pathway [3]. Functional imaging and invasive neuronal recording provide rich brain-activity measurements in humans and animals, but a challenge is to leverage such data to gain insight into the brain's computational mechanisms. I will discuss statistical inference techniques that enable us to adjudicate among deep neural network models on the basis of brain and behavioral data [4-5]. In order to capture the dynamic computations in biological brains, neural network models need to be recurrent. Recurrent networks can recycle their limited neuronal resources to enhance their performance, trading off speed and energy in exchange for higher accuracy [6, 7, 8]. Recurrent convolutional neural networks also provide better accounts of the dynamics of human ventral-stream visual representations, as measured with magnetoencephalography (MEG) [9]. Finally, I will discuss the method of controversial stimuli [10], which enables us to optimize experiments for adjudicating among computational theories that are implemented in neural network models. Controversial stimuli are stimulus that models disagree over, in terms of their representations or classifications. Human psychophysical experiments with controversial stimuli suggest that generative models might be critical for explaining human perception [10]. Current models still fall short of explaining how humans can so rapidly, robustly, and deeply understand the causes and implications of a visual image. However, the existing tools of measurement and modeling and the emerging methods for testing models with measurements are accelerating progress in cognitive computational neuroscience [1].

[1] Cognitive computational neuroscience. Kriegeskorte N, Douglas PK (2018) *Nature neuroscience* [pdf](#)

[2] Deep neural networks: A new framework for modeling biological vision and brain information processing Kriegeskorte N (2015) *Annual Review of Vision Science* [pdf](#)

[3] Deep Supervised, but Not Unsupervised, Models May Explain IT Cortical Representation Khaligh-Razavi SM, N Kriegeskorte (2014) *PLoS Computational Biology* [pdf](#)

[4] Inferring brain-computational mechanisms with models of activity measurements Kriegeskorte N, Diedrichsen J (2016) *Philosophical Transactions of the Royal Society B* [pdf](#)

- [5] Peeling the Onion of Brain Representations Kriegeskorte N, Diedrichsen J. (2019) *Annual Review of Neuroscience* [pdf](#)
- [6] Recurrent Convolutional Neural Networks: A Better Model of Biological Object Recognition Spoerer CJ, McClure P, Kriegeskorte N (2017) *Frontiers* [pdf](#)
- [7] Recurrent networks can recycle neural resources to flexibly trade speed for accuracy in visual recognition Spoerer CJ, Kietzmann TC, Kriegeskorte N. (2019) *bioRxiv* [pdf](#)
- [8] Going in circles is the way forward: the role of recurrence in visual inference van Bergen RS, Kriegeskorte N (under review) [pdf](#)
- [9] Recurrence required to capture the dynamic computations of the human ventral visual stream Kietzmann TC, Spoerer CJ, Sørensen L, Cichy RM, Hauk O, Kriegeskorte N (2019) *PNAS* [pdf](#)
- [10] Controversial stimuli: pitting neural networks against each other as models of human recognition Golan T, Raju P, Kriegeskorte N (under review) *arXiv* [pdf](#)

Biography: Nikolaus Kriegeskorte is a computational neuroscientist who studies how our brains enable us to see and understand the world around us. He received his PhD in Cognitive Neuroscience from Maastricht University, held postdoctoral positions at the Center for Magnetic Resonance Research at the University of Minnesota and the U.S. National Institute of Mental Health in Bethesda, and was a Programme Leader at the U.K. Medical Research Council Cognition and Brain Sciences Unit at the University of Cambridge. Kriegeskorte is a Professor at Columbia University, affiliated with the Departments of Psychology and Neuroscience. He is a Principal Investigator and Director of Cognitive Imaging at the Zuckerman Mind Brain Behavior Institute at Columbia University. Kriegeskorte is a co-founder of the conference “Cognitive Computational Neuroscience”, which had its inaugural meeting in September 2017 at Columbia University.

Prof. Pulin Gong

Title: Propagating activity patterns in cortical circuits: dynamical properties and computational roles

Abstract: Experimental studies have begun revealing essential properties of the structural connectivity and the spatiotemporal activity dynamics of cortical circuits. To integrate these properties from anatomy and physiology, we develop a novel cortical circuit model that captures a range of realistic features of synaptic connectivity. Based on this circuit model, we reveal a dynamical working regime of the cortex, in which propagating activity patterns with complex spatiotemporal dynamics emerge. Such propagating patterns provide a mechanistic explanation for a great variety of neurophysiological data measured at different neural levels, including balanced excitation and inhibition, variable spiking dynamics and high-frequency oscillations with bursting properties. We develop a fractional diffusion theory to gain a fundamental understanding of how this dynamical regime emerges from cortical circuits. In addition, we demonstrate that propagating activity patterns with complex dynamics provide a framework for understanding the neurophysiological mechanisms of cognitive functions such as attention.



Biography: Dr Pulin Gong is an Associate Professor at The University of Sydney (USyd). He is the Head of the Theoretical and Computational Neuroscience Group. Before joining USyd, he was a staff scientist at RIKEN Brain Science Institute in Japan. Dr Gong is interested in better understanding the self-organizing mechanisms of brain spatiotemporal dynamics and the principles underlying how these dynamics implement neural computation.

Prof. GuoQiang Bi

Title: Multi-scale analyses of neurons: from synaptic proteins to brain-wide circuits

Abstract: To be Determined

Biography: Dr. Bi Guoqiang received his B.S. in physics from Peking University (1989), M.S. in physics from New York University (1991) and Ph.D. in biophysics from University of California at Berkeley (1996). He was postdoctoral fellow at University of California at San Diego (1996-2000). He was appointed as Assistant Professor at the Department of Neurobiology, University of Pittsburgh School



of Medicine in 2000, where he was promoted to Associate Professor with tenure. In 2007, he established the Laboratory of Neurophysics the University of Science and Technology of China, where he is Xinchuang Professor and Changjiang Scholar. Dr. BI was recipient of Burroughs Wellcome Fund Career Award in the Biomedical Sciences (2000), University of Pittsburgh Chancellor's Distinguished Research Award (2006), National Outstanding Young Scientist Award (2007). He has served as Chair of the Department of Neurobiology and Biophysics at USTC, and founding co-Director of the Center for Integrative Imaging at Hefei National Laboratory for Physical Sciences at the Microscale. He is also Council Member of the Biophysical Society of China (BSC) and the Chinese Neuroscience Society (CNS), and Executive member of Biomedical Photonics Committee of the Chinese Optical Society. He was the chief scientist of the 973 project "Neural Developmental Basis of Depression and Alzheimer 's Disease", head of the "Key Technology" project in the CAS Strategic Priority Research Program "Mapping of Brain Functional Connectivity", and head of the MOST Innovation Team "Neural Circuitry Basis of Brain Diseases". He has proposed well-known spiking timing dependent plasticity and now he is interested in understanding the biophysical rules and mechanisms underlying the structure, dynamics and functioning of neuronal synapses and circuits, also developing cutting-edge photonics and imaging tools.

Prof. Anna Wang Roe (王菁)

Title: A roadmap to a columnar visual cortical prosthesis

Abstract: Visual blindness affects many millions globally and severely impacts quality of life. One approach to overcome visual blindness is the direct electrical microstimulation of brain circuits normally engaged in visual function. Attempts to do so with traditional brain-machine interfaces (BMI) in monkeys and humans have evoked percepts (phosphenes) described as crude featureless spots of light. Here, we propose to qualitatively enhance these percepts by recruiting units of cortical representation (cortical columns) which encode rich visual features such as color, motion, shape, and faces. A three step roadmap is proposed comprising: (1) the mapping of columnar connectomes, (2) connectome-guided studies of circuitry and perception, and (3) column-targeted design of optical BMIs. We predict this approach will increase the specificity and sophistication needed for realistic, vibrant visual perception.



Biography: Dr. Roe is the Director of the Interdisciplinary Institute of Neuroscience and Technology at Zhejiang University (ZIINT), which she established in 2014. She is known for her studies in visual and somatosensory processing in primate cerebral cortex. She obtained her B.A. degree in from Harvard University (1984) and her Ph.D. from MIT (1991). Her doctoral work on the 'rewired ferret' preparation is a well-known paradigm for studying brain development and plasticity. In 1991, she joined the group of Torsten Wiesel at Rockefeller University. There, under the mentorship of Dr. Daniel Ts'o, she used intrinsic signal optical imaging methods to examine the functional organization of primary and second visual cortical areas in the primate (1991-1993) and continued these studies at Baylor College of Medicine (1993-1995). In 1996, she pursued studies in the marmoset and flying fox as a visiting scholar at the University of Queensland in Brisbane, Australia. In 1996, she began her first faculty position in the Department of Neurobiology at Yale University School of Medicine. From 2003-2015, she was a Professor of Psychology, Radiology, and Biomedical Engineering at Vanderbilt University. In recognition for her contributions in science, she was elected AAAS Fellow in 2016.

Prof. Minmin Luo

Title: Reward processing by the Dorsal Raphe

Abstract: Reward motivates animal behaviors, produces the feelings of pleasure, and guides learning and memory formation. The brain reward system – a group of interconnected brain structures – participates in various aspects of reward processing and its malfunctions are associated with numerous psychiatric disorders. Although dopamine neurons in the midbrain ventral tegmental area (VTA) receive much focus, whether and how neurons in the dorsal raphe nucleus (DRN) contribute to reward processing remain controversial. The DRN represents the major source of serotonin in the forebrain and contains also glutamate, GABA, and dopamine neurons. Here I will summarize recent evidences indicating that the DRN contributes to reward processing in a cell type-specific manner. First, I will present optogenetic studies indicating that DRN neurons produce reward signals through the release of serotonin and glutamate. Second, physiological recordings reveal that DRN serotonin neurons positively encode a wide range of reward signals and drugs of abuse that are associated with pleasure. Our recordings suggest that DRN serotonin neurons encode beneficialness signals and may be important for reward belief. The beneficialness model of serotonin contrast with VTA dopamine neurons that encode reward prediction error and crucially organize reward seeking and reinforcement learning. Finally, I will present more recent data indicating that DRN dopamine neurons encode saliency and play an important role in memory expression. Therefore, the DRN contributes to various aspects of reward processing through different neuron types associated with distinct neurotransmitter phenotypes.

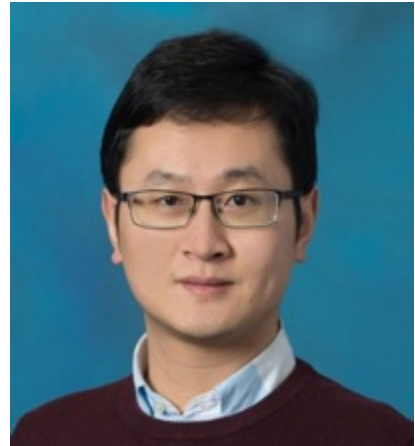


Biography: Dr. Luo is the Director and distinguished investigator of Chinese Institute for Brain Research, Beijing, Professor of School of Life Science, Tsinghua University, and Professor of National Institute of Biological Science. He focusses on the functions and mechanism of the brain 5-HT neurons in the dorsal raphe and the neural pathway from the medial habenula to the interpeduncular nucleus. His research aims to understand the basic neural circuits that control reward and punishment related behaviours, and also contribute to clinical treatment. He received B.S. from Peking University 1995, PhD in Neuroscience from University of Pennsylvania 2000.

Dr. WenHao Zhang

Title: A normative theory of how neural circuits perform causal inference in cue integration

Abstract: Causal inference is important in cognition and perception. In perceptual inference such as cue integration, the nervous system needs to infer the underlying causal structures of whether the cues are from the same or different sources, and based on which to choose whether to integrate or segregate inputs from different sensory modalities. It is still an open question in computational neuroscience that how neural circuits implement the causal inference. To shed light to this question, we consider the causal inference in multisensory processing and propose a novel generative model based on neural population code which takes into account both stimulus feature and stimulus strength in the inference. In the case of circular variables such as heading direction, our normative theory yields an analytical solution with a clear geometric interpretation, and can be implemented by simple additive mechanisms in neural population code. Numerical simulation shows that the tunings of the neurons inferring the causal structure are consistent with the "opposite neurons" discovered in dorsal medial superior temporal (MSTd) and the ventral intraparietal (VIP) areas for visual-vestibular processing. This study illuminates a potential neural mechanism for causal inference in the brain.



Biography: Wenhao Zhang is a postdoc studying theoretical neuroscience with Prof. Brent Doiron at the University of Pittsburgh. Before that, he did his postdoc with Prof. Tai Sing Lee at Carnegie Mellon University (2016-2017), and obtained his PhD with Prof. Si Wu at the Institute of Neuroscience, Chinese Academy of Sciences on 2016. His recent research focuses on how neural circuits perform probabilistic inference, aiming to link abstract normative theories with concrete cortical circuits.

Dr. YunZhe Liu

Title: Prioritizing Replay for Model-based Learning

Abstract: Humans can learn, not only from direct trial and error but also based on a model of the world, i.e., a relational structure between elements of the task. This ability to learn based on a world model is termed "model-based" learning. It is unknown how such learning is achieved in the brain.

Here, taking advantage of a new method advance in measuring sequential replay noninvasively in the human brain, we probed the role of replay in model-based learning using MEG. We found, after reward receipt, the sequential replay is facilitating model-based learning through non-local backups, with a state-to-state time lag of 160 ms. It is in a backward direction and prioritized for more policy informative experience so that optimal policy can be learnt faster. On the other hand, a faster forward replay with 30 ms time lag is also identified, but it is dominantly for local experiences, paired with ripple frequency (120-160 Hz) power increase, and independent from the learning process. No results were found with only reactivation. Together, our findings reveal a distinct on-task replay sequence, prioritized for the model-based learning and suggest sequences as a fundamental principle of neural computation.

Biography: Yunzhe Liu is a PhD student at the Wellcome Centre for Human Neuroimaging and Max Planck UCL Centre for Computational Psychiatry. His PhD work focuses on the neuro-computational mechanism of abstraction and inference in the human brain. His research combines quantitative human behaviours with non-invasive neuroimaging (fMRI and MEG), computational modelling, and theoretical investigation of reinforcement learning based agent model. His supervisors are Profs. Ray Dolan and Tim Behrens.



Prof. Keren Haroush

Title: Social representations in the primate brain



Abstract: A cornerstone of human interaction is the ability to build internal models of other individuals in our environment, based on our past interactions, which in turn enable assessing and predicting another individual's current hidden state of mind, for example, what other individuals are thinking or feeling. Such predictions are key for successful social engagement, mutual reciprocity and cooperative behavior, the glue that holds together our societies. Yet, despite their importance, how social prediction computations are implemented at the single-neuronal and population level, and their causal underpinnings have remained a mystery. This presents a major roadblock to the development of neural circuit-based therapies for an array of neurological and psychiatric disorders in which social interaction deficits are a debilitating factor. Key to our unique approach for rendering the complex psychological problem of predicting another's hidden state of mind a biologically tractable question is using game theory to provide a mathematically driven, well-controlled encapsulation of real-world interactions. Specifically, we adapted the canonical iterated Prisoner's Dilemma (iPD) game in which each agent can choose to cooperate or defect on each trial. Critically, as one's outcome depends on the other's decision in a series of repeating encounters, anticipating the other's intention and upcoming choice is key to one's success. Temporal separation between a monkey's choice, the time the opponent's decision was revealed, and delivery of reward, allowed to explicitly dissect the neuronal signals that predict the other's yet unknown decision from one's own concurrent choice, while dissociating past responses, social context, reward expectancy and outcome. Using this approach, we discovered that monkeys play similarly to humans, using mixed strategies, and identified a previously unknown class of "other-predictive" neurons in the dorsal Anterior Cingulate Cortex (dACC), that signal the opponent's choice well before the other's decision. These neurons distinguish between self and other agency and are modulated by social context, likely constituting a key circuit component for social prediction. Disruption of dACC activity using microstimulation selectively biased mutually beneficial interactions but, surprisingly, had no effect on their decisions when no net-positive outcome was possible. These results indicate that the cingulate plays an important role in guiding animals' behavior in social context. To complement our non-human primate results, we investigate the representation of the other in humans. We will discuss our work recording single neuronal activity in intraoperative patients and using deep brain stimulation to further dissect how interconnected brain regions such as the dorsolateral prefrontal cortex and the periaqueductal gray take part in building the internal subjective representation of other agents. Together, this body of work begins to delineate the brain-wide neuronal foundation of social prediction.

Biography: Keren Haroush is an assistant professor of Neurobiology at Stanford and an affiliate faculty of the Wu Tsai Neurosciences Institute, Bio-X, and the Maternal & Child Health Research Institute. Her lab is interested in understanding the neural circuits underlying dynamic social interactions. Keren received her Ph.D. in Neurobiology at the Hebrew University in 2011, advised by Shaul Hochstein, and obtained her postdoctoral training at Harvard Medical School,

Massachusetts General Hospital, with Ziv Williams. Her research has been recognized with the Society for Neuroscience's Peter and Patricia Gruber International Research Award, SFARI Bridge to Independence Award, NARSAD Young Investigator Grant, Whitehall Foundation Research Grant and a Sloan Fellowship.

Prof. Wu Li

Title: Learning-induced changes in visual cortical processing

Abstract: The brain and its inherent functions are subject to modifications by various forms learning. Learning-induced changes are seen even in basic perceptual functions. In particular, repeated practice of a perceptual task can lead to a significant improvement in the trained task—a phenomenon known as perceptual learning whose neural substrates remain elusive. Our studies in awake monkeys have shown that extended training in visual detection tasks can induce adaptive changes in the primary visual cortex (area V1), allowing V1 neurons to generate a more informative representation of the trained stimulus, which in turn contributes to a more efficient and less effortful readout at subsequent processing stages. The learning-induced changes in V1 are mainly seen in the late component of neuronal responses to the trained stimuli, suggesting an important role of top-down feedback modulation in perceptual learning. While extensive detection training has little effect on early feedforward processing, visual fear learning—the acquisition of aversive emotion and memory associated with a visual stimulus—can rapidly and specifically modify the early component of V1 responses, implicating a change in the feedforward process for proactive tagging of visual inputs that are predictive of imminent threat. Our studies indicate that the response properties of V1 neurons are highly pliable, subject to modifications by training and prior experience, and that the output visual signals from V1 also convey behavior- and emotion-relevant information.



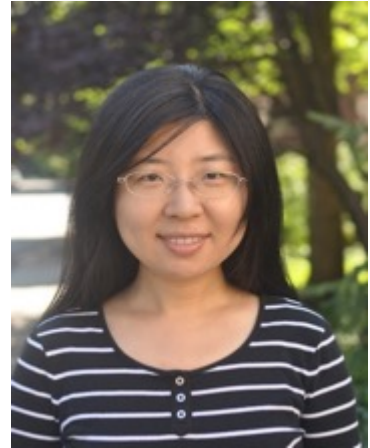
Biography: Wu Li is professor and director of the IDG/McGovern Institute for Brain Research at Beijing Normal University, and director of the State Key Laboratory of Cognitive Neuroscience and Learning. He received the bachelor's degree (1989) in biophysics from University of Science and Technology of China, and the PhD degree (1994) in neurobiology from Shanghai Institute of Physiology, Chinese Academy of Sciences. He had his postdoctoral training (1994-1996) on visual psychophysics at University of California, Berkeley. After that he brought together psychophysical and neurophysiological approaches in awake monkeys to explore the cortical mechanisms of visual information processing, first in Max Planck Institute for Biological Cybernetics (1996-1999) and then at the Rockefeller University (1999-2007). He joined Beijing Normal University in 2007. Wu Li's research work focuses on how image components are grouped and segmented in the cortical circuitry to form coherent percepts; how the cortical processes are reshaped by training and experience to enhance perceptual abilities; and how non-sensory factors (e.g. attention and emotion) modulate visual cortical processing according to behavioral context.

Prof. Liang Liang

Title: Organization and modulation of distinct information lines in mouse visual thalamus

Abstract: Visual information is parsed into specific features and encoded in diverse types of retinal ganglion cells (RGCs) in the eye. Many of these RGCs project to the visual thalamus, the primary relay station in the image-forming pathway, and form connections with thalamocortical neurons. Yet it was unclear how distinct lines of information converge and diverge across retinthalamic synapses, and whether visual signals are already influenced by behavioral states before reaching thalamic neurons.

Using a chronic, deep-brain, high-resolution two-photon imaging platform to simultaneously record neural activity from large numbers of individual retinthalamic axonal boutons in awake behaving mice, I investigated the fine-scale functional organization and arousal-dependent gating of these distinct information lines. I discovered that retinal boutons from different axons but localized in close proximity to each other have similar preferences for one visual feature but can exhibit different preferences for other features. Individual retinal axons often diverge to innervate multiple distinct bouton clusters specialized for one or another visual feature, thus extracting multiplexed information into specific and often novel output channels. My recent work further demonstrated robust arousal-dependent modulation on the visual responses in retinal axons, in a manner that differs across functionally distinct subsets of boutons. These results point to a surprisingly exquisite functional organization of retinogeniculate synapses, and an efficient and dynamic state-dependent modulation mechanism for filtering out specific information channels at the early stage of visual processing.



Biography: Dr. Liang is an Assistant Professor in the Department of Neuroscience at Yale University. She grew up in Dalian, China, and received her B.S. in mathematics and physics from Tsinghua University in China. She then moved to the United States and obtained her M.S. and Ph.D. in Applied Physics at Stanford University under the supervision of Drs. Liqun Luo and Mark Schnitzer. She was supported by a Stanford Graduate Fellowship and a Lubert Stryer Stanford Interdisciplinary Graduate Fellowship. Liang completed her postdoctoral training at Harvard Medical School in the groups of Drs. Chinfei Chen and Mark Andermann, where she was supported by a Simons Collaboration on the Global Brain postdoctoral fellowship. Dr. Liang started her own lab at Yale in January, 2020. Together with her postdoctoral fellows and graduate students, Dr. Liang seeks to systematically understand how visual information is represented, modulated and integrated in the thalamic circuit, and how neural computation happening in the thalamus underlies visual perception.

Dr. YuHan Chen

Title: Predicting large-scale primate brain networks and revealing a Benefit-Risk Balancing Mechanism in the Human Brain

Abstract: As a substrate for function, large-scale brain structural networks are crucial for fundamental and systems-level understanding of primate brains. However, it is challenging to acquire a complete primate whole-brain structural connectome due to experimental limitations. Here, we predicted the missing information for the macaque tract-tracing network and human structural network from imaging data, respectively. First, we acquired a weighted brain structural network across 91 cortical regions of a whole macaque brain hemisphere with a connectivity density of 59% by predicting missing links from the CoCoMac-based binary network with a low density of 26.3%. The prediction model combines three factors, including spatial proximity, topological similarity, and cytoarchitectural similarity—to predict missing links and assign connection weights. Interestingly, the areas that act as integrators linking the segregated modules are mainly distributed in the frontoparietal network and correspond to regions with large wiring costs in the predicted weighted network for the macaque brain. For the human brain, we proposed a weighted regional distance-dependent model to estimate the total length of the axonal projections of a given brain node as a measure of regional wiring length. This model has been validated in a macaque connectome derived from tract-tracing data, and shows a high correspondence between experimental and estimated axonal lengths. When applied to the human connectome from diffusion MRI data, we find significant associations between the estimated wiring lengths and the important metabolism of aerobic glycolysis (AG), that is seen in PET data, with higher levels primarily located in the default-mode and prefrontal regions. Our results suggest that high-AG regions have expensive but still highly optimized wiring cost to fulfil metabolic requirements and simultaneously avoid excessive vulnerability, thus revealing a benefit-risk balancing mechanism in the human brain. Predicting the whole-brain structural connectome of the large-scale primate brain would boost further exploration of relationships between structure, function, and metabolism in the primate brain.



Biography: Dr. Yuhuan Chen is currently assistant researcher of state key laboratory for cognitive neuroscience and learning, Beijing Normal University. She received her PhD from Hong Kong Baptist University 2013 and BS from University of Science and technology of China 2006. Her research focus on the nonlinear analysis of neural activity and brain connectome.

Dr. PengCheng Zhou

Title: Fusing electron microscopy data and calcium imaging data to achieve functional connectomics

Abstract: Combining two-photon calcium imaging (2PCI) and electron microscopy (EM) provides arguably the most powerful current approach for connecting function to structure in neural circuits. Recent years have seen dramatic advances in obtaining and processing CI and EM data separately. In addition, several joint CI-EM datasets (in which CI was performed in intact tissue, followed by EM reconstruction of the same volume) have been collected. However, no automated analysis tools yet exist that can match each signal extracted from the CI data to a cell segment extracted from EM; previous efforts have been largely manual and focused on analyzing calcium activity in cell bodies, neglecting potentially rich functional information from axons and dendrites. There are two major roadblocks to solving this matching problem: first, dense EM reconstruction extracts orders of magnitude more segments than are visible in the corresponding CI field of view, and second, due to optical constraints and noisy expression of the calcium indicator in each cell, direct matching of EM and CI spatial components is nontrivial.



In this work we develop a pipeline for fusing CI and densely-reconstructed EM data. We model the observed CI data using a constrained nonnegative matrix factorization (CNMF) framework, in which segments extracted from the EM reconstruction serve to initialize and constrain the spatial components of the matrix factorization. We apply this model to joint CI-EM data from mouse visual cortex and recover hundreds of dendritic components from the CI data (outnumbering somatic components by about 5x), visible across multiple functional scans at different depths, matched with densely-reconstructed three-dimensional neural segments recovered from the EM volume. We use the resulting database to train a stand-alone neural network module to denoise spatial components estimated from 2PCI data.

Biography: Pengcheng Zhou is currently a postdoc in the Department of Statistics and Center for Theoretical Neuroscience at Columbia University, working with Liam Paninski. Previously, he received his Doctor degree in Neural Computation and Machine learning under the supervision of Robert Kass at Carnegie Mellon University. His research lies at the intersection of computational neuroscience and machine learning, focusing on the applications of quantitative approaches to the study of the brain. His current project is to develop new methods for analyzing large-scale multi neuronal recordings, with an emphasis on calcium imaging data.

Prof. Xiaoqin Wang

Title: Computational Principles of Auditory Cortex

Abstract: Auditory cortex is located at the top of a hierarchical processing pathway in the brain that encodes acoustic information. This brain region is crucial for speech and music perception and vocal production. Auditory cortex has long been considered a difficult brain region to study and remained one of less understood sensory cortices. Studies have shown that neural computation in auditory cortex is highly nonlinear. In contrast to other sensory systems, the auditory system has a longer pathway between sensory receptors and the cerebral cortex. This unique organization reflects the needs of the auditory system to process time-varying and spectrally overlapping acoustic signals entering the ears from all spatial directions at any given time. Unlike visual or somatosensory cortices, auditory cortex must also process and differentiate sounds that are externally generated or self-produced (during speaking). Neural representations of acoustic information in auditory cortex are shaped by auditory feedback and vocal control signals during speaking. Our laboratory has developed a unique and highly vocal non-human primate model (the common marmoset) and quantitative tools to study neural mechanisms underlying audition and vocal communication.



Biography: Xiaoqin Wang is a professor of biomedical engineering, neuroscience and otolaryngology at the Johns Hopkins University School of Medicine. He received B.S. degree in electrical engineering from Sichuan University (China) in 1984, MS degree in electrical engineering and computer science from University of Michigan in 1986 and Ph.D. degree in biomedical engineering from Johns Hopkins University in 1991, and conducted postdoctoral research in University of California at San Francisco between 1991-1995. He joined the faculty of Biomedical Engineering Department at Johns Hopkins University in 1995 as an assistant professor and was promoted to full professor in 2005. He was the recipient of US Presidential Early Career Award for Scientists and Engineers in 1999. Dr. Wang's research is in the areas of auditory neuroscience and neural engineering. His work has focused on the understanding of the structure and functions of the auditory cortex and the neural basis of vocal communication. His laboratory has pioneered a unique animal model, a highly vocal New World primate, the common marmoset (*Callithrix jacchus*), for auditory neuroscience. Using this model system, his laboratory has systematically studied neural coding properties of the auditory cortex in awake and behaving conditions and revealed specialized cortical representations of complex sound features such as pitch and harmonicity. His laboratory has also discovered neural mechanisms involved in vocal feedback control and self-monitoring during speaking.

Prof. Brent Doiron

Title: Dimensions of variability in circuit models of cortex

Abstract: An unavoidable reality of cortical response is the sizable dynamic and trial-to-trial variability of neuronal spiking activity. Circuit models with strong excitation that is balanced by strong inhibition have long been known to successfully model key aspects of single neuron variability. However, over the last decade population recordings from varied cortical areas now show that response variability is shared across a population. I will outline a general theoretical program that aims to uncover how structured circuit wiring in balanced networks creates rich population-wide variability. In particular, I will focus on how the dimension of variability (i.e how many latent variables are needed to explain population covariance) is determined by nonlinear recurrent dynamics in structured balanced networks. Our modelling efforts are guided by close collaborations with experimental groups recording distributed neuronal activity along the visual pathway.

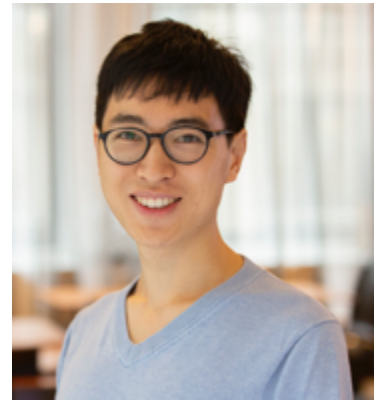


Biography: Brent Doiron received his PhD in Physics in 2004 from the University of Ottawa, where he modelled neuronal activity in the electrosensory system. After he completed postdoctoral studies at New York University in 2007 he began his professorship in the Mathematics Department at the University Pittsburgh. He was promoted to full professor in 2017. In July of 2020 he moved his research group to the University of Chicago where he is the inaugural director for the Grossman center for neuroscience, quantitative biology, and human behavior. Dr. Doiron's research focuses on circuit mechanics or varied sensory systems. He uses techniques from nonlinear dynamics, statistical mechanics, and information theory to uncover how the synaptic wiring of neuronal networks supports population activity and how that activity subtends neuronal computation.

Dr. Guangyu Robert Yang

Title: Machine evolution of olfactory systems

Abstract: Flies and mice are separated by 600 million years of evolution yet they have evolved olfactory systems that share many anatomic and functional features. The similarity of the olfactory systems in evolutionarily distant organisms may reflect a common drive to enable rapid learning of novel olfactory associations and to elicit innate behavioral responses to salient odors. We asked whether networks constructed by the machine learning to perform olfactory tasks converge on the same structural organization as these natural olfactory systems. Artificial network trained to classify odor identity recapitulate structural principles inherent in the olfactory system, including input units driven by a single receptor type, the convergence of similarly responding input units onto 'glomeruli', and sparse unstructured connectivity to a large third-layer representation.



Biography: Guangyu Robert Yang (杨光宇) is a postdoctoral research scientist at the Center for Theoretical Neuroscience at Columbia University and a junior fellow at the Simons Society of Fellows. He is advised by Larry Abbott. He obtained his PhD from New York University, advised by Xiao-Jing Wang.

Dr. Yang Zhou

Title: Decision-making Across Parietal and Frontal Cortices

Abstract: Decision-making is a fundamental cognitive process underlying our daily life. Previous neurophysiological studies in behaving monkeys have suggested that the frontal-parietal cortices are involved in mediating decision-making. However, the particular roles of different frontal-parietal cortical areas during the decision process are still unclear. Here, we recorded and reversibly inactivated neural activity from several posterior parietal and prefrontal areas while monkeys performed different decision tasks. We found that the lateral intraparietal cortex plays a causal role during the sensorimotor decision-making, with preferential involvement in evaluating sensory stimuli compared to motor planning. Furthermore, we found that the prefrontal cortex leads the abstract decision process relying on nonlinear neuronal integration of sensory and mnemonic information in a sequential decision task. These results illuminate the differential and distributed roles of frontal-parietal network nodes in the decision process and suggest that decisions emerge through a distributed consensus across many levels of representation.



Biography: Yang Zhou is currently research Professional specialist, Department of Neurobiology, The University of Chicago. Previously, he was a postdoc scholar at Department of Neurobiology, the university of Chicago from 2016.3 to 2020.1 and postdoc fellow at State Key Lab of Cognitive Neuroscience & Learning, Beijing Normal University from 2013.9 to 2016.2. He has received his PhD from Institute of Neuroscience, Chinese Academy of Sciences in 2013.

Hosting Organization:

School of Systems Science, Beijing Normal University

The school (<https://sss.bnu.edu.cn/>) works on the fundamental theory of complex system and the principles of specific complex system such as Socioeconomical system, Geo-environmental system, Atmosphere and climate system, Collective behavior in artificial and life system, Brain system. The school is a national pioneer of Systems Science research and education, and aims to be an internationally excellent base for complex scientific research and talents-training.



State Key Laboratory of Cognitive Neuroscience and Learning, Beijing Normal University

The State Key Laboratory of Cognitive Neuroscience and Learning at Beijing Normal University (<http://brain.bnu.edu.cn/>) was established in 2005. Its mission is to understand how the brain learns and develops so as to promote children's education and development and to alleviate the suffering of children with cognitive and other developmental disorders. It is currently the only national key laboratory in China that aims to bridge neuroscience, psychology, and education.

The Key Lab has been focusing on the following lines of research: 1) the neurocognitive mechanisms of human behaviors; 2) the development of human brain and cognition; 3) the neurocognitive mechanisms of language, mathematics and music learning as well as related learning disorders; 4) the neurocognitive mechanisms and interventions of emotional and behavioral disorders among children and adolescents.

The Key Lab has established a strong research team with cross-disciplinary background such as neurobiology, psychology, education, computer science and medicine. Correspondingly, the research methods cover multiple levels, ranging from molecular genetics to non-invasive functional brain imaging and behavior, using different types of brain models such as mice, monkeys and humans. During the past 15 years, the Key Lab has become a key innovation hub for brain and cognitive sciences in China.

