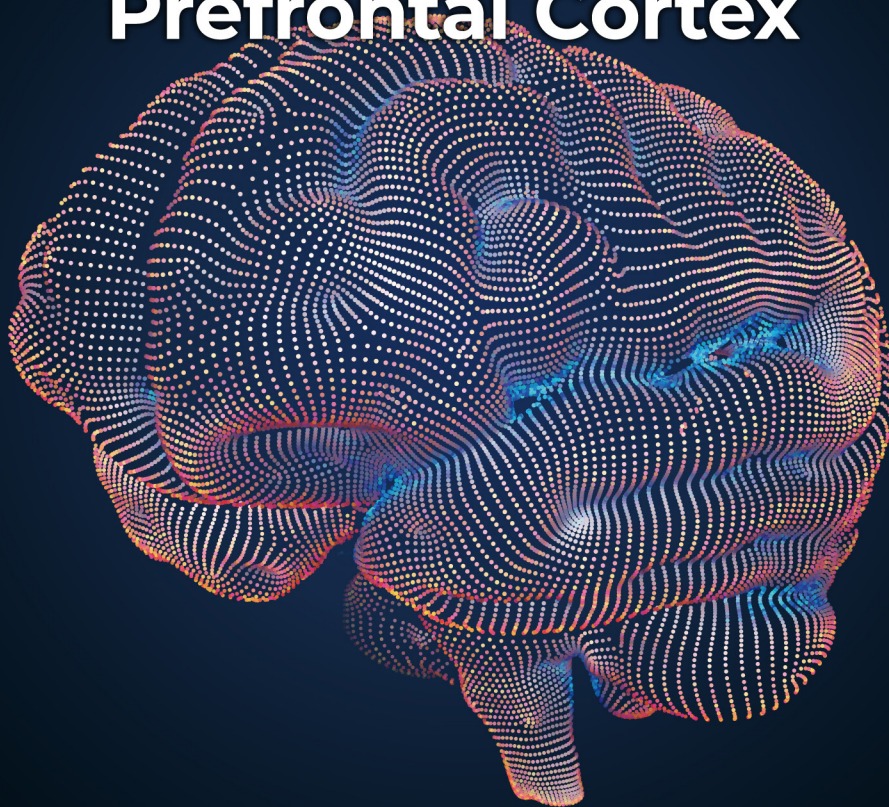


ABSTRACTS



IBS Conference on
**Neuronal and
Glial Functions**

TOPIC
Prefrontal Cortex



OCTOBER 23^{THU}-24^{FRI}, 2025

Auditorium, Natural Science Campus,
Sungkyunkwan University, Suwon, Korea

Contents

PROGRAM	02
SESSION 1: Cortical Waves	03
SESSION 2: Stress and the Prefrontal Cortex	12
SESSION 3: Rodent Prefrontal Cortex	21

Program

DAY 1, October 23 (Thu.)

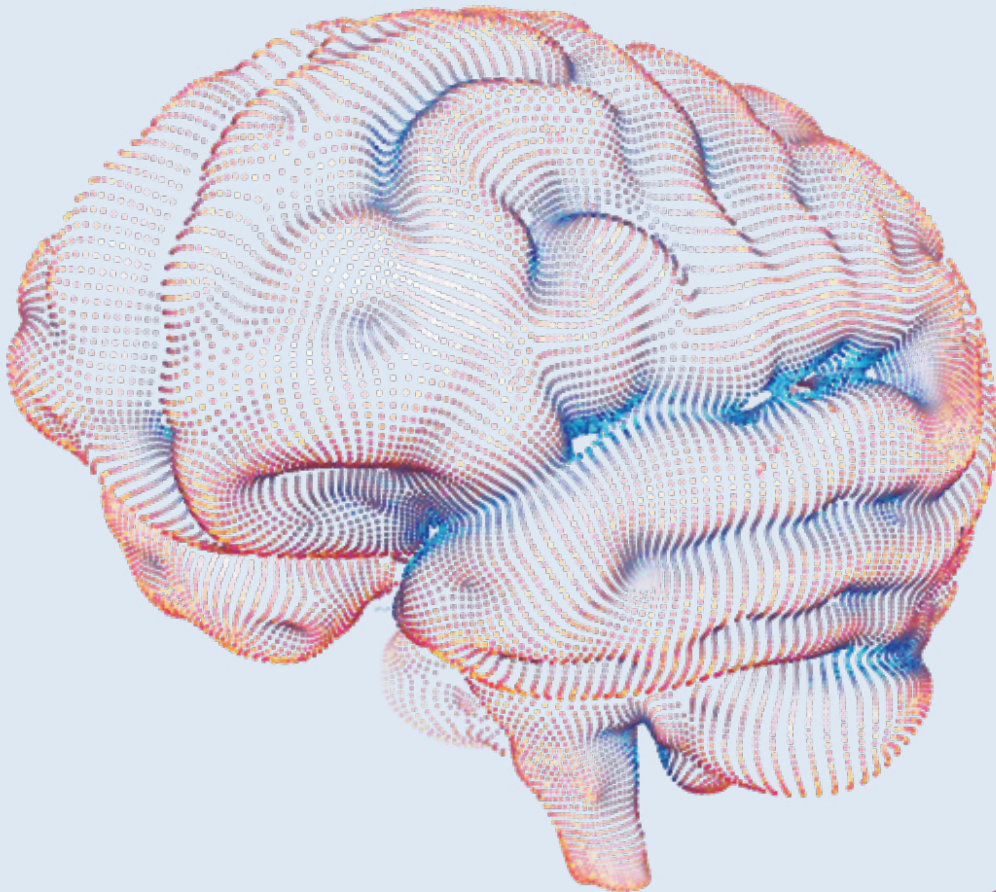
09:30 - 10:00	Registration	
10:00 - 10:10	Opening, Director Hakwan Lau	
SESSION 1	Cortical Waves	Chair: Hakwan Lau (IBS CNIR)
10:10 - 10:55	Lyle Muller (Western University, Canada) Neural traveling waves shape dynamics and computation in sensory and cognitive processing	Plenary Lecture 1
10:55 - 11:10	Coffee Break	
11:10 - 11:35	Laura Dugué (Université Paris Cité & CNRS) Traveling waves in the human brain	
11:35 - 12:00	Seok-Jun Hong (IBS CNIR) The Many Faces of Brain Functional Dynamics: Long-Range Connectome and Cortical Waves	
12:00 - 12:25	Taro Toyozumi (RIKEN Center for Brain Science) Modeling computation and learning with brain waves	
12:30 - 14:00	Lunch	
SESSION 2	Stress and the Prefrontal Cortex	Chair: Bong-Kiun Kaang (IBS CMG)
14:00 - 14:45	J. John Mann (Columbia University) Neuroinflammation, Recent Life Stress and Depression and Suicidal Psychopathology	Plenary Lecture 2
14:45 - 15:00	Coffee Break	
15:00 - 15:25	Rosemary Bagot (McGill University) A novel regulator of stress resilience in the prefrontal cortex	
15:25 - 15:50	Min Soo Kim (KIST) Reversal of suicide-like behaviors in a social defeated stress model	
15:50 - 16:15	C. Justin Lee (IBS CMG) Astrocytic gamma-aminobutyric acid dysregulation as a therapeutic target for posttraumatic stress disorder	
16:15 - 17:15	Poster Reception	
17:15 - 18:00	N Center Tour	

DAY 2, October 24 (Fri.)

SESSION 3	Rodent Prefrontal Cortex	Chair: Min W. Jung & Seung-Hee Lee (IBS CSBD)
09:30 - 10:10	Yang Dan (UC Berkeley / SMART) Sleep-immune interaction through microglia and adrenergic signaling	Plenary Lecture 3
10:10 - 10:40	Abhishek Banerjee (University of Oxford and Queen Mary University of London) Frontal feedback dependent and independent adaptive learning	
10:40 - 10:50	Coffee Break	
10:50 - 11:20	Tsukasa Kamigaki (Nanyang Technological University) Aging impact on the prefrontal cortex network	
11:20 - 11:40	Eunee Lee (Yonsei University College of Medicine) Restoring interbrain prefrontal theta synchronization reverses social deficits	
11:40 - 12:20	Adam Kepecs (Washington University School of Medicine) From Uncertainty to Action: How the Prefrontal Cortex Computes Confidence	Plenary Lecture 4
12:20 - 12:30	Closing, Director Seong-Gi Kim	
12:30 - 12:40	Group Photo	

Session 1

Cortical Waves



CHAIR

Hakwan Lau

IBS CNIR

SPEAKER

Lyle Muller

Western University, Canada

Laura Dugué

Université Paris Cité & CNRS

Seok-Jun Hong

IBS CNIR

Taro Toyozumi

RIKEN Center for Brain Science

**Speaker**

Lyle Muller

Assistant Professor, Department of Mathematics
Western University, Canada
Email: lmuller2@uwo.ca

Lyle Muller's research centers on developing new approaches to analyze and model large-scale recordings of neural population dynamics in cortex.

After studying computational neuroscience at Brown University, Lyle completed a PhD in computational and theoretical neuroscience with Alain Destexhe (CNRS Gif-sur-Yvette). He then moved to San Diego for postdoctoral research with Terry Sejnowski in the Computational Neurobiology Laboratory (CNL) at the Salk Institute.

In 2019, he started a research group in computational neuroscience at Western University, in the Department of Applied Mathematics and the Brain and Mind Institute. At Western, his group conducts analysis- and model-driven research in collaboration with colleagues in systems and clinical neuroscience.

Lyle helped to found the Fields Center for Network Computation, where he serves as Chair. The Fields Lab for Network Computation brings together experts in discrete mathematics, graph theory, number theory, and physics to spur new work in neural network theory. Collaborations at the lab focus on developing new mathematical approaches to neural networks, and applications of these techniques to large-scale network data across science, technology, medicine, and sociology. In this way, the Lab aims to create a hub that can address questions central to human society over the next few years through the study and applications of network theory.

Traveling waves of neural activity shape computation across sensory maps

Lyle Muller

Western University, Canada

Large-scale recording technologies now enable simultaneous measurement of neural activity across individual cortical regions with high spatial and temporal resolution. In these recordings, we have found that visual stimuli evoke waves traveling outward from input sites in primary visual cortex (Muller et al., *Nature Communications*, 2014). These spatiotemporally structured patterns are composed of sparse spiking activity, where only a few neurons spike as the wave passes through a local network. This is analogous to “the wave” in a stadium, but where only a few fans stand at each point. During visual detection tasks, these neural traveling waves (nTWs) dynamically modulate both neural excitability and visual perception (Davis*, Muller*, et al., *Nature*, 2020). nTWs thus actively affect visual processing — but what could be their computational role? We have developed a novel recurrent neural network where brief input sequences trigger wave patterns that forecast upcoming inputs (Benigno et al., *Nature Communications*, 2023). This demonstrates that nTWs can augment visual computation by embedding spatiotemporal dependencies that unfold across maps of sensory space. We have now developed mathematically solvable networks that can perform more general computations through their spatiotemporal dynamics (Budzinski*, Busch* et al., *Communications Physics*, 2024). The complex, overlapping wave patterns generated by these mathematically interpretable neural networks have guided new analyses of spatiotemporal activation patterns that encode specific items held in prefrontal cortex during naturalistic working memory tasks (Busch*, Roussy* et al., *Nature Communications*, 2024).

**Speaker**

Laura Dugué

Professor of cognitive and computational neuroscience
Université Paris Cité and CNRS
Email: laura.dugue@u-paris.fr

Laura Dugué is currently a Full Professor of cognitive and computational neuroscience at Université Paris Cité, Paris, France. She uses a multi-modal approach including neuroimaging, computational modeling and behavioral measures to investigate the spatio-temporal organization of brain oscillations and their role in perception and attention.

She started her professional career as an Associate Professor at the Integrative Neuroscience and Cognition Center at Université Paris Cité in 2016 and was promoted to full professor in 2024. She has received various awards including a nomination to the prestigious Institut Universitaire de France in 2019 and the Théodule Ribot award in Scientific Psychology in 2021. She was awarded several important grants including an ANR-DFG grant in 2018 and an ERC Starting Grant in 2020.

She received the B.S. degree in Biology in 2008 and an M.S. degree in cognitive neuroscience in 2010 from Université de Toulouse. She obtained her Ph.D. degree in cognitive neuroscience in 2013 from Université de Toulouse under the supervision of Rufin VanRullen. From 2014 to 2016, she did a postdoc with a FYSEN fellowship under the supervision of Marisa Carrasco at New York University.

Traveling Waves in the human brain

Laura Dugué

*Université Paris Cité, CNRS, Integrative Neuroscience and Cognition Center, France
Institut Universitaire de France (IUF), France*

Neural oscillations have been observed across scales, species and recording methods. Recently, researchers have focused on their spatial organization across the cortex. Traveling Waves patterns, specifically, correspond to smooth phase shifts in the direction of signal propagation and appear to play a role in cognitive functions. Identifying spatio-temporally consistent patterns, however, in non-invasively obtained human data (EEG or MEG recordings) poses significant technical challenges, such as source summation, volume conduction, and low signal-to-noise ratios, which complicate the interpretation of cortical activity from surface sensor measurements. In this talk, I will outline a variety of approaches—including psychophysics, computational modeling, and novel time series analysis tools developed by our lab—to address these challenges. Through psychophysics, we have shown that visual percepts can propagate as waves across retinotopic space [1,2]. Our theoretical work suggests that this effect is driven by cortical propagation within V1 [1]. Moreover, we demonstrated that the propagation of neural activity within individual cortical regions can be detected in EEG and MEG recordings [3], and developed a model-based neuroimaging approach to overcome the aforementioned technical issues and drive future experimental work [4]. In addition, we found that stereotactic EEG can be employed to capture phase dynamics across different brain regions [5]. Lastly, our lab has developed Waves Space, a modular traveling waves simulation and analysis tool [6]. This toolbox implements a range of methods to detect, characterize, and statistically assess traveling waves.

1. Cardoso J.X.V., Li H.-H., Heeger D.J. and Dugué L. (**in press**) Attention induced perceptual traveling waves in binocular rivalry. *Journal of Vision*. Currently on: bioRxiv 2025.04.18.649496
2. Fakche C. and Dugué L. (**2024**). Perceptual cycles travel across the retinotopic space. *Journal of Cognitive Neuroscience* 36:1, 200-216.
3. Petras K., Grabot L. and Dugué L. (**2025**) Locally induced traveling waves generate globally observable traveling waves. *Journal of Neuroscience* e0089-25.2025.
4. Grabot L., Merholz G., Winawer J., Heeger D. and Dugué L. (**2025**) Traveling Waves in the Human Visual Cortex: an MEG-EEG Model-Based Approach. *PLOS Computational Biology* 21(4):e1013007.
5. Alexander D.M. and Dugué L. (**2024**). The dominance of global phase dynamics in human cortex, from delta to gamma. *eLife* 100674.1
6. Petras K., and Dugué L. (**submitted**) Wave Space: simulation, detection and analysis of cortical traveling waves.

**Speaker**

Seok-Jun Hong

Associate Professor
Sungkyunkwan University, IBS Center for Neuroscience Imaging Research
Email: hongseokjun@skku.edu

Education

2011-2016 Ph.D. in Neuroscience, McGill University, Montreal, Canada
2008-2010 MSc in Neuroscience, Seoul National University, Seoul, Korea
2001-2007 BSc in Computer Science and Cognitive Science, Yonsei University, Seoul, Korea

Research experience

2025-present Chair of the Department of Brain Science and Engineering
2024-present Associate Professor of Biomedical Engineering, Sungkyunkwan University, Korea
2020-present Principal Investigator, CNIR, Institute for Basic Science, Korea
2020-2023 Assistant Professor of Biomedical Engineering, Sungkyunkwan University, Korea
2019-present Research Scientist, Child Mind Institute, New York, USA
2018-2019 Postdoctoral Research Fellow, Child Mind Institute, New York, USA
2016-2018 Postdoctoral Research Fellow, McGill University, Montreal, Canada

Honors and Awards

2024 Teaching award, Sungkyunkwan University, S.Korea
2019 NARSAD Young Investigator award, Brain-Behavior Research
2018 Young Investigator Award, 72nd American Epilepsy Society, USA
2018 Canadian Institutes of Health Research, Postdoc Fellowship
2018 Simon Groom Travel Award, Montreal Neurological Institute
2017 Jeanne Timmins Fellowship, Montreal Neurological Institute
2017 Travel award, 20th International Conference on MICCAI
2017 Canadian League Against Epilepsy, Post-Graduate Training Fellowship
2017 Organization for Human Brain Mapping, Merit Abstract Award, Canada
2016 American Epilepsy Society, Jack Pellock Award, Houston, USA
2016 Top trainee in Canadian League Against Epilepsy, Canada
2015 Jeanne Timmins Costello Studentship, Montreal Neurological Institute
2015 Canadian League Against Epilepsy, Publication award for student
2015 Student travel award, 18th International Conference on MICCAI
2015 Best poster presentation, 31st International Epilepsy Congress, Istanbul
2014 Grass Young Investigator Award, 68th American Epilepsy Society, Seattle
2014 Desjardins Outstanding Student Award, Montreal Neurological Institute
2013 Simon Groom Travel Award, Montreal Neurological Institute

The Many Faces of Brain Functional Dynamics: Long-Range Connectome and Cortical Waves

Seok-Jun Hong

IBS Center for Neuroscience Imaging Research, Republic of Korea

In this talk, I will examine two prominent frameworks for understanding the large-scale basis of functional spatiotemporal dynamics in the human brain—namely, **Geometric Eigenmodes** and **Functional Modes**—and propose a synthesis to reconcile their perspectives.

First, I will revisit the key topological features identified by traditional network neuroscience, and apply these to interpret the principal modes of functional flow observed in whole-brain fMRI signals, with a particular focus on **wave-like dynamics**.

Next, I will contrast this connectome-centric view with the recently proposed concept of **structural eigenmodes** and compare the efficacy of these different dynamic decomposition approaches—including functional modes, connectome eigenmodes, and structural eigenmodes—in reconstructing temporally evolving, whole-brain fMRI signals.

Finally, I will conclude by offering my perspective on this critical, yet unresolved question, “*What is the most **biologically plausible** and **computationally meaningful** way to describe the brain's functional dynamics?*”.

**Speaker**

Taro Toyoizumi

Team Director
RIKEN Center for Brain Science
Email: taro.toyoizumi@riken.jp

Taro Toyoizumi is the Team Leader at the RIKEN Center for Brain Science. He received his B.S. in Physics from the Tokyo Institute of Technology in 2001, followed by his M.S. and Ph.D. in Computational Neuroscience from the University of Tokyo in 2003 and 2006, respectively. After completing his doctoral studies, he joined the Center for Theoretical Neuroscience at Columbia University as a JSPS and Patterson Trust Postdoctoral Fellow. In 2010, Toyoizumi was appointed as a Special Postdoctoral Researcher at the RIKEN Brain Science Institute and was promoted to Laboratory Head the following year. He undertook his current position at RIKEN in 2018 and was also named an adjunct professor at the Graduate School of Information Science and Technology at the University of Tokyo in 2019. He has served as a Co-Editor-in-Chief of *Neural Networks* from 2022. Taro Toyoizumi's research focuses on the computational principles underlying the experience-based organization of neural circuits. Among his honors are the International Neural Network Society's Young Investigator Award in 2008, the Commendation for Science and Technology by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) of Japan, the Young Scientists' Prize in 2016, and RIKEN Baihou-prize in 2023.

Modeling computation and learning with brain waves

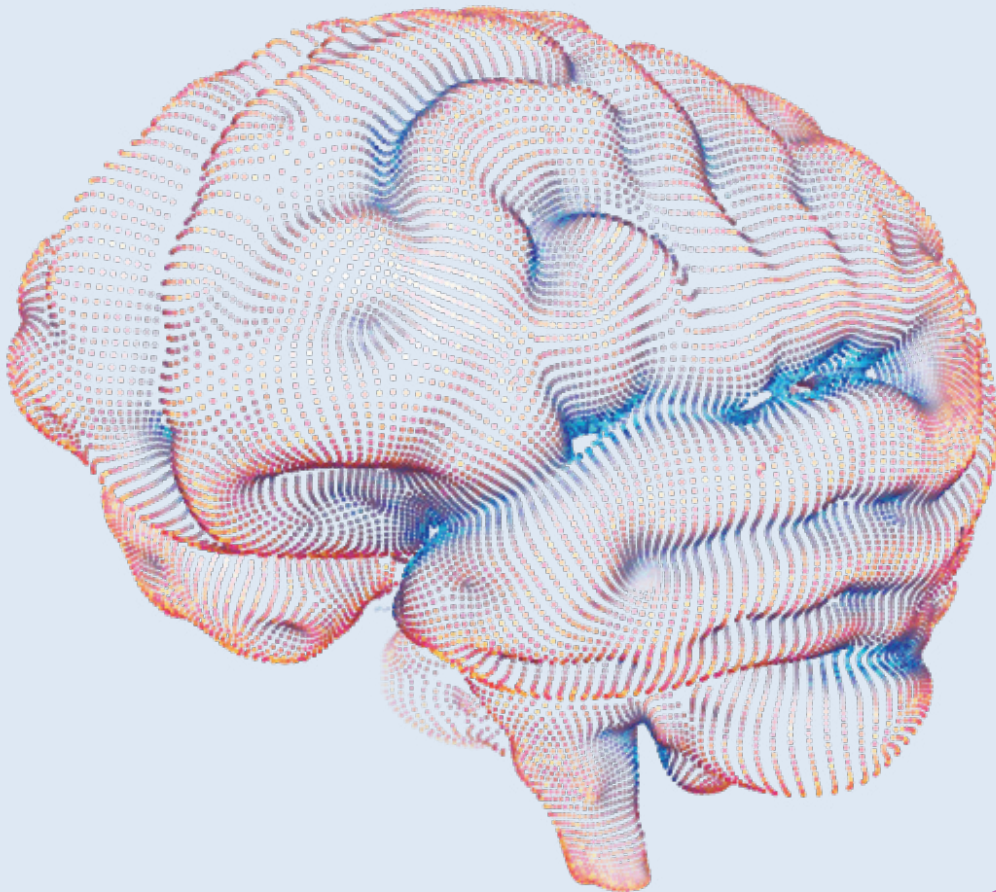
Taro Toyoizumi

RIKEN Center for Brain Science, Japan

In this talk, I present a series of computational modeling studies that reveal how brain oscillations shape learning and memory processes. First, we examine how slow waves modulate inter-neuronal information transmission and derive an optimal, state-dependent learning rule. This theoretical rule reproduces key features of synaptic changes observed during non-REM sleep (Yoshida & Toyoizumi, PNAS Nexus 2023). The second study explores how traveling waves coordinate spatially distributed synaptic updates under a local, reward-dependent plasticity rule. Our simulations demonstrate that these waves not only facilitate learning of polysynaptic network paths but also accelerate the identification of shortcut routes and the learning of nonlinear input-output mappings, such as the XOR function (Ito & Toyoizumi, PLOS Comput. Biol. 2021). Finally, inspired by the dual-pathway inputs to hippocampal CA3, we model a Hopfield-like network storing both dense, correlated and sparse, decorrelated encodings of memories. We show that oscillatory dynamics can drive the retrieval process to alternate between specific examples and abstract concepts, effectively bridging the two encodings (Kang & Toyoizumi, Nat. Commun. 2024). Together, these studies highlight the multifaceted roles of brain waves in optimizing neural computation and learning.

Session 2

Stress and the Prefrontal Cortex



CHAIR

Bong-Kiun Kaang
(IBS CMG)

SPEAKER

J. John Mann
Columbia University

Rosemary Bagot
McGill University

Min Soo Kim
KIST

C. Justin Lee
IBS CMG

**Speaker**

J. John Mann

Professor
Columbia University
Email: jjm@columbia.edu

J. John Mann is The Paul Janssen Professor of Translational Neuroscience (in Psychiatry and in Radiology) at Columbia University and Director, Molecular Imaging and Neuropathology Division at the New York State Psychiatric Institute. He is a Past President of the Society of Biological Psychiatry and the International Academy of Suicide Research.

Dr. Mann was trained in Psychiatry and Internal Medicine and has a Doctorate in Neurochemistry. His research employs functional brain imaging, neurochemistry and molecular genetics to probe the causes of depression and suicide. Dr. Mann has published over 900 peer-reviewed papers and edited 11 books.

Dr. Mann has received the Colvin Prize from the Brain Behavior Research Foundation, American Suicide Prevention Foundation Research Award, the American Association of Suicidology Louis I. Dublin Award, the New York State Office of Mental Health Research Award, the Klerman Senior Investigator Award from the National Depressive and Manic Depressive Association, the Stengel Award from the International Association for Suicide Prevention, the Morselli Medal from the International Academy of Suicide Research, The Julius Axelrod Mentorship Award from the American College of Neuropsychopharmacology and the Mood Disorders Research Award from the American College of Psychiatrists.

Neuroinflammation, Recent Life Stress and Depression and Suicidal Psychopathology

J. John Mann MD

Columbia University, USA

Depression and suicidal behavior are frequently preceded by life stressors that appear to trigger this psychopathology. Most studies have employed rating scales that depend on retrospective recall. Such an approach is open to recall bias. Ecological momentary assessment (EMA) offers a better approach. We employ a method that assesses roughly 2-hour epochs or time periods during waking hours for one-week periods. We have employed this method to detect stress-related increases in suicidal ideation and negative affect. We have shown that this increase correlates with degree of suicide intent in the most recent suicide attempt and it therefore is of great clinical importance. Results from our studies will relate the EMA to the BOLD signal responses to negative autobiographical memories cues during fMRI. How the stressor leads to these psychopathologies has been unclear, but we will report positron emission tomography scans of the TSPO protein as a marker of neuroinflammation. Our findings show that recent life stressors trigger suicidal ideation and depression, and that this relationship is mediated by degree of neuroinflammation. Future applications of these research methods include their potential use as biomarkers of antidepressant and suicidal ideation treatments.

**Speaker**

Rosemary Bagot

Associate Professor and Canada Research Chair in Behavioural Neurogenomics
McGill University
Email: rosemary.bagot@mcgill.ca

Dr. Rose Bagot is an Associate Professor in Behavioural Neuroscience in the Department of Psychology at McGill University, Montréal, Canada and the Canada Research Chair in Behavioural Neurogenomics. She is also a Primary Investigator at the Ludmer Centre for Neuroinformatics and Mental Health, an Associate Member of the Department of Psychiatry at McGill University and the.

Dr. Bagot graduated from the University of New South Wales, Sydney, Australia with a B.Sc. in Psychology before completing her Ph.D. in Neuroscience at McGill University, Montréal, Canada and postdoctoral research at the Icahn School of Medicine at Mount Sinai in New York, USA.

Dr. Bagot received a number of prestigious early-career awards including the NARSAD Young Investigator Award (2014) and the ACNP Travel Award (2015). In recognition of her contributions to understanding the molecular and behavioral underpinnings of mental health, Dr. Bagot was named a William Dawson Scholar by McGill University in 2017 and was appointed as the Canada Research Chair in Behavioural Neurogenomics in 2019. Her research is highly cited and has been recognized by the Ziskind-Somerfeld award for best paper published in the journal *Biological Psychiatry*. In 2022, she was selected as a Scialog Fellow in the Molecular Basis of Cognition, recognizing her commitment to interdisciplinary and collaborative neuroscience research. Dr. Bagot's leadership in the field has been recognized through election to the American College of Neuropsychopharmacology, first as an Associate Member (202) and then as a full member (2024).

Research in the Bagot lab focuses on understanding the mechanisms of affective processing and the impact of chronic stress to gain insight into neural circuit mechanisms of stress-related disorders such as depression and anxiety. Ongoing research in her lab aims to understand the unique behavioral significance and microcircuit mechanisms of glutamatergic projections to the nucleus accumbens in affective behaviour as well as how affective information is dynamically encoded in these circuits as well as the role of novel transcriptional regulators in shaping prefrontal circuit function and mechanisms of novel antidepressant drugs. Her team uses a multi-disciplinary approach founded on robust mouse behavioural models and integrating in vitro electrophysiology, in vivo calcium imaging, in vivo neural activity manipulations, and single-cell transcriptional profiling. Her research has identified key neural and molecular circuit mechanisms that interact with stress to shape affective behavior and uncovered the fundamental role of these circuits in integrating information about both threat and reward.

A novel circuit regulator of stress resilience in the prefrontal cortex

Vedrana Cvetkovska, Peter Vitaro, Mariana Alonso, Yiu-Chung Tse, Eshaan Iyer, Serena Wu, Emily Cha, Katrina Khosravi, Delong Zhou, Joëlle Lopez, Rosemary C Bagot

Department of Psychology, McGill University, Montreal, Quebec, Canada

Stress is a major risk factor for depression, yet some individuals remain resilient to stress. Both environmental and genetic factors contribute to the dysregulation of neural circuits in depression and genes that regulate the formation, maintenance, and plasticity of synapses are of particular interest as potential molecular hubs for regulation of circuit function. We previously identified *Sidekick-1* (*Sdk1*) as an affective circuit hub gene in a network regulating stress resilience and overexpression of *Sdk1* in the prefrontal cortex (PFC) increased resilience to stress in male mice. Separately, several genome-wide association studies in humans found *SDK1* variants associated with depression, suggesting an evolutionarily conserved role in regulation of emotional behavior. *Sdk1* is a cell surface molecule implicated in circuit formation in the developing retina. However, little is known about cell-specific expression patterns of *Sdk1* in the adult brain and its function within affective circuits. Here we probe *Sdk1* cell-type and layer-specific expression in the PFC, conservation between mice and humans, its modulation by stress, and effects on reward learning in both male and female. Circuit tracing and targeted in vivo manipulation in transgenic mice points to a key role for this circuit in modulating reward sensitivity. Single-cell sequencing identifies a signature of natural resilience that is induced in this circuit in mice that are resilient to chronic stress. As a cell surface receptor, *Sdk1* is a potential target for pharmacological intervention. Understanding how *Sdk1* confers resilience may lead to development of new mechanistically-informed treatments for depression.

**Speaker**

Min Soo Kim

Senior Research Scientist
Korea Institute of Science and Technology (KIST)
Email: minsoo.kim@kist.re.kr

Dr. Min Soo Kim is a Senior Research Scientist at the Brain Science Institute of the Korea Institute of Science and Technology (KIST) and an Associate Professor at the University of Science and Technology (UST), Korea. He received his Ph.D. in Nutrition from Seoul National University and completed postdoctoral training at the Albert Einstein College of Medicine in New York, focusing on neuroinflammation and brain-metabolic interactions. His current research centers on the neurobiological mechanisms underlying stress-related mood disorders, aging, and neurodegeneration, with an emphasis on translational approaches using natural compounds and neuroimmune modulation. Dr. Kim has published extensively in high-impact journals, including *Nature*, *Nature Immunology* and *Nature Aging*, and leads the Minsoo Lab at KIST, which investigates brain-immune-metabolic circuits in health and disease.

Reversal of suicide-like behaviors in a social defeated stress model

Jeongyoon Choi¹, C. Justin Lee² and Min Soo Kim¹

¹*Brain Science Institute, Korea Institute of Science and Technology (KIST), Seoul, Republic of Korea*

²*Institute for Basic Science (IBS), Daejeon, Republic of Korea*

Suicide is a major public health concern with few effective treatments targeting its underlying neurobiological components. To model suicide-relevant endophenotypes, we employed a chronic social defeat stress (SDS) paradigm in mice and defined suicide-like behavior as the co-expression of depressive mood and impulsivity, assessed using the Social Interaction Test (SIT) for social withdrawal, Tail Suspension Test (TST) for behavioral despair, and Cliff Avoidance Reaction Test (CART) for impaired risk avoidance. SDS-exposed mice exhibited persistent deficits across all three tests, modeling core features of suicidal vulnerability. We evaluated KDS12025, a novel compound, and found it completely protected against suicide-like behaviors, normalizing performance in SIT, TST, and CART. Mechanistically, KDS12025 reversed stress-induced neuroplastic and inflammatory changes. These results suggest that suicide-like behaviors in susceptible individuals are reversible and highlight KDS12025 as a promising candidate for therapeutic development targeting stress-related mood disorders.

**Speaker**

C. Justin Lee

Director
IBS Center for Memory and Glioscience
Email: cjl@ibs.re.kr

Dr. Changjoon Justin Lee is a distinguished neuroscientist and co-director of the Center for Cognition and Sociality at the Institute for Basic Science (IBS) in South Korea. He earned his B.A. in Chemistry from the University of Chicago and completed his Ph.D. in Physiology and Cellular Biophysics at Columbia University in 2001. He then conducted postdoctoral research at Emory University in the Department of Pharmacology.

In 2004, Dr. Lee joined the Korea Institute of Science and Technology (KIST) as a senior research scientist and later became the Director of the Center for Neuroscience. He founded the WCI Center for Functional Connectomics in 2009 and went on to establish the Center for Glia–Neuron Interaction at KIST in 2015, following his receipt of the Creative Research Investigator Award.

Dr. Lee is internationally recognized for pioneering work in cognitive glioscience, particularly the role of astrocytes in brain function and disease. His groundbreaking discoveries include identifying astrocyte-derived GABA release and its link to memory impairment in Alzheimer’s disease models—findings that have significantly shifted the traditional neuron-centered view of neuroscience.

He has received numerous honors, including the Presidential Science Medal, Kyung-Ahm Prize, and FILA Basic Science Award. As a group leader at IBS, Dr. Lee continues to explore glial mechanisms in cognition, neurodegeneration, and brain plasticity using advanced imaging, genetics, and behavioral approaches.

Astrocytic gamma-aminobutyric acid dysregulation as a therapeutic target for posttraumatic stress disorder

C. Justin LEE

Center for Memory and Glioscience, Institute for Basic Science, Republic of Korea

Post-traumatic stress disorder (PTSD) remains a debilitating psychiatric condition with limited pharmacological treatment options. Identifying novel therapeutic targets is critical for addressing its unmet clinical needs.

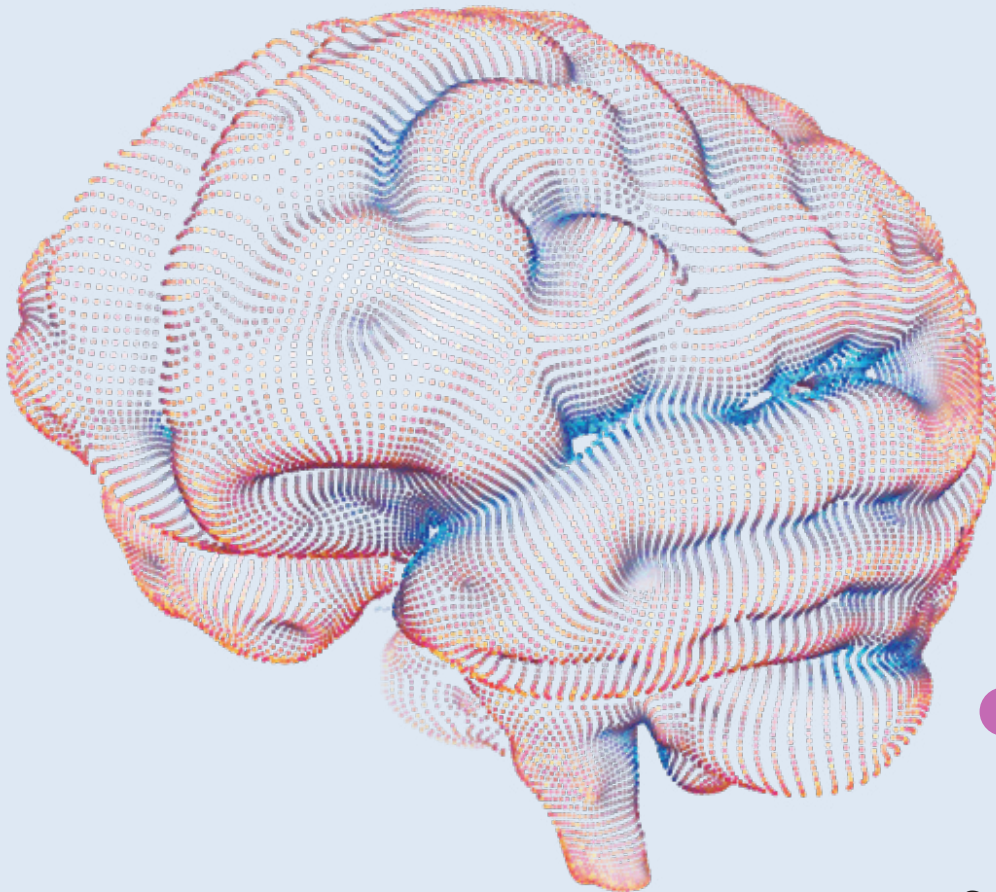
Through our comprehensive human clinical research, including both cross-sectional and longitudinal studies, we revealed a compelling link between dysregulated prefrontal gamma-aminobutyric acid (GABA) levels and PTSD symptoms. Notably, elevated prefrontal GABA levels in PTSD patients are associated with impaired cerebral blood flow (CBF) and symptom severity, normalizing with recovery, highlighting GABA dysregulation as a key mechanism in the disorder. Postmortem and PTSD-like mouse models implicated monoamine oxidase B (MAOB)-dependent astrocytic GABA as a primary driver of this imbalance, exacerbating deficit in fear extinction retrieval. Genetic and pharmacological inhibition of MAOB effectively restored astrocytic GABA and improved fear extinction retrieval in PTSD-like mouse models.

Specifically, KDS2010, a recently developed highly selective and reversible MAOB inhibitor, not only restored astrocytic GABA homeostasis but also rescued CBF deficits and reduced tonic GABA and astrogliosis in the prefrontal cortex. Moreover, KDS2010 successfully advanced through Phase 1 clinical trials, showing a favorable safety profile and paving the way for Phase 2 trials to evaluate its therapeutic potential in PTSD.

Our findings highlight the pivotal role of astrocytic GABA in PTSD pathophysiology and establish MAOB inhibition as a mechanistically targeted approach to alleviate symptoms. By bridging human and animal studies with translational clinical trials, this work positions KDS2010 as a promising first-in-class therapy, offering a novel paradigm for PTSD treatment.

Session 3

Rodent Prefrontal Cortex



CHAIR

Min W. Jung
(IBS CSBD)

Seung-Hee Lee
(IBS CSBD)

SPEAKER

Yang Dan
UC Berkeley / SMART

Abhishek Banerjee
University of Oxford and Queen Mary University of London

Tsukasa Kamigaki
Nanyang Technological University

Eunee Lee
Yonsei University College of Medicine

Adam Kepecs
Washington University School of Medicine

**Speaker**

Yang Dan

Senior Principal Investigator
Shenzhen Medical Academy of Research and Translation
Email: danyang@smart.org.cn

Prof. Dan is a Senior Principal Investigator at the Shenzhen Medical Academy of Research and Translation (SMART).

She received her B.S. in Physics from Peking University in 1988 and her Ph.D. in Neurobiology from Columbia University in 1994. Following postdoctoral research at Rockefeller University, she joined the faculty at the University of California, Berkeley in 1997, rising to Professor and becoming a Howard Hughes Medical Institute Investigator.

In recognition of her contributions to neuroscience, Prof. Dan was elected to the US National Academy of Sciences and the American Academy of Arts and Sciences. Her accolades include the American Neurological Association's Award for Innovation in Neuroscience (2009), the Scolnick Prize in Neuroscience (2023), and the Seeburg Integrative Neuroscience Prize (2024).

As a leading researcher, she has authored or co-authored over 70 high-impact papers, including 16 in *Nature*, *Science*, and *Cell*, and 27 in *Nature Neuroscience* and *Neuron*. Her research has been continuously supported by multiple grants from the NIH, NSF, and private foundations such as the Michael J. Fox Foundation for Parkinson's Research. An active participant in the global scientific community, she also serves as an editor for prestigious journals including *Cell*, *Neuron*, and *PNAS*.

Sleep-immune interaction through microglia and adrenergic signaling

Yang Dan

University of California, Berkeley, USA / Shenzhen Medical Academy of Research and Translation, China

Sleep interacts with the immune system, but the mechanism remains illusive. We showed that the resident immune cells in the brain - microglia - can regulate sleep through a mechanism involving Gi-coupled GPCRs, intracellular Ca^{2+} signaling, and suppression of norepinephrine transmission. Norepinephrine in turn can suppress microglia Ca^{2+} activity, indicating reciprocal interactions. I will also discuss our recent data showing that peripheral immune activation induced by LPS also regulates sleep-wake states through norepinephrine signaling.

**Speaker**

Abhishek Banerjee

Professor
University of Oxford and Queen Mary University of London
abhishek.banerjee@pharm.ox.ac.uk

Abhishek (Abhi) Banerjee is Professor of Neuroscience and a Wellcome Trust Fellow at the University of Oxford and Barts and Queen Mary University of London. He completed his DPhil in Neuroscience at Oxford and held fellowships at MIT and the University of Zürich. The research in his lab explores cortical plasticity and neural circuit mechanisms underlying flexible learning, with a special focus on neurodevelopmental disorders. He has contributed to understanding inhibitory circuit dysfunctions and the mechanisms of therapeutic rescue using IGF1 in preclinical ASD models, such as Rett syndrome. Professor Banerjee is a recipient of the Wellcome Trust Investigator Award, a FENS-Kavli Scholar Award, and previously held positions at Harvard and ETH Zürich.

Frontal feedback dependent and independent adaptive learning

Abhishek Banerjee

University of Oxford and Queen Mary University of London, U.K.

Animals adapt their behaviour in response to variable changes in reward reinforcement. The prefrontal areas of the mammalian neocortex, particularly the orbitofrontal cortex (OFC), play a crucial role in implementing rule-based strategies to facilitate flexible learning. However, the neural circuit mechanisms in OFC and its interactions with different hierarchical cortical areas underlying such processes remain elusive. In my talk, I will discuss the interactions between the orbitofrontal and somatosensory cortices that enable flexible decision-making in a tactile reversal-learning task in mice, and also briefly highlight similar circuit mechanisms at work in humans.

**Speaker**

Tsukasa Kamigaki

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Dr. Tsukasa Kamigaki is an Assistant Professor at LKCMedicine. He obtained a Ph.D. in 2010 at the University of Tokyo School of Medicine, where he investigated the cellular mechanisms for cognitive flexibility in non-human primates. After graduation, he worked as a postdoc at the University of California Berkeley.

He is a recipient of series of awards and scholarships including Human Frontier Science Program (HFSP) Long-Term Fellowship, Uehara Memorial Foundation, Japan Neuroscience Society Young Investigator Award, and MCB Outstanding Postdoc award in Neurobiology at UC Berkeley.

Aging impact on the prefrontal cortex network

Tsukasa Kamigaki

Lee Kong Chian School of Medicine, Nanyang Technological University, Singapore

The prefrontal cortex (PFC) is essential for executive functions and exhibits remarkable neuronal heterogeneity, with individual neurons showing diverse connectivity and functional roles. Using in vivo calcium imaging in the medial PFC (mPFC) of mice, we examined how local circuit connectivity—quantified by degree centrality during spontaneous resting-state activity—relates to functional specialization, and how this relationship is affected by aging. In young adult mice, neurons with high connectivity exhibited robust and reliable action-plan selectivity during memory-guided behavior, including across sensory modalities¹. However, from middle age onward, this connectivity-function relationship progressively deteriorated: connectivity became a weaker predictor of task-related selectivity, and recurrent connectivity among memory-coding neurons was particularly reduced. A computational model simulating age-related declines in synaptic plasticity successfully recapitulated these changes, linking network disruption to diminished functional integrity. Optogenetic inactivation further revealed that middle-aged mPFC circuits are more vulnerable to perturbation compared to those in young adults, indicating reduced resilience of recurrent connectivity². Together, these findings demonstrate how aging impairs the structural and functional organization of PFC circuits, providing mechanistic insight into the neural basis of cognitive aging.

1. Ranjbar-Slamloo Y., Chong HR., and Kamigaki T. (2025) Aging disrupts the link between network centrality and functional properties of prefrontal neurons during memory-guided behavior. *Communications Biology*, 8: 62.
2. Chong HR., Ranjbar-Slamloo Y., Ho MZH., Ouyang X., and Kamigaki T.(2023) Functional alterations of the prefrontal circuit underlying cognitive aging in mice. *Nature Communications*,14:7254.



Speaker

Eunee Lee

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Eunee Lee M.D., Ph.D. is an assistant professor in Yonsei University College of Medicine.

She delves into the intricate mechanisms of social behavior and uncovers the causes and treatments for neurodevelopmental disorders, including autism spectrum disorder and epileptic encephalopathy. Utilizing advanced mouse models and human patient tissue, her team's research aims to pioneer new understandings and innovative therapies in the field.

Restoring interbrain prefrontal theta synchronization reverses social deficits

Eunee Lee

Yonsei University College of Medicine, Republic of Korea

Social interaction requires the integration of information about oneself, others, and the shared environment. One proposed mechanism for this coordination is interbrain synchrony – correlated neural activity between interacting individuals –observed in both humans and animals. However, whether this synchrony plays a functional role in orchestrating social behavior remains unclear. Here, we show that theta-band synchronization in the medial prefrontal cortex (mPFC) is essential for naturalistic social interactions in mice. Using a genetic model of social dysfunction, we demonstrate that disruptions in mPFC synchrony correlate with impaired social behaviors. We identify a population of social behavior-encoding neurons that are directly linked to interbrain synchrony. Optogenetically enhancing theta synchronization restores both interbrain synchrony and social behaviors, while desynchronization impairs social interactions in wild-type mice. Our findings establish prefrontal theta synchrony as a fundamental mechanism for social behavior with therapeutic implications for disorders characterized by social deficits. More broadly, this work provides a framework for understanding how neural circuits across brains dynamically interact to shape behavior.

**Speaker**

Adam Kepecs

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Prof. Adam Kepecs is a Professor of Neuroscience and Psychiatry at Washington University in St. Louis. His research investigates the computational and circuit-level mechanisms by which the brain generates cognition, makes decisions, and regulates emotion—work that informs both psychiatry and artificial intelligence.

Prof. Kepecs received his B.Sc. in Computer Science from Eötvös Loránd University in Budapest, Hungary, and earned his Ph.D. in Neuroscience from Brandeis University. He conducted postdoctoral research at Cold Spring Harbor Laboratory, where he later became a faculty member and served as Program Chair in neuroscience. He was subsequently recruited to Washington University as a BJC Investigator.

His lab combines quantitative behavioral analysis, high-density neural recordings, imaging, optogenetics, anatomical tracing, and computational modeling to reverse-engineer how neural circuits perform cognitive tasks—often outperforming current AI models. This work has led to key discoveries, including how the brain computes decision confidence, how rats use it to guide behavior, and identified the role of specific cortical cell types, such as disinhibitory VIP interneurons.

His group has also developed new animal models and circuit-level frameworks to approach psychiatric questions, from hallucination-like perception to apathy in cancer cachexia. By integrating neuroscience and behavioral psychiatry, his work aims to translate basic circuit principles into insights that improve mental health care as well as AI architectures.

From Uncertainty to Action: How the Prefrontal Cortex Computes Confidence

Adam Kepecs

Department of Neuroscience and Psychiatry, Washington University School of Medicine in St Louis, USA

How does the brain evaluate confidence in its own judgments—and why do today's AI systems struggle to do the same? Confidence is a critical yet elusive component of cognition; its misestimation contributes to psychiatric conditions and hinders the development of reliable AI.

In this talk, I'll present an interdisciplinary approach combining statistical modeling, human behavior, and rodent neural circuit studies to uncover the neurobiology of confidence. We developed a computational-behavioral framework linking statistical definitions of confidence to human self-assessments and animal decision-making.

Contrary to the view that rats have limited cognitive capacity, we found they use statistical confidence to optimize decisions. Orbitofrontal cortex activity encodes this confidence signal, and its inhibition selectively disrupts confidence-guided time investments. I'll also introduce a method to infer the underlying cortical algorithm for these time investments directly from neural spiking data: an interpretable recurrent dynamical model recovered from prefrontal population activity that reproduces confidence estimates and predicts both neural dynamics and behavior. I'll close with insights into cell-type-specific dynamics in cortex and implications for building confidence-aware AI systems.

ABSTRACTS



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