Kavli
NEUROSCIENCE
DISCOVERY
INSTITUTE

Annual **Symposium 2026**

Neuromodulation Across Scales

November 4
1 to 6 p.m.

Table of Contents

Welcome 3

Agenda 4

Poster Order 5

Directory 9

Keynote: Bios and Abstracts 10

- Yulong Li 10
- Dayu Lin 12

Faculty: Bios and Abstracts 14

- Kathleen Cullen 14
- Ilya Monosov 16

Short Talk: Bios and Abstracts 18

- Varun B. Chokshi 18
- Leslie Sibener 20
- Christian Wesselborg 22

Lightning Talks: Abstracts 24

- Janie Chang-Weinberg 24
- Lin Lin 26
- Julia Pai 28
- Drishti Soneja 29
- Kimberley Wyse-Sookoo 31

Looking Ahead 33

Welcome

We warmly welcome you to the third annual Kavli NDI Symposium and thank you for joining us.

This year's theme, **"Neuromodulation Across Scales,"** brings together molecular, circuit, computational, technological, and clinical perspectives to explore how neuromodulatory systems shape brain function and behavior. Through talks and panel discussions, we hope to highlight recent advances, illuminate important challenges, and inspire new cross-disciplinary collaborations.

Kavli NDI is committed to advancing neuroscience through the integration of basic biology, engineering, and computational data science. We are also dedicated to empowering the next generation of scientists through our fellowships and are proud to showcase the work of our fellows and postdoctoral and doctoral researchers in the field.

We encourage you to engage fully throughout the day by exchanging ideas and sharing expertise. Please join us after the program for the reception and poster session, which will celebrate our fellows' research and foster connections across the Johns Hopkins and broader Kavli communities.

We wish you an insightful, productive, and enriching symposium.

Dwight Bergles

Michael Miller

Sarada Viswanathan

Kishore Kuchibhotla

Tomomi Karigo

Sharlen Moore

Agenda

1 to 1:10 p.m.	**Opening Remarks**	***Dwight Bergles and Sarada Viswanathan, Kavli NDI***
1:10 to 1:15 p.m.	**Institutional Remarks**	***Denis Wirtz, Johns Hopkins University***
1:15 to 1:55 p.m.	**Keynote Address**	***Yulong Li, Peking University*** *"Quantitative Imaging of Neuromodulator Dynamics In Vivo by Constructing New GRAB Sensors"*
1:55 to 2:25 p.m.	**Faculty Talk**	***Kathleen Cullen, Johns Hopkins University*** *"From Stimulation to Computation: Neuromodulation of Sensorimotor Circuits"*
2:25 to 3:10 p.m.	**Short Talks** with Emerging Scientists	***Varun B. Chokshi, Neuroscience Department, Johns Hopkins University*** ***Leslie Sibener, Kavli Neural Systems Institute, The Rockefeller University**** ***Christian Wesselborg, Biology (CMDB), Johns Hopkins University***
3:10 to 3:40 p.m.	**Faculty Talk**	***Ilya Monosov, Johns Hopkins University*** *"Curiosity and Calm: A Shared, Targetable Circuit for Curiosity, Risk, and Bodily State"*
3:40 to 4:10 p.m.	**Coffee Break**	
4:10 to 4:50 p.m.	**Keynote Address**	***Dayu Lin, New York University*** *"Neuromodulation of Aggression"*
4:50 to 5:05 p.m.	**Lightning Talks**	***Janie Chang-Weinberg, University of California San Diego**** ***Lin Lin, Yale University School of Medicine**** ***Julia Pai, Johns Hopkins University*** ***Drishti Soneja, Johns Hopkins University*** ***Kimberley Wyse-Sookoo, Johns Hopkins University***
5:05 to 5:45 p.m.	**Panel Discussion** "Neuromodulation Across Scales: Concepts, Tools and New Frontiers"	*Panelists:* ***Kathleen Cullen, Johns Hopkins University*** ***Yulong Li, Peking University*** ***Dayu Lin, New York University*** ***Ilya Monosov, Johns Hopkins University*** *Moderator:* ***Kishore Kuchibhotla, Johns Hopkins University***
5:45 to 6 p.m.	**Closing Remarks**	***Michael Miller, Kavli NDI***
6 to 7:30 p.m.	**Poster Session and Reception**	

**These speakers' participation is made possible by support from the National Science Foundation.*

Poster Order

Posters 1–18

We are proud to highlight the research of
Kavli NDI Distinguished Fellows: Class of 2026–2028

Presenter	Title	Poster Number	Location
Chenhao Bao	***Graded Encoding of Sensory Prediction Errors by Purkinje Cell Populations During Novel Active Self-Motion***	1	Greenhouse
Yu Li	***Investigating the Role of the Cerebellum in Hippocampal State Estimation During Spatial Navigation***	2	Greenhouse
Cheng-Yu Lee	***Quantitative OCT for Assessing Peripheral Nerve Injury***	3	Greenhouse
Josiah Chang	***Making Volumetric Voltage Imaging Viable for Whole-Body Zebrafish Larvae Analysis***	4	Greenhouse
Mohammad Rabiei	***Construction of Context-Dependent Auditory Rules in Mice***	5	Greenhouse
Drishti Soneja	***Hypothalamic Circuits Underlying Emergence of Maternal Care***	6	Greenhouse
Yongzhi Sun	***Geometry-Matched Curved Implantation of Ultra-Flexible Neural Probes for Region-Specific and Circuit-Level Brain Recording***	7	Greenhouse
Kyla Woyshner	***Multimodal Analysis of Region and Cell-Type Specific Programs in Alzheimer's Disease Using Semi-Supervised NMF***	8	Greenhouse
Donald Kramer	***Three-Dimensional Molecular Cartography of the Glioblastoma-Brain Microenvironment Interface***	9	Greenhouse
Oce Bohra	***Mapping the Cerebellar-Neocortical Circuit with Dual-Barcoded Yellow Fever Virus 17D***	10	Greenhouse
Shivam Kalhan	***Anterior Cingulate Cortex Encodes Cue Uncertainty that Scales with Learning Rates***	11	Greenhouse
Amit Khandhadia	***Macaque VIP Responses Differ During Active Head Turns and Passive Whole-Body Rotation***	12	Greenhouse

Poster Order (continued)

Posters 1–18

We are proud to highlight the research of
Kavli NDI Distinguished Fellows: Class of 2026–2028

Presenter	Title	Poster Number	Location
Yuehan Liu	***Ultracompact, Ultralight Two-Photon Fiberscopy Enabling Neuromaging in Freely Behaving Rodents at Cortical and Deep Brain Region***	13	Greenhouse
Dominic Padova	***From Molecules to Morphology: Bridging the Spatial Tower of Babel to Understand Alzheimer's Resilience***	14	Greenhouse
Davi Drieskens	***The Midbrain Superior Colliculus Orients Eye, Pinna and Tongue Movements in Egyptian Fruit Bats***	15	Greenhouse
Andrea Santi	***Revealing Hidden Knowledge in Amnestic Mice***	16	Greenhouse
Mahsa Khoshkhou	***Shared Network Dynamics of Native and Cognitively Interrupted Seizure Termination Reveal Neuromodulation Targets in Medically Refractory Epilepsy***	17	Greenhouse
Jaime Eugenin von Bernhardi	***Differentiating Oligodendrocytes Control the Spatial Timing of Oligodendrogenesis Through Bmp4 Dependent Inhibition of Opc Differentiation***	18	Greenhouse

Poster Order (continued)

Posters 19–32

We are proud to showcase the breadth of neuromodulation research across Johns Hopkins University and the global Kavli Neuroscience Institutes.

Presenter	Title	Poster Number	Location
Anh-Tuan Trinh*	***Thalamocortical-Like Circuits Reveal Hidden Hierarchies in the Zebrafish Brain***	19	Greenhouse
Kimberley Wyse-Sookoo,	***Effects of Phase-Dependent Stimulation on Upper Limb Bradykinesia in Parkinson's Disease***	20	Greenhouse
Julia Pai	***Ventral Striatal Astrocytes Contribute to Reinforcement Learning***	21	Mountcastle (Hallway)
Janie Chang-Weinberg*	***Treating Pain by Training Brains***	22	Mountcastle (Hallway)
Lin Lin*	***A Critical Role for Oxytocin in the Emergence of Social Touch Representation***	23	Mountcastle (Hallway)
Rafal Fejfer	***Developmental Emergence of a Latent Mating Drive State During Puberty***	24	Mountcastle (Hallway)
Jennifer Lawlor	***Role of the Cholinergic System in Early Sensorimotor Acquisition***	25	Mountcastle (Hallway)
Daniel Severin	***A Neuromodulatory AND Gate for Long-Term Depression in Visual Cortex***	26	Mountcastle (Hallway)
Teresa Osorio	***Entangling the Neuromodulatory Role of Oxytocin in Driving Pup-Induced Nest Building Behaviors***	27	PCTB 115
Zyan Wang	***Revealing Abrupt Transitions From Goal-Directed To Habitual Behavior***	28	PCTB 115
Ada Genesis Rodriguez-Campuzano	***Perinatal Opioid Exposure Disrupts Maternal Behavioral Predictability and Is Associated with Impaired Hippocampal-Dependent Memory in Adult Offspring***	29	PCTB 115
Rodrigo Guerra	***Open-Label Psilocybin Tms-Eeg (Opte) Pilot: Assessing the Acute Effects of Psilocybin on Neural Complexity***	30	PCTB 115

**This presenter's participation is made possible by support from the National Science Foundation.*

Poster Order (continued)

Posters 19–32

We are proud to showcase the breadth of neuromodulation research across Johns Hopkins University and the global Kavli Neuroscience Institutes.

Presenter	Title	Poster Number	Location
Yijing Gong	***Synthetic Biology Approach to Redirect Pronociceptive Signaling Pathways Toward Antihyperalgesic***	31	PCTB 115
Nikita Lebedz	***Cerebellar Anterior Interposed Nucleus StimulationModulates Movement Kinematics And Reshapes Motor Cortical Activity During Primate Reachin***	32	PCTB 115

Directory

Dwight Bergles
Professor
Department of Neuroscience
Director Kavli NDI
Opening Remarks
1 to 1:10 p.m.

Janie Chang-Weinberg*
Graduate Student
Department of Neurobiology
University of California San Diego
Lightning Talks
4:50 to 5:05 p.m.

Varun B. Chokshi
Assistant Research Scientist
Neuroscience Department
Johns Hopkins University
Short Talks with Emerging Scientists
2:25 to 3:10 p.m.

Kathleen Cullen
Raj and Neera Singh Professor of Biomedical Engineering
Department of Biomedical Engineering
Whiting School of Engineering
Johns Hopkins University
Co-Director
Center for Hearing and Balance
Johns Hopkins University
Faculty Talk
1:55 to 2:25 p.m.
Panel Discussion
5:05 to 5:45 p.m.

Tomomi Karigo
Assistant Professor of Neuroscience
The Solomon H. Snyder Department of Neuroscience
Johns Hopkins University School of Medicine
Symposium Co-Organizer

Kishore Kuchibhotla
Associate Professor
Department of Psychological and Brain Sciences
Krieger School of Arts and Sciences
Johns Hopkins University
Symposium Co Organizer
Panel Discussion Moderator
5:05 to 5:45 p.m.

Yulong Li
Professor
School of Life Sciences
Peking University
Keynote Address
1:15 to 1:55 p.m.
Panel Discussion
5:05 to 5:45 p.m.

Dayu Lin
Recanati Family Professor of Science
Department of Neuroscience
Professor
Department of Psychiatry
New York University Grossman School of Medicine
Keynote Address
4:10 to 4:50 p.m.
Panel Discussion
5:05 to 5:45 p.m.

Lin Lin*
Postdoctoral Fellow
Department of Psychiatry
Yale University School of Medicine
Lightning Talks
4:50 to 5:05 p.m.

Michael Miller
Bessie Darling Massey Professor and Director of Biomedical Engineering
Co-Director
Kavli NDI
Closing Remarks
5:45 to 6 p.m.

Ilya Monosov
Bloomberg Distinguished Professor
Department of Neuroscience
Krieger School of Arts and Sciences
Johns Hopkins University
Adjunct Professor
Biomedical Engineering and Psychiatry
School of Medicine
Johns Hopkins University
Faculty Talk
3:10 to 3:40 p.m.
Panel Discussion
5:05 to 5:45 p.m.

Sharlen Moore
Postdoctoral Fellow
Johns Hopkins University
Symposium Co-Organizer

Leslie Sibener*
Postdoctoral Fellow
Kavli Neural Systems Institute
The Rockefeller University
Short Talks with Emerging Scientists
2:25 to 3:10 p.m.

Drishti Soneja
Graduate Student
Neuroscience Department
Johns Hopkins University
Lightning Talks
4:50 to 5:05 p.m.

Sarada Viswanathan
Scientific Director
Kavli NDI
Symposium Co Organizer
Opening Remarks
1 to 1:10 p.m.

Christian Wesselborg
Graduate Student
Biology (CMDB)
Johns Hopkins University
Short Talks with Emerging Scientists
2:25 to 3:10 p.m.

Denis Wirtz
Vice Provost for Research and Theophilus Halley Smoot Professor
Department of Chemical and Biomolecular Engineering
Johns Hopkins University
Institutional Remarks
1:10 to 1:15 p.m.

Kimberley Wyse-Sookoo
Graduate Student
Department of Biomedical Engineering
Johns Hopkins University
Lightning Talks
4:50 to 5:05 p.m.

*These speakers' participation is made possible by support from the National Science Foundation.

Keynote: Bios and Abstracts



Yulong Li

Professor, School of Life Sciences, Peking University

Research Areas

Development of non-invasive systems for opto-genetic mapping of electric synapses, and geneticallyencoded sensors for imaging neurotransmitters/ modulators

Lab

yulonglilab.org

Schedule

Keynote Address
1:15 to 1:55 p.m.

Panel Discussion
5:05 to 5:45 p.m.

Bio

YULONG LI is a professor at Peking University and a New Cornerstone Investigator. Li received his bachelor's degree from Peking University and PhD from Duke University. He took postdoctoral training at Stanford University. After that, he started his lab at Peking University in 2012. Now his lab focuses on developing advanced imaging probes to untangle the complexity of nervous system in space and in time. Capitalizing on the advancement of research toolkits, he also studied the regulation of synaptic transmission. Li has received the National Science Fund for Distinguished Young Scholars, the National Award for Excellence in Innovation, the "XPLORER PRIZE" by Tencent Foundation, the CNS-CST Outstanding Neuroscientist Award, and the PKU & Boehringer-Ingelheim Faculty Research Award, among others.

Abstract

Quantitative Imaging of Neuromodulator Dynamics In Vivo by Constructing New GRAB Sensors

The human brain comprises billions of neurons that communicate primarily through chemical synapses by releasing diverse neuromodulators, which regulate perception, movement, learning, and memory. Dissecting the neural mechanisms in both physiology and disease requires precise in vivo monitoring of neuromodulator dynamics. In the past few years, we and others have developed a series of GPCR-activation–based (GRAB) sensors that enable

high-resolution monitoring of extracellular neuromodulator dynamics in behaving animals. Here, I will present our latest GRAB sensors, featuring large fluorescence lifetime changes, which allow precise quantification of both phasic and tonic neuromodulator release. With these GRAB sensors, we have monitored the dynamics of neuromodulators in mice in a wide range of physiological processes (reward, motion, etc.) and pathological conditions (Parkinson's disease, etc.).

Keynote: Bios and Abstracts



Dayu Lin

Recanati Family Professor of Science, Department of Neuroscience; Professor, Department of Psychiatry, New York University Grossman School of Medicine

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Research Areas

social behaviors, neural circuits, plasticity, dopamine, oxytocin

Lab

dayulinlab.org

Schedule

Keynote Address
4:10 to 4:50 p.m.

Panel Discussion
5:05 to 5:45 p.m.

Bio

DAYU LIN is the Recanati Family Professor of Science in the Department of Neuroscience and professor in the Department of Psychiatry at New York University Grossman School of Medicine. For two decades, she has studied the neural mechanisms underlying social behaviors, particularly aggression and parental behavior. Her laboratory seeks to identify the neural circuits that generate and regulate these behaviors and to understand how social experience and reproductive state reshape circuit function. Her work has identified more than 10 molecularly defined neural populations with essential roles in aggression, social avoidance, parental care, infanticide, sexual receptivity, and predator defense. Lin received her BS from Fudan University, earned her PhD in neurobiology from Duke University, and completed postdoctoral training at the California Institute of Technology before establishing her laboratory at NYU in 2010. Her contributions have been recognized with many honors, including the McKnight Scholar Award and the Capranica Award for Outstanding Achievement in Neuroethology.

Abstract

Neuromodulation of Aggression

Social behaviors, such as aggression and parental care, are essential for the survival of individuals and the species. Given their fundamental roles, the neural circuits underlying these innate behaviors are often viewed as genetically and developmen-

tally hardwired. Yet the readiness to express them is highly plastic and can be shaped by social experience, internal state, and reproductive condition. In this talk, I will present our recent work on how neuromodulators provide this flexibility in aggression. I will focus on two major classes of signals—monoamines and neuropeptides—that convey information about an animal's experience and physiological needs to aggression circuits. Rather than simply turning aggression on or off, these signals alter how the underlying circuits respond to social cues and can produce both rapid and lasting changes in behavior. Together, our findings show that aggression circuits are not fixed command systems but adaptable networks whose operation is shaped by neuromodulators that reflect the animal's history and current state.

Faculty: Bios and Abstracts



Kathleen Cullen

Raj and Neera Singh Professor of Biomedical Engineering, Department of Biomedical Engineering, Whiting School of Engineering, Johns Hopkins University; Co-Director, Center for Hearing and Balance, Johns Hopkins University

kathleen.cullen@jhu.edu

Research Areas

Multisensory integration for action and perception
neural mechanisms of motor learning
neural prosthesis and rehabilitation
computational neuroscience
therapeutic advances for treating movement disorders

Lab

thecullenlab.org

Schedule

Faculty Talk
1:55 to 2:25 p.m.

Panel Discussion
5:05 to 5:45 p.m.

Bio

KATHLEEN CULLEN is the Raj and Neera Singh Professor of Biomedical Engineering at Johns Hopkins University and director of the Center for Hearing and Balance. Her research investigates how neural circuits integrate sensory and motor signals to guide movement and maintain balance during natural behavior, and how these computations can be harnessed to restore function. Her laboratory combines large-scale neural recordings with targeted stimulation and quantitative analysis of behavior to study vestibular, cerebellar, and thalamocortical circuits. This work spans fundamental studies of how neural circuits respond and adapt to perturbation to the development of vestibular prostheses and emerging closed-loop neuromodulation approaches. A central goal is to move beyond conventional stimulation toward circuit-informed strategies that engage the brain's own computations and dynamics to restore sensorimotor function.

Abstract

From Stimulation to Computation: Neuromodulation of Sensorimotor Circuits

Neuromodulation is increasingly used to alter neural function, yet we still understand remarkably little about how externally imposed signals interact with the computations performed by the circuits they target. Our work addresses this question in sensorimotor systems, where neural activity can be linked quantitatively to both natural movement

and behavior. I will discuss studies combining neural recordings, precisely controlled stimulation, and freely moving behavior to determine how artificial input is represented, integrated, and adapted within vestibular, cerebellar, and thalamocortical circuits. This work shows that the consequences of stimulation depend critically on the ongoing computations and behavioral state of the targeted network. I will highlight how these principles are informing our development of vestibular prostheses and emerging closed-loop approaches that use ongoing neural dynamics to determine when and how stimulation is delivered. Together, these studies move beyond stimulation as an external perturbation toward neuromodulation strategies designed around the computations of the neural circuits themselves.

Faculty: Bios and Abstracts



Ilya Monosov

Bloomberg Distinguished Professor, Department of Neuroscience, Krieger School of Arts and Sciences, Johns Hopkins University; Adjunct Professor, Biomedical Engineering and Psychiatry, School of Medicine, Johns Hopkins University

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Research Areas

Neural Circuits

Ensembles and Connectomes

Systems, Cognitive and Computational Neuroscience

Neurobiology of Disease

Lab

neuroscience.jhu.edu/research/faculty/176

Schedule

Faculty Talk
3:10 to 3:40 p.m.

Panel Discussion
5:05 to 5:45 p.m.

Bio

ILYA MONOSOV is a neuroscientist and Bloomberg Distinguished Professor at Johns Hopkins University, with appointments in the departments of Neuroscience, Biomedical Engineering, Electrical and Computer Engineering, and Psychiatry. He directs the Laboratory of Adaptive and Maladaptive Behavior and is a member of the Zanvyl Krieger Mind/Brain Institute and the Data Science and AI Institute. His research centers on the mechanisms that govern motivation, emotion, curiosity, and decision-making under uncertainty, and spans computational and animal models. The laboratory investigates how these mechanisms break down in disorders of cognition and mood. Recent work also examines brain–body interactions, including how prefrontal and hypothalamic circuits regulate the body's autonomic state. By uncovering how biological circuits produce adaptive and maladaptive behavior and translating these principles into computational psychiatry and machine learning, the lab aims to improve mental and physical health and to build algorithms that better serve human goals.

Abstract

Curiosity and Calm: A Shared, Targetable Circuit for Curiosity, Risk, and Bodily State

Curiosity evolved under constraints of time, effort, and risk. We previously showed that it is regulated by conserved valuation circuitry that weighs the value of resolving uncertainty against its costs.

I will discuss how the neural circuitry that computes these tradeoffs and processes uncertainty about the future also regulates physiological responses in the body. I will present our recent work in non-human primates showing that the circuits that encode risk and information preferences also control heart rate and heart rate variability through prefrontal-to-hypothalamic projections, and that targeting these circuits directly alters both bodily state and individual risk attitudes, pointing toward new interventions for stress and mood disorders, in which the adaptive link between mind and body is often disrupted. I will conclude by arguing that because uncertainty processing and heart rate regulation share a biological substrate, ongoing shifts in how we seek and consume information may also retune autonomic reactivity. Viewing both as outputs of a partly overlapped conserved system offers a unified account of how the age of information shapes our mind and body.

Short Talk: Bios and Abstracts



Varun B. Chokshi

Assistant Research Scientist, Neuroscience Department, Johns Hopkins University

Lab

Daniel H. O'Connor

Schedule

Short Talks with Emerging Scientists
2:25 to 3:10 p.m.

Bio

Systems neuroscientist studying how neural circuits adapt across development, learning, disease. My work spans experience-dependent synaptic plasticity in the visual cortex currently, neuromodulatory (locus coeruleus–norepinephrine) control of movement behavior, using chronic and single-unit electrophysiology, optogenetics, and quantitative behavior. My broader goal is to understand how neuromodulatory systems shape its refinement through learning.

Abstract

Dorsoventral Gradient in the Locus Coeruleus for Signaling Different Aspects of Movement

Arousal and movement are tightly linked to the locus coeruleus norepinephrine (LC-NE) system, yet the relationships between specific features of movement and LC neuron activity remain largely unclear. LC-NE organization follows a dorsoventral gradient, with dorsal neurons projecting to the forebrain and ventral neurons to the hindbrain (Su et al., *Nature,* 2026). We asked how LC activity along this axis maps onto movement, from the shift between rest and action to fast kinematics.

We recorded optogenetically-identified LC-NE neurons across both hemispheres while mice performed a "sequence-licking" task. An auditory cue drove mice from rest into action, guiding a lick port through a left-to-right or right-to-left sequence; on

25% of trials, an unexpected “missed lick” required a rapid switch to an alternative sequence.

LC-NE neurons responded robustly to two salient stimuli at the two boundaries of action: the initiating cue and the rewarded licks that ended the sequence, bookending each bout of motor engagement. Strikingly, responses to the mid-sequence omission were mostly weak despite its salience. These engagement signals were more prominent in dorsal neurons. A second signal tracked movement itself: LC-NE activity was correlated on trial-by-trial basis with tongue and jaw kinematics, licking sequence direction, and reaction time, and this kinematic-linked signals were more prominent in ventral neurons.

Together, these data show that LC neurons signal distinct aspects of movement, engagement transitions and ongoing kinematics, segregated along the dorsoventral axis, implying that the LC can route different movement signals to forebrain and hindbrain targets.

Short Talk: Bios and Abstracts



This speaker's participation is made possible by support from the National Science Foundation.

Leslie Sibener

Postdoctoral Fellow, Kavli Neural Systems Institute, The Rockefeller University

Simons Postdoctoral Fellow, Laboratory of Neural Dynamics and Cognition, Kavli Neural Systems Institute at The Rockefeller University (Mentor: Priya Rajasethupathy)

Lab

Priya Rajasethupathy, Kavli Neural Systems Institute, The Rockefeller University

Schedule

Short Talks with Emerging Scientists
2:25 to 3:10 p.m.

Bio

LESLIE SIBENER, A&S '16, grew up in Chicago. She received her BA and BS in creative writing and neuroscience from Johns Hopkins University, and completed her PhD in neurobiology and behavior at Columbia University in Rui Costa's Lab. In the Rajasethupathy Lab, she is interested in exploring the underlying mechanisms that select specific memories for long-term storage in the brain. Outside of the lab, Leslie is passionate about writing poetry, hitting the trails at national parks, and enjoying a pot of tea with friends.

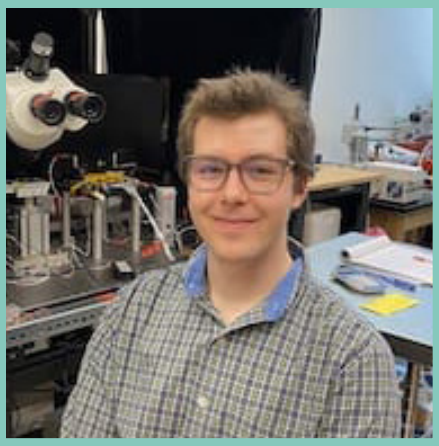
Abstract

Neuromodulatory Signals in the Anteromedial Thalamus and the Selection of Long-Term Memories

The ability to store information about significant events while discarding irrelevant ones is essential for survival. How that selection is computed, and where in the brain it happens, remains an open question. Recent work identified the anteromedial thalamus (AM) as a gate for hippocampal-to-cortical consolidation, stabilizing salient memories through recurrent interactions with anterior cingulate cortex (ACC). However, it is still unknown how this gate operates locally within AM. We hypothesized that context-dependent neuromodulatory signals in AM provide a selection signal for long-term memory. To test this, we developed a virtual reality task for mice in which four contexts vary in frequency and outcome, yielding three remem-

bered contexts and one forgotten context within the same animal. After mapping neuromodulatory inputs to AM, we used multi-site fiber photometry with GRAB sensors to survey candidate neuromodulators in AM and ACC during learning and recall of the contextual memory task. Acetylcholine (ACh) and norepinephrine (NE) emerged as carrying complementary signals. In AM, but not ACC, ACh responded phasically to aversive outcomes, whereas NE developed reward-specific responses over training. Encoding models showed that task variables explained more ACh than NE variance in both regions. Notably, trial-matched decoders trained on cue zone ACh or NE signals discriminated all remembered contexts but failed to classify the forgotten context from others during learning. These results show that thalamic ACh and NE carry context-specific signals that track which memories are later retained, identifying AM neuromodulation as a candidate mechanism for memory selection.

Short Talk: Bios and Abstracts



Christian Wesselborg

Graduate Student, Biology (CMDB), Johns Hopkins University

Lab

Alfredo Kirkwood,
Hey-Kyoung Lee

Schedule

Short Talks with Emerging Scientists
2:25 to 3:10 p.m.

Bio

CHRISTIAN WESSELBORG completed his undergraduate studies at Rensselaer Polytechnic studying biochemistry and biophysics before starting his PhD at the Biology Department at Johns Hopkins, making a sharp change in direction to neuroscience mentored by Alfredo Kirkwood and Hey-Kyoung Lee. He studies how neurons delayed release of chemical neuromodulators to modify synapses in a pathway specific manner in the mouse visual cortex, and is supported by an F31 fellowship from the NIH.

Abstract

Pathway Specific Eligibility Traces: Reinforcement-Like Plasticity in the Visual Cortex

Coincident pre- and post-syanaptic activity is the basis of Hebbian plasticity. However, behaviorally relevant feedback information conveying saliency and valance, is often delayed on the order of seconds after neural activity. Therefore, Hebbian mechanism alone is insufficient to account for reinforcement-based learning. To address this, an eligibility trace or eTrace was suggested. An eTrace alone is silent and transient, and only when a delayed signal arrives within its transient time window does synaptic modification occur. Experimental evidence for eTraces has been described recently in several brain regions indicating a common and widespread mechanism for reinforcementlike learning on behavioral

timescales. In our previous work, we demonstrated that delayed neuromodulators, norepinepherine (NE) and serotonin (5-HT), are responsible for converting eTraces into synaptic plasticity in the mouse primary visual cortex (V1) at the feedforward Layer 4 to Layer 2/3 pathway. Whether such neuromodulator-dependent eTraces are universal across all synapses or are limited to a subset has not been established. We investigate the pathway specificity of eTraces using whole-cell patchclamp electrophysiology, recording from L2/3 pyramidal cells while stimulating two independent pathways: feedforward L4 to L2/3 and lateral intracortical L2/3 to L2/3 connections. We demonstrate that NE and 5-HT coupled eTraces in V1 are restricted to feedforward connections. Furthermore, we found that the intracortical pathways express a distinct eTrace mechanism converted by Acetylcholine, which is not found in the feedforward pathway. Our results support a novel view that distinct information streams in V1 are modified by behavioral-timescale reinforcement-like mechanisms coupled to distinct neuromodulatory signals.

Lightning Talks: Abstracts

This speaker's participation is made possible by support from the National Science Foundation.

Janie Chang-Weinberg

Graduate Student, Department of Neurobiology, University of California San Diego

Lab

Matthew Banghart, University of California San Diego

Schedule

Lightning Talks

4:50 to 5:05 p.m.

Abstract

Treating Pain by Training Brains

In placebo analgesia, prior experience and expectations lead to pain suppression upon administration of an inert substance. Although endogenous opioid neuropeptide signaling is strongly associated with placebo analgesia, it has been difficult to establish the underlying circuit mechanisms due to a lack of tools for precision monitoring and manipulation in vivo. To identify sites in the brain at which endogenous signaling is causal and establish the precise timing of peptide release, we reverse-translated a placebo protocol from humans to mice that involves contextual conditioning with morphine to produce endogenous opioid-dependent placebo analgesia. Extensive behavioral characterization revealed that the placebo effect suppressed both nociception and unconditioned emotional-motivational pain-related behavior. Remarkably, the analgesic effect generalizes across pain modalities, and conditioning in pain-naive animals produces lasting, opioid-dependent placebo analgesia after a subsequent injury. Fiber photometry recordings in the periaqueductal grey (PAG) using the genetically-encoded opioid sensor—deltaLight—revealed increased endogenous opioid activity in response to noxious stimulus presentation only after conditioning. Photopharmacological blockade of opioid receptors using the light-activated naloxone derivative—PhNX—prior to noxious stimulus presentation established the necessity of endogenous opioid

signaling in the PAG for placebo analgesia. Complementary activity-dependent neuronal labeling and chemogenetic manipulations uncovered a critical cortico-PAG-medullary signaling axis. Our data reveal that placebo conditioning potentiates noxious stimulus-evoked endogenous opioid release in the vlPAG, which causally gates descending pain modulation. These results suggest a translational strategy in which preventive placebo conditioning can build resilience to pain via enhanced endogenous opioid signaling in the brain.

Lightning Talks: Abstracts

This speaker's participation is made possible by support from the National Science Foundation.

Lin Lin

Postdoctoral Fellow, Department of Psychiatry, Yale University School of Medicine

Lab

Alicia Che,Department of Psychiatry, Yale University School of Medicine

Schedule

Lightning Talks

4:50 to 5:05 p.m.

Abstract

A Critical Role for Oxytocin in the Emergence of Social Touch Representation

Sensory cortex represents the world not rigidly, but in a manner constantly shaped by an animal's behavioral context and internal state. Neuromodulators are often the bridge linking sensory processing to these demands. I study one such link: how oxytocin signaling allows social context to shape tactile representation in primary somatosensory cortex (S1), enabling the encoding of social touch, and how this capacity emerges during development.

In a developing pup, social context, such as the presence of the dam, increases oxytocin release from the hypothalamus and oxytocin levels in S1. SST interneurons, which suppress weak excitatory inputs in active cortical networks, are a principal cell type expressing the oxytocin receptor (OXTR) in S1. I found that dam presence elevated SST activity in vivo and sparsified the S1 excitatory population's response to touch, suppressing weakly and unreliably responsive neurons to reduce noise and enhance salience. Bidirectional pharmacological manipulation of OXTR recapitulated or blocked this sparsification, and SST-specific OXTR deletion abolished it. Developmentally, this modulation emerged in the third postnatal week, as S1 OXTR expression peaked. Building on these findings, I am now asking whether oxytocin only acutely mediates the representation of social information, or also durably shapes the developing circuit, starting

with whether SST-OXTR deletion alters inhibitory connectivity. In the longer term, I aim to investigate whether these developmental changes in S1 affect social behavior, linking S1's integration of social and tactile information to the functions it may ultimately serve.

Lightning Talks: Abstracts

Julia Pai

Postdoctoral Fellow,
Neuroscience Department,
Johns Hopkins University

Lab

Ilya Moniosov

Schedule

Lightning Talks
4:50 to 5:05 p.m.

Abstract

Ventral Striatal Astrocytes Contribute to Reinforcement Learning

Astrocytes influence synaptic plasticity and neuronal function through astrocytic calcium signaling. However, astrocytes' contribution to cognitive operations like reinforcement learning (RL) remains unclear. To examine this, we trained mice on a RL dependent probabilistic decision-making task. We attenuated astrocyte Ca++ across distinct striatal regions, and found astrocyte Ca++ attenuation specifically in ventral striatum (VS) increased decision noisiness and impaired reward-guided choice performance. This effect was largely due to a reduction in "win-stay" behavior. Using in-vivo calcium imaging, we found that VS astrocyte Ca++ correlated with reward prediction errors (RPEs). Furthermore, these trial-by-trial Ca++ fluctuations predicted trial-by-trial choice variability. In-silico lesions of a biologically constrained circuit model suggest that astrocytes could regulate behavioral variability by sharing dopaminergic RPE signals across populations of striatal neurons. Together, these results suggest that VS astrocytes actively mediate learning signals in cortico-striatal function to mediate learning and decision-making.

Lightning Talks: Abstracts

Drishti Soneja

Graduate Student, Neuroscience Department, Johns Hopkins University

Lab

Tomomi Karigo

Schedule

Lightning Talks

4:50 to 5:05 p.m.

Abstract

Hypothalamic Circuits Underlying Emergence of Maternal Care

Authors: Drishti Soneja[1], Adam Charles[1], Tomomi Karigo[1,2]

Affiliations: Johns Hopkins University[1], Kennedy Krieger Institute[2]

Maternal behaviors are critical adaptive responses essential for the survival and well-being of the offspring. These behaviors are multifaceted, mainly comprising protective behaviors, such as aggression towards unfamiliar adults, and nurturing behaviors towards offspring. Although both behaviors are enhanced during motherhood, the neural mechanisms that control these behaviors, and importantly, how they are coordinated, are not well understood. Our work has identified a novel role for ventrolateral hypothalamic (VMHvl) Npy2r+ neurons in regulating protective and nurturing aspects of maternal behavior, indicating this population may function as a hub for coordinating distinct maternal behaviors. In virgin females, initial stimulation of this population results in mixed responses of aggression or care towards pups. In contrast, stimulation of this population in experienced virgins, lactating dams and post-lactating females results in aggression selectively towards intruders and results in increased grooming behaviors towards pups. We further investigated the functional role of the projection of Npy2r+ neurons from the VMHvl to MPOA and identified the role of this projection

in enhancing pup grooming behavior in lactating dams and post-lactating females. These findings uncover a previously unexplored role of VMHvl Npy2r+ neurons in supporting flexible caregiving responses across reproductive states, highlighting the dynamic reorganization of hypothalamic circuits after pregnancy. To understand how different social stimuli evoke different behaviors, we recorded the neural activity of VMHvl Npy2r+ neurons and characterized how neural activity of this population encodes behavioral outputs and social stimuli across reproductive stages. This work reveals how a “maternal state” emerges in the brain and alters behaviors in a life-stage dependent manner.

Lightning Talks: Abstracts

Kimberley Wyse-Sookoo

Graduate Student, Department of Biomedical Engineering, Johns Hopkins University

Lab

Kelly Mills

Schedule

Lightning Talks

4:50 to 5:05 p.m.

Abstract

Effects of Phase-Dependent Stimulation on Upper Limb Bradykinesia in Parkinson's Disease

Parkinson's disease (PD) is the second most common neurodegenerative disorder. PD motor symptom severity correlates with the power of beta-band oscillations in the subthalamic nucleus and the level of beta-gamma phase-amplitude coupling (PAC) in the motor cortex. PAC in PD decreases in a dose-dependent manner in response to both therapeutic dopaminergic medication and deep brain stimulation (DBS). Recently, it has also been shown that PAC can be modulated by stimulation pulses delivered to the motor cortex that are locked to a specific beta-band phase (phase-dependent stimulation, PDS). This study aims to determine whether PDS can alleviate PD motor symptoms, particularly bradykinesia. Repetitive grasping tasks were captured using LEAP infrared motion sensors during DBS implantation procedures in human participants with PD. Prior to DBS implantation, a 63-channel high density electrocorticography (ECoG) array which was able to simultaneously record neural signals and deliver stimulation pulses was placed over the hand region of the motor cortex. Each task was run once without stimulation (baseline), and twice with PDS with varied phase targets. When compared to baseline, grasping acceleration and velocity increased as the mean stimulation phase approached the trough phase of the recorded beta oscillation (180º), and decreased

as the mean stimulation phase approached the peak phase (0º). Grasping amplitude showed a similar, though somewhat weaker, response that appeared to be inversely correlated with changes in grasping frequency. Our results suggest that PDS has the potential to be an option for treating PD bradykinesia that avoids the parenchymal penetration required for DBS.

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