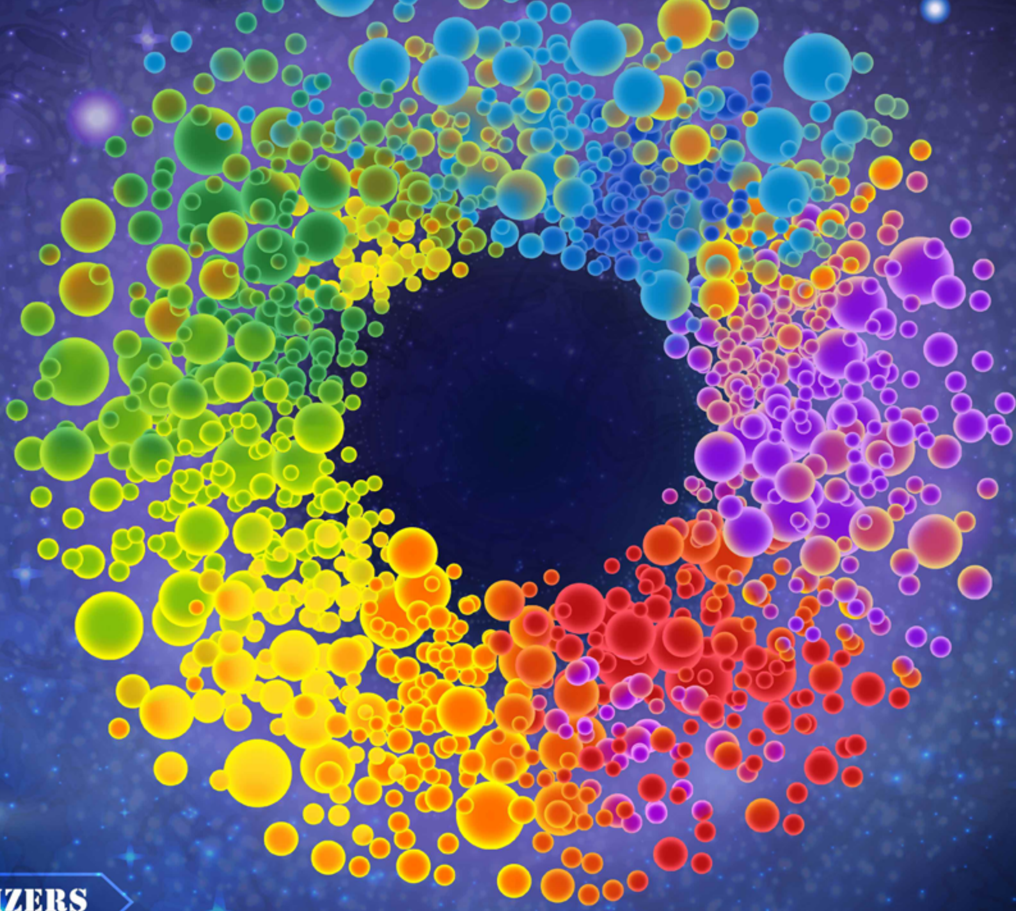
CNeuro2020

THEORETICAL AND COMPUTATIONAL NEUROSCIENCE Summer School

Online, hosted by Tsinghua University
August 17th - August 23rd, 2020



ORGANIZERS

Rava Azeredo da Silveira Ecole Normale Superieure, France
Sen Song Tsinghua University, China
Louis Tao Peking University, China
Xiaoqin Wang Johns Hopkins University, USA
Quan Wen University of Science and Technology of China

FACULTY

Rava Azeredo da Silveira (ENS)
Stella Christie (Tsinghua University)
Damon Clark (Yale University)
Carina Curto (Penn State University)
Ralf Haefner (University of Rochester)
Yu Hu (HKUST)
Daniel Lee (Cornell University)
Songting Li (Shanghai JiaoTong University)
Zhaoping Li (MPI of Biologial Cybernetics)
Cristina Savin (NYU)
Eric Shea-Brown (University of Washington)
Sara Solla (Northwestern University)
Sen Song (Tsinghua University)
Louis Tao (Peking University)
Xiaoqin Wang (Johns Hopkins University)
Quan Wen (USTC)
Hang Zhang (Peking University)
Kechen Zhang (Johns Hopkins University)
Douglas Zhou (Shanghai JiaoTong University)

CNeuro2020 is a zoom online school

清华大学脑与智能实验室 Tsinghua Laboratory of Brain and Intelligence
清华大学 Tsinghua University
丘成桐数学科学中心 YAU MATHEMATICAL SCIENCES CENTER

CNeuro2020 Summer School

How intelligence and behavior emerge from complex and intricate interactions within the brain remains a deep and unsolved mystery, central to an exciting area of interdisciplinary research. The past decade has seen rapid progress in experimental tools that now make it possible to monitor and manipulate brain circuits in unprecedented detail. This evolution presents challenges and opportunities for both experimentalists and theorists, as the complex algorithmics of brain function and the intricate interactions among neurons cannot be approached with experiments alone. Mathematical theory is instrumental in the emergence of theoretical insights and frameworks that can help guide experimental work and identify unifying principles of brain function.

The aim of the one-week summer school will be to introduce students with a strong quantitative background (in mathematics, physics, computer science, and engineering) to the emerging field of theoretical and computational neuroscience. The course will bring together leading scientists in the field, who will deliver lectures, take part in small-group discussions, and share their personal experience and views on a range of research topics. The distinguishing feature of CNeuro is the emphasis it places on the role of systematic mathematical theory for understanding the brain, in part by stressing the connections between neuroscience, statistics, machine learning, and artificial intelligence. The summer school will serve as a pedagogical introduction to some of the methods particularly relevant to exploring these connections. This year is the third installment of the CNeuro summer school. Participants of CNeuro2020 are from more than 20 countries and 50 universities with a diverse background, from fields in Mathematics, Physics, Computer Science, Cognitive Sciences, Quantitative Life Sciences, and Biomedical Engineering, 30% of this this year’s participants are females. We expect that you will fully engage with the lectures and interactive discussions, and learn from each other. We hope that CNeuro2020 will be an unforgettable experience for all of you!

About THBI

Tsinghua Laboratory of Brain and Intelligence (THBI) is an interdisciplinary research institute established in 2017. The institute aims to answer foundational questions about brain-mind and intelligence through cutting edge, interdisciplinary research efforts. To do so, THBI brings together experts from all over the world from the fields of brain science, computational neuroscience, engineering, artificial intelligence, and cognitive science. THBI houses 10 research centers, each headed by a permanent faculty member, as well as a large number of affiliated members from various schools and departments at Tsinghua University. Scholars at THBI have access to excellent research support and facilities, including the largest marmoset facility in China, an advanced imaging center, computing facilities, and a developmental laboratory. THBI adopts an English-speaking working environment to foster vibrant, international academic collaborations.
http://brain.tsinghua.edu.cn/column/English

CNeuro2020: Theoretical and Computational Neuroscience Summer School

Speaker & Moderator	Lecture Title	Date & Time GMT+8 (Beijing)	Date & Time GMT+2 (Paris)	Date & Time GMT-4 (New York)
Xiaoqin Wang (Johns Hopkins U) & Rava da Silveira (ENS)	CNeuro2020 Introduction	August 17 (Monday) 8:00-8:30	August 17 (Monday) 2:00-2:30	August 16 (Sunday) 20:00-20:30
Eric Shea-Brown (U of Washington) Moderator: Xiaoqin Wang	Dimensionality in Neural Networks	8:30-9:15 lecture	2:30-3:15 lecture	20:30-21:15 lecture
		9:15-9:25 break	3:15-3:25 break	21:15-21:25 break
		9:25-10:10 lecture	3:25-4:10 lecture	21:25-22:10 lecture
		10:10-10:30 questions	4:10-4:30 questions	22:10-22:30 questions
Organizers & Lecturers	Group Discussion 1	10:30-11:00	4:30-5:00	22:30-23:00
Songting Li (SJTU) Moderator: Quan Wen (USTC)	Dendritic Integration and Computation	12:00-12:45 lecture	6:00-6:45 lecture	August 17 (Monday) 0:00-0:45 lecture
		12:45-12:55 break	6:45-6:55 break	0:45-0:55 break
		12:55-13:40 lecture	6:55-7:40 lecture	0:55-1:40 lecture
		13:40-14:00 questions	7:40-8:00 questions	1:40-2:00 questions
Songting Li (SJTU) Moderator: Louis Tao (PKU)	Dendritic Integration and Computation	20:00-20:45 lecture	14:00-14:45 lecture	8:00-8:45 lecture
		20:45-20:55 break	14:45-14:55 break	8:45-8:55 break
		20:55-21:40 lecture	14:55-15:40 lecture	8:55-9:40 lecture
		21:40-22:00 questions	15:40-16:00 questions	9:40-10:00 questions
Organizers & Lecturers	Group Discussion 2	22:00-22:30	16:00-16:30	10:00-10:30
Xiaoqin Wang (Johns Hopkins U) & Rava da Silveira (ENS)	CNeuro 2020 Introduction	23:00-23:30	17:00-17:30	11:00-11:30
Eric Shea-Brown (U of Washington) Moderator: Rava da Silveira	Dimensionality in Neural Networks	23:30-0:15 lecture	17:30-18:15 lecture	11:30-12:15 lecture
		0:15-0:25 break	18:15-18:25 break	12:15-12:25 break
		0:25-1:10 lecture	18:25-19:10 lecture	12:25-13:10 lecture
		1:10-1:30 questions	19:10-19:30 questions	13:10-13:30 questions
Kechen Zhang (Johns Hopkins U) Moderator: Sen Song (Tsinghua U)	Dynamical models of spatial representations in the hippocampal system	August 18 (Tuesday) 8:00-8:45 lecture	August 18 (Tuesday) 2:00-2:45 lecture	20:00-20:45 lecture
		8:45-8:55 break	2:45-2:55 break	20:45-20:55 break
		8:55-9:40 lecture	2:55-3:40 lecture	20:55-21:40 lecture
		9:40-10:00 questions	3:40-4:00 questions	21:40-22:00 questions
Organizers & Lecturers	Group Discussion 3	10:00-10:30	4:00-4:30	22:00-22:30
Yu Hu (HKUST) Moderator: Louis Tao (PKU)	Relating Dynamics and Connectivity in Recurrent Neuronal Networks	12:00-12:45 lecture	6:00-6:45 lecture	August 18 (Tuesday) 0:00-0:45 lecture
		12:45-12:55 break	6:45-6:55 break	0:45-0:55 break
		12:55-13:40 lecture	6:55-7:40 lecture	0:55-1:40 lecture
		13:40-14:00 questions	7:40-8:00 questions	1:40-2:00 questions
Yu Hu (HKUST) Moderator: Quan Wen	Relating Dynamics and Connectivity in Recurrent Neuronal Networks	20:00-20:45 lecture	14:00-14:45 lecture	8:00-8:45 lecture
		20:45-20:55 break	14:45-14:55 break	8:45-8:55 break
		20:55-21:40 lecture	14:55-15:40 lecture	8:55-9:40 lecture
		21:40-22:00 questions	15:40-16:00 questions	9:40-10:00 questions

Organizers & Lecturers	Group Discussion 4	22:00-22:30	16:00-16:30	10:00-10:30
Kechen Zhang (Johns Hopkins U) Moderator: Rava da Silveira	Dynamical models of spatial representations in the hippocampal system	August 19 (Wednesday) 0:00-0:45 lecture	18:00-18:45 lecture	12:00-12:45 lecture
		0:45-0:55 break	18:45-18:55 break	12:45-12:55 break
		0:55-1:40 lecture	18:55-19:40 lecture	12:55-13:40 lecture
		1:40-2:00 questions	19:40-20:00 questions	13:40-14:00 questions
Damon Clark (Yale University) Moderator: Quan Wen	Modeling Visual Motion Estimation	8:00-8:45 lecture	August 19 (Wednesday) 2:00-2:45 lecture	20:00-20:45 lecture
		8:45-8:55 break	2:45-2:55 break	20:45-20:55 break
		8:55-9:40 lecture	2:55-3:40 lecture	20:55-21:40 lecture
		9:40-10:00 questions	3:40-4:00 questions	21:40-22:00 questions
Organizers & Lecturers	Group Discussion 5	10:00-10:30	4:00-4:30	22:00-22:30
Zhaoping Li (MPI Biological Cybernetics) Moderator: Sen Song	From V1SH to CPD in the Encoding-Selection-Decoding (ESD) framework for understanding vision	14:00-14:45 lecture	8:00-8:45 lecture	August 19 (Wednesday) 2:00-2:45 lecture
		14:45-14:55 break	8:45-8:55 break	2:45-2:55 break
		14:55-15:40 lecture	8:55-9:40 lecture	2:55-3:40 lecture
		15:40-16:00 questions	9:40-10:00 questions	3:40-4:00 questions
Organizers & Lecturers	Group Discussion 6	16:00-16:30	10:00-10:30	4:00-4:30
Zhaoping Li (MPI Biological Cybernetics) Moderator:Rava da Silveira	From V1SH to CPD in the Encoding-Selection-Decoding (ESD) Framework for Understanding Vision	21:00-21:45 lecture	15:00-15:45 lecture	9:00-9:45 lecture
		21:45-21:55 break	15:45-15:55 break	9:45-9:55 break
		21:55-22:40 lecture	15:55-16:40 lecture	9:55-10:40 lecture
		22:40-23:00 questions	16:40-17:00 questions	10:40-11:00 questions
Damon Clark (Yale University) Moderator: Rava da Silveira	Modeling Visual Motion Estimation	August 20 (Thursday) 0:00-0:45 lecture	18:00-18:45 lecture	12:00-12:45 lecture
		0:45-0:55 break	18:45-18:55 break	12:45-12:55 break
		0:55-1:40 lecture	18:55-19:40 lecture	12:55-13:40 lecture
		1:40-2:00 questions	19:40-20:00 questions	13:40-14:00 questions
Carina Curto (Penn State University) Moderator: Quan Wen	Dynamic Attractors in Threshold-Linear Networks	8:00-8:45 lecture	August 20 (Thursday) 2:00-2:45 lecture	20:00-20:45 lecture
		8:45-8:55 break	2:45-2:55 break	20:45-20:55 break
		8:55-9:40 lecture	2:55-3:40 lecture	20:55-21:40 lecture
		9:40-10:00 questions	3:40-4:00 questions	21:40-22:00 questions
Organizers & Lecturers	Group Discussion 7	10:00-10:30	4:00-4:30	22:00-22:30
Douglas Zhou (SJTU) Moderator: Sen Song	Modeling and Analysis of Balanced State in Neuronal Networks	12:00-12:45 lecture	6:00-6:45 lecture	August 20 (Thursday) 0:00-0:45 lecture
		12:45-12:55 break	6:45-6:55 break	0:45-0:55 break
		12:55-13:40 lecture	6:55-7:40 lecture	0:55-1:40 lecture
		13:40-14:00 questions	7:40-8:00 questions	1:40-2:00 questions

Douglas Zhou (SJTU) Moderator: Louis Tao	Modeling and Analysis of Balanced State in Neuronal Networks	20:00-20:45 lecture	14:00-14:45 lecture	8:00-8:45 lecture
		20:45-20:55 break	14:45-14:55 break	8:45-8:55 break
		20:55-21:40 lecture	14:55-15:40 lecture	8:55-9:40 lecture
		21:40-22:00 questions	15:40-16:00 questions	9:40-10:00 questions
Organizers & Lecturers	Group Discussion 8	22:00-22:30	16:00-16:30	10:00-10:30
Carina Curto (Penn State University) Moderator: Rava da Silveira	Dynamic Attractors in Threshold-Linear Networks	August 21 (Friday) 0:00-0:45 lecture	18:00-18:45 lecture	12:00-12:45 lecture
		0:45-0:55 break	18:45-18:55 break	12:45-12:55 break
		0:55-1:40 lecture	18:55-19:40 lecture	12:55-13:40 lecture
		1:40-2:00 questions	19:40-20:00 questions	13:40-14:00 questions
Cristina Savin (NYU) Moderator: Quan Wen	Probabilistic computation in the brain	8:00-8:45 lecture	August 21 (Friday) 2:00-2:45 lecture	20:00-20:45 lecture
		8:45-8:55 break	2:45-2:55 break	20:45-20:55 break
		8:55-9:40 lecture	2:55-3:40 lecture	20:55-21:40 lecture
		9:40-10:00 questions	3:40-4:00 questions	21:40-22:00 questions
Organizers & Lecturers	Group Discussion 9	10:00-10:30	4:00-4:30	22:00-22:30
Hang Zhang (Peking University) Moderator: Louis Tao	Decision-Theoretic Modeling of Perception and Cognition	12:00-12:45 lecture	6:00-6:45 lecture	August 21 (Friday) 0:00-0:45 lecture
		12:45-12:55 break	6:45-6:55 break	0:45-0:55 break
		12:55-13:40 lecture	6:55-7:40 lecture	0:55-1:40 lecture
		13:40-14:00 questions	7:40-8:00 questions	1:40-2:00 questions
Hang Zhang (Peking University) Moderator: Rava da Silveira	Decision-Theoretic Modeling of Perception and Cognition	20:00-20:45 lecture	14:00-14:45 lecture	8:00-8:45 lecture
		20:45-20:55 break	14:45-14:55 break	8:45-8:55 break
		20:55-21:40 lecture	14:55-15:40 lecture	8:55-9:40 lecture
		21:40-22:00 questions	15:40-16:00 questions	9:40-10:00 questions
Organizers & Lecturers	Group Discussion 10	22:00-22:30	16:00-16:30	10:00-10:30
Cristina Savin (NYU) Moderator: Rava da Silveira	Probabilistic Computation in the Brain	August 22 (Saturday) 0:00-0:45 lecture	18:00-18:45 lecture	12:00-12:45 lecture
		0:45-0:55 break	18:45-18:55 break	12:45-12:55 break
		0:55-1:40 lecture	18:55-19:40 lecture	12:55-13:40 lecture
		1:40-2:00 questions	19:40-20:00 questions	13:40-14:00 questions
Sara Solla (Northwestern University) Moderator: Xiaoqin Wang	Models for Unsupervised and Supervised Learning	6:00-6:45 lecture	August 22 (Saturday) 0:00-0:45 lecture	18:00-18:45 lecture
		6:45-6:55 break	0:45-0:55 break	18:45-18:55 break
		6:55-7:40 lecture	0:55-1:40 lecture	18:55-19:40 lecture
		7:40-8:00 questions	1:40-2:00 questions	19:40-20:00 questions
Ralf Halfner (University of Rochester) Moderator: Louis Tao	Neural Population Coding in a Hierarchical Bayesian Inference Framework	8:00-8:45 lecture	2:00-2:45 lecture	20:00-20:45 lecture
		8:45-8:55 break	2:45-2:55 break	20:45-20:55 break
		8:55-9:40 lecture	2:55-3:40 lecture	20:55-21:40 lecture
		9:40-10:00 questions	3:40-4:00 questions	21:40-22:00 questions
Organizers & Lecturers	Group Discussion 11	10:00-10:30	4:00-4:30	22:00-22:30

Sara Solla (Northwestern University) Moderator: Rava da Silveira	Models for Unsupervised and Supervised Learning	20:00-20:45 lecture	14:00-14:45 lecture	August 22 (Saturday) 8:00 -8:45 lecture
		20:45-20:55 break	14:45-14:55 break	8:45-8:55 break
		20:55-21:40 lecture	14:55-15:40 lecture	8:55-9:40 lecture
		21:40-22:00 questions	15:40-16:00 questions	9:40-10:00 questions
Organizers & Lecturers	Group Discussion 12	22:00-22:30	16:00-16:30	10:00-10:30
Ralf Halfner (University of Rochester) Moderator: Rava da Silveira	Neural Population Coding in a Hierarchical Bayesian Inference Framework	August 23 (Sunday) 0:00-0:45 lecture	18:00-18:45 lecture	12:00-12:45 lecture
		0:45-0:55 break	18:45-18:55 break	12:45-12:55 break
		0:55-1:40 lecture	18:55-19:40 ecture	12:55-13:40 lecture
		1:40-2:00 questions	19:40-20:00 questions	13:40-14:00 questions
Daniel Lee (Cornell University) Moderator: Sen Song	Artificial Intelligence vs. Biological Computation	8:00-8:45 lecture	August 23 (Sunday) 2:00-2:45 lecture	20:00-20:45 lecture
		8:45-8:55 break	2:45-2:55 break	20:45-20:55 break
		8:55-9:40 lecture	2:55-3:40 lecture	20:55-21:40 lecture
		9:40-10:00 questions	3:40-4:00 questions	21:40-22:00 questions
Organizers & Lecturers	Group Discussion 13	10:00-10:30	4:00-4:30	22:00-22:30
Stella Christie (Tsinghua University) Moderator: Quan Wen	The Computational Mind: Insights from Cognitive Development	12:00-12:45 lecture	6:00-6:45 lecture	August 23 (Sunday) 0:00-0:45 lecture
		12:45-12:55 break	6:45-6:55 break	0:45-0:55 break
		12:55-13:40 lecture	6:55-7:40 lecture	0:55-1:40 lecture
		13:40-14:00 questions	7:40-8:00 questions	1:40-2:00 questions
Stella Christie (Tsinghua University) Moderator: Louis Tao	The Computational Mind: Insights from Cognitive Development	20:00-20:45 lecture	14:00-14:45 lecture	8:00-8:45 lecture
		20:45-20:55 break	14:45-14:55 break	8:45-8:55 break
		20:55-21:40 lecture	14:55-15:40 lecture	8:55-9:40 lecture
		21:40-22:00 questions	15:40-16:00 questions	9:40-10:00 questions
Organizers & All Students	Round-Up Discussion	22:00-23:00	16:00-17:00	10:00-11:00
Daniel Lee (Cornell University) Moderator: Rava da Silveira	Artificial Intelligence vs. Biological Computation	August 24 (Monday) 0:00-0:45 lecture	18:00-18:45 lecture	12:00-12:45 lecture
		0:45-0:55 break	18:45-18:55 break	12:45-12:55 break
		0:55-1:40 lecture	18:55-19:40 lecture	12:55-13:40 lecture
		1:40-2:00 questions	19:40-20:00 questions	13:40-14:00 questions

CNeuro2020 Organizers

Rava Azeredo da Silveira

Rava Azeredo da Silveira obtained his B.S. in physics at the University of Geneva and his Ph.D. in theoretical physics at the Massachusetts Institute of Technology. Subsequently, he was a Junior Fellow of the Harvard University Society of Fellows. He is currently a CNRS Directeur de Recherche at the Ecole Normale Supérieure, in Paris, and the Professor of Theoretical and Computational Neuroscience at IOB, University of Basel, in Basel. He was also a Global Scholar at Princeton University.

Research Interests

Rava Azeredo da Silveira's lab focuses on a range of topics in theoretical and computational neuroscience and cognitive science. These topics, however, are tied together through a central question: How does the brain represent and manipulate information? Among the more concrete approaches to this question, the lab analyzes and models neural activity in circuits that can be identified, recorded from, and perturbed experimentally. On a more abstract level, the lab investigates the representation of information in populations of neurons, from a statistical and algorithmic—rather than mechanistic—point of view, through theories of coding and data analyses. In the context of cognitive studies, the lab investigates mental processes such as inference, learning, and decision-making, through both theoretical developments and behavioral experiments. A particular focus is the study of neural constraints and limitations and, further, their impact on mental processes.

Sen Song

2010-Present, Principal Investigator / Associate Professor with tenure, Department of Biomedical Engineering, Tsinghua University
2004-2010, Postdoctoral Fellow, Department of Brain and Cognitive Sciences, MIT
2002-2004, Postdoctoral Fellow, Cold Spring Harbor Laboratory
2001-2002, Computational Biologist, GPC Biotech
1996-2002, Ph.D., Department of Biology, Brandeis University

Research Interests

Dr. Song is interested in how neural circuits carry out computations. In collaboration with experts in chip design, he is interested in applying such insights to building systems for neuromorphic computing. He also works on deciphering the neural circuits underlying emotion and motivation using optogenetics in rodent models.

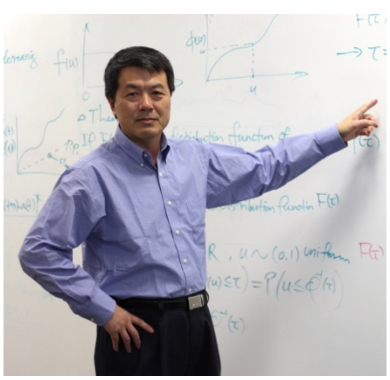
Louis Tao

2008-Present, Principal Investigator, Peking University School of Life Sciences
2003-2007, Assistant Professor, Department of Mathematics, New Jersey Institute of Technology
2000-2003/, Associate Research Scientist, Courant Institute, Department of Mathematics, New York University
1997-2000, Assistant Research Fellow, Department of Astronomy, Columbia University
1995-1997, Assistant Research Fellow, Department of Applied Mathematics and Theoretical Physics, University of Cambridge, UK
1990-1995, Ph.D. in Physics, University of Chicago
1986-1990, A.B. in Physics, Harvard University

Research Interests

Louis was transplanted from Taipei to New York at an early age and had dreams of becoming an astrophysicist. Later on, after two degrees and two postdocs in Physics, he found computational neuroscience to be his true calling. Most recently he has worked on modeling primary visual cortex, theoretical aspects of neuronal population dynamics, information transfer and processing in neural circuits, neuromorphic computations, and live, optical imaging of *C. elegans* behavior and its underlying neural circuits.

Xiaoqin Wang



2005-Present, Professor, Department of Biomedical Engineering, Johns Hopkins University
2002-2005, Associate Professor, Johns Hopkins University
1995-2002, Assistant Professor, Johns Hopkins University
1991-1995, Postdoctoral Fellow, UCSF
1986-1991, PhD in Biomedical Engineering, Johns Hopkins University
1985-1986, MSE in Electrical Engineering and Computer Science, University of Michigan
1980-1984, B.S. in Electrical Engineering, Sichuan University

Research Interests

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 developed a unique experimental model, a highly vocal New World primate - the common marmoset (*Callithrix jacchus*). Using this model system, Dr. Wang’s lab has systematically studied neural coding properties of the auditory cortex in awake and behaving conditions. This work has revealed specialized cortical representations of complex sound features such as pitch and harmonicity, and discovered neural mechanisms involved in vocal feedback control and self-monitoring during speaking. Using newly developed cochlear implant and wireless neural recording techniques in freely roaming marmosets, Dr. Wang’s laboratory is currently studying neural mechanisms underlying cortical processing of vocal communication signals in both normal and hearing-impaired conditions.

Quan Wen

2014-Present, Professor, USTC
2009-2013, Postdoctoral Fellow, Department of Physics and Center for Brain Science, Harvard University
2008, Associate, Janelia Farm Research Campus, HHMI
2001-2007, PhD in Physics, Stony Brook University and Cold Spring Harbor Laboratory
1997-2001, BS in Physics, Fudan University, China

Research Interests

Dr. Wen’s lab is interested in identifying basic principles for motor control and computational algorithms for sensorimotor transformation. By combining a range of experimental and theoretical approaches, his lab aims to tackle these questions by focusing on the nervous systems of *C. elegans* and larval zebrafish, which are relatively compact and optically transparent. These advantages allow his lab to develop optical and computational tools for imaging and manipulating whole brain neural activity in freely behaving animals, which may provide deep insights into how collective activity in a neural network gives rise to complex behaviors.

CNeuro2020 Lecturers

Stella Christie

2018-Present, Research Chair, Associate Professor with Tenure, Tsinghua University
2018, Associate Professor with Tenure, Swarthmore College
2015-2016, Visiting Scholar, Stanford University
2010-2012, Postdoctoral Fellow, University of British Columbia
2010, Ph.D., Northwestern University
2004, B.A. Magna Cum Laude with Highest Honor, Harvard University

Research Interests

Stella Christie is a native of Indonesia; she received her B.A. from Harvard University and Ph.D. from Northwestern University. After getting tenure at Swarthmore College in 2018, Stella made the bold move of relocating to China. She is now Research Chair at Tsinghua Laboratory of Brain and Intelligence, and a tenured associate professor at the Department of Psychology, Tsinghua University. At Tsinghua she founded and directs the THBI Child Cognition Center, the largest child development laboratory in China; one of the largest in Asia.

Dr. Christie researches how humans and other animals acquire relational knowledge, including language learning, spatial intelligence, numerical concepts, social cognition, and creative problem solving. Her work on comparison learning received the 2010 Best Paper Award from the Journal of Cognition and Development. In 2016 she was nominated for the James McDonnell Understanding Human Cognition Award. Having lived in six countries on all hemispheres, Stella holds a special interest in how relational reasoning is influenced by and influences language, culture, and social interactions.

Lecture topic: The Computational Mind: Insights from Cognitive Development

What does the mind compute? What kind of computational mechanisms do the mind employ to solve everyday problems like learning language and acquiring concepts? In this lecture I will chart some answers to these two fundamental questions about computation, using findings and insights from developmental science. The lecture will cover two broad research areas. First, the origins of knowledge: what are the computational problems that infants have to solve at the beginning to make sense of the world? Second, the domain-general computational mechanisms that infants and young children use to solve problems in (1)—such as rule learning, statistical learning, and analogical reasoning. After this overview, I hope to discuss with students whether these domain-general computational mechanisms in cognition can be mapped to neural computations.

Damon Clark

Damon A. Clark, PhD, is an Associate Professor in the Department of Molecular, Cellular, and Developmental Biology, and in the Department of Physics of Yale University. He received his A.B. in physics from Princeton University, after which he spent one year as an intern and data analyst working on refugee issues in Somaliland for the International Rescue Committee. He returned to the US and received his PhD in physics at Harvard University, where he studied how the small nervous system in *C. elegans* encodes temperature preference behaviors. During his postdoctoral work at Stanford, he studied how early visual neurons guide behavior in the fruit fly *Drosophila*.

Research Interests

Damon Clark received his PhD in physics, but his research has always been in neuroscience. He is interested in visual processing, and especially in how visual motion cues are detected and used to guide different behaviors. His lab investigates these questions in the fruit fly Drosophila, where powerful genetic tools can be used to manipulate and measure from identified neurons, providing strong tests of models. The lab is especially interested in describing the mathematical operations involved in motion detection, understanding how they are implemented using circuits and biophysics, and relating them to performance under natural conditions.

Lecture topic: Modeling visual motion estimation

Animals use visual cues to extract motion from scenes, and they use those motion signals to guide many behaviors. In this session, I will discuss how this problem of motion estimation may be framed as an inference problem, how people have solved that abstract problem, and how those solutions relate to theoretical and mechanistic models developed to explain experimental measurements in direction-selective visual circuits.

Carina Curto

2019-Present, Professor, Department of Mathematics, Pennsylvania State University
2014-2019, Associate Professor, Department of Mathematics, Pennsylvania State University
2009-2014, Assistant Professor, Department of Mathematics, University of Nebraska-Lincoln
2008-2009, Courant Instructor, Courant Institute, New York University
2005-2008, Postdoctoral Associate, Center for Molecular and Behavioral Neuroscience
Ph.D. in Mathematics, Duke University
A.B. in Physics, Harvard University

Research Interests

Dr. Curto's research focuses on the mathematical theory and analysis of neural networks and neural codes, using tools and ideas from topology, geometry, algebra, and combinatorics.

Lecture topic: Dynamic attractors in threshold-linear networks

Many networks in the brain display internally-generated patterns of activity—that is, they exhibit emergent dynamics that are shaped by intrinsic properties of the network rather than inherited from an external input. While a common feature of these networks is an abundance of inhibition, the role of network connectivity in pattern generation remains unclear. In this talk I will introduce Combinatorial Threshold-Linear Networks (CTLNs), which are simple "toy models" of recurrent networks consisting of threshold-linear neurons with effectively inhibitory interactions. The dynamics of CTLNs are controlled solely by the structure of an underlying directed graph. By varying the graph, we observe a rich variety of nonlinear dynamics including: multistability, neuronal sequences, and complex rhythms. These patterns are reminiscent of population activity in cortex, hippocampus, and central pattern generators for locomotion. I will present some theorems about CTLNs, and explain how they allow us to predict features of the dynamics by examining properties of the underlying graph.

Ralf Haefner

2014 - current, Assistant Professor, Brain & Cognitive Sciences, University of Rochester (NY)
2013 - 2014, Visiting Research Fellow, Department of Neurobiology, Harvard Medical School
2011 - 2014, Swartz Fellow, Sloan-Swartz Center for Theoretical Neurobiology, Brandeis University
2009 - 2011, Postdoc, Max Planck Institute for Biological Cybernetics
2004 - 2009, Postdoc, Laboratory for Sensorimotor Research, National Eye Institute, NIH
1999 - 2001, MPA as McCloy Scholar, Kennedy School of Government, Harvard University
1995 - 1999, D.Phil on PPARC Fellowship, Department for Theoretical Physics, Oxford University
1992 -1994, Undergraduate studies, Majors: Mathematics, Physics, Bonn University

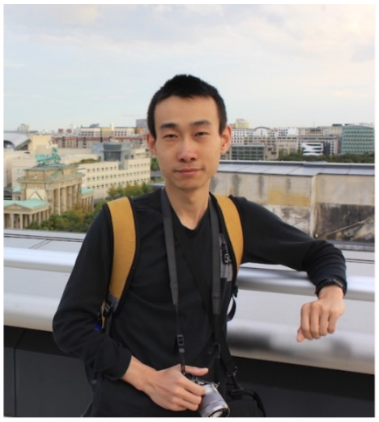
Research Interests

Dr. Ralf Haefner's primary scientific interest lies in understanding how the brain forms percepts and how it uses them to make decisions, especially in the visual domain. In particular, he's interested in how the brain's perceptual beliefs about the outside world are represented by the responses of populations of cortical neurons. To that end he uses tools from machine learning to construct mathematical models that aim to explain neural responses and behavior.

Lecture topic: Neural population coding in a hierarchical Bayesian inference framework

My lecture will start with describing classical approaches for interpreting the responses of populations of sensory neurons in the context of psychophysical tasks, and discuss tuning curves, noise correlations and decision-related signals. I will then relate these quantities to a more recent perspective that interprets sensory responses as encoding probabilistic beliefs about the outside world。

Yu Hu



2018-Present, Assistant Professor, Department of Mathematics and Division of Life Science, HKUST
2014-2018, Postdoctoral Fellow, Harvard University and The Hebrew University
2009-2014, Ph.D. in Applied Mathematics, University of Washington
2005-2009, B.S. in Mathematics, Peking University

Research Interests

Dr. Hu's research focuses on new models and theories to understand the mechanisms and principles of how neural circuits allow the animal to process information and generate behaviors. Advanced data analysis methods to uncover structures and to infer biologically important features.

Lecture topic: Relating dynamics and connectivity in recurrent neuronal networks

We will discuss several theoretical approaches in understanding the dynamics-connectivity relation in neural circuits at a simplified, principle level. In particular, both dynamics and connectivity are described at a statistical level, such as population average correlations and motif frequencies. Such assumptions are consistent with the goal of bridging large-scale neural activity recordings and connectivity reconstructions. If time allows, we will review some recent literature on low-dimension/low-rank structures.

Daniel Lee

Dr. Daniel D. Lee is currently the Tisch University Professor in Electrical and Computer Engineering at Cornell Tech and Executive Vice President for Samsung Research. He received his B.A. summa cum laude in Physics from Harvard University and his Ph.D. in Condensed Matter Physics from the Massachusetts Institute of Technology. After completing his studies, he was a researcher at AT&T and Lucent Bell Laboratories in the Theoretical Physics and Biological Computation departments. He is a Fellow of the IEEE and AAAI and has received the National Science Foundation CAREER award and the Lindback award for distinguished teaching. He was also a fellow of the Hebrew University Institute of Advanced Studies in Jerusalem, an affiliate of the Korea Advanced Institute of Science and Technology, and organized the US-Japan National Academy of Engineering Frontiers of Engineering symposium and Neural Information Processing Systems (NeurIPS) conference.

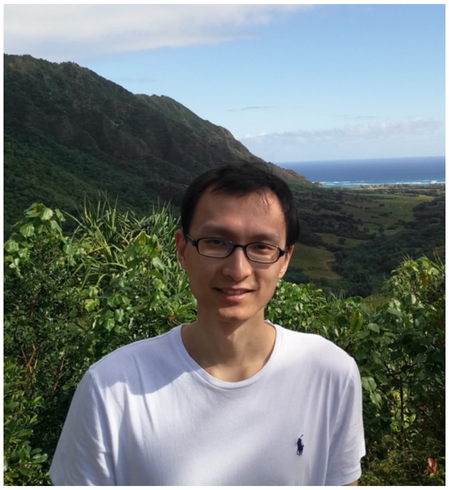
Research Interests

Dr. Lee's research focuses on understanding general computational principles in biological systems, and on applying that knowledge to build intelligent robotic systems that can learn from experience.

Lecture topic: Artificial Intelligence vs. Biological Computation

Recent achievements in Artificial Intelligence and Machine Learning have accomplished feats that surpass human performance; does this mean these techniques will soon scale to achieve machine superintelligence? This lecture will examine some techniques used in modern machine learning algorithms: deep networks, state estimation, and reinforcement learning. These techniques will be compared and contrasted with models of the brain from computational neuroscience, followed by a discussion of potential future research directions.

Songting Li



Associate Professor, the Institute of Natural Sciences and the School of Mathematical Sciences, Shanghai Jiao Tong University
2015-2018, Postdoc, New York University
2014, Ph.D. in Mathematics, Shanghai Jiao Tong University
2010, B.S. in Mathematics, Shanghai Jiao Tong University

Research Interests

The research in Dr. Li's lab focuses on the mathematical theory of single neuron computation, the dynamics and function of neuronal networks, and brain-inspired machine learning algorithms.

Lecture topic: Dendritic Integration and Computation

In the lecture, I will first introduce basic properties of dendrites, and review studies of how dendrites contribute to signal integration and neuronal computation in multiple ways. I will then introduce our own research on investigating dendritic integration and computation using modeling, analysis, simulation, and experiments, in particular, the discovery of a bilinear integration rule of synaptic inputs. In the end, I will share some of my research experience, and opinions on challenges in understanding dendrites and its computational roles etc.

Zhaoping Li

2018-Present, Professor in University of Tuebingen, Head of Department of Sensory and Sensorimotor Systems at the Max Planck Institute for Biological Cybernetics in Tuebingen, Germany
2007-2018, Professor, University College London
1998-2007, Reader, University College London
1994-1997, Assistant Professor in Computer Science, Hong Kong University of Science and Technology
1990-1994 Postdoctoral researcher, Fermi National Laboratory in Batavia, Illinois USA, Institute for Advanced Study in Princeton New Jersey, USA, and Rockefeller University in New York USA
1989, Ph.D. in Physics, California Institute of Technology
1984, B.S. in Physics, Fudan University, Shanghai

Research Interests

Theory and experiments on sensory processing, particular vision and olfaction, and on sensorimotor transformations, in humans and animals.

Lecture topic: From V1SH to CPD in the Encoding-Selection-Decoding (ESD) framework for understanding vision

V1SH is the V1 Saliency Hypothesis that the primary visual cortex, V1, creates a bottom-up saliency map to guide gaze to salient locations so as to devote the limited brain resources to scrutinizing the visual input within the attentional spotlight. CPD is the central-peripheral dichotomy that central and peripheral vision differ such that top-down feedback from higher to lower visual cortical areas to aid visual recognition is mainly directed to the central rather than the peripheral visual field (and this central-peripheral difference is in addition to their difference in visual resolution). In the ESD framework that vision is composed of encoding, selection, and decoding stages, encoding means to represent visual inputs optimally, e.g., for better information representation efficiency; selection means to select only a tiny fraction of visual input into the attentional or information bottleneck for deeper processing, and decoding means to infer visual scene properties (e.g., a face identity) from the selected visual inputs. In this framework, V1SH pertains to the selection stage, and implies that the attentional bottleneck starts at the output of V1 to higher visual areas. CDP pertains to the decoding stage, is in light of the selection behavior, and is also motivated by experimental evidence for V1SH. I will explain in detail the computational formulations, theoretical predictions, and experimental evidences for V1SH and CDP, and relate them to visual behavior and phenomena such as eye movements and visual illusions. Recommended preparation materials for this lecture can be obtained from http://www.lizhaoping.org/zhaoping/CNeuro2020_teaching.html.

Cristina Savin

After a PhD at Goethe University in Frankfurt, studying the role of different forms of plasticity in unsupervised learning, Cristina worked as postdoctoral researcher at Cambridge U. developing normative models of memory. This was followed by a short stint at ENS in Paris, modeling probabilistic computation in spiking neurons, and an independent research fellowship at IST Austria, building statistical tools for quantifying learning in multiunit recordings. Since 2017 she has been an Assistant Professor in Neural Science and Data Science at NYU.

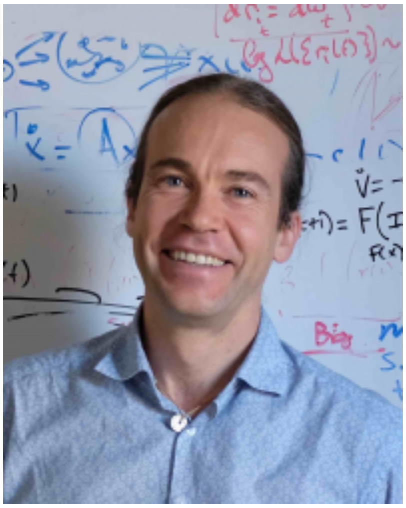
Research Interests

Dr. Savin's lab combines theory and data analysis to study neural computation at the level of neural circuits, with a particular emphasis on learning. Her research relies on tools from machine learning and statistics and is done in close collaboration with several experimental partners.

Lecture topic: Probabilistic computation in the brain

The lecture will cover basic concepts of Bayesian inference, evidence of probabilistic computations in the brain and some key ideas about how such computations could be performed in neural circuits (PPCs, DDCs and sampling).

Eric Shea-Brown



Dr. Shea-Brown studied engineering physics at UC-Berkeley and began his research life with a group of wonderful mentors at the Lawrence Livermore National Laboratory, good fortune in this regard that continued in the years to follow. In 2004, he completed his Ph.D. in Princeton's Program in Applied and Computational Mathematics, where was advised by Profs. Phil Holmes and Jonathan Cohen at the interface of dynamical systems and neuroscience. His postdoctoral training was with Prof. John Rinzel at NYU's Courant Institute and Center for Neural Science, working on mathematical models in cognitive neuroscience and in the dynamics of neural circuits.

Lecture topic: Dimensionality in neural networks

There is an avalanche of new data on the brain's activity, revealing the collective dynamics of vast numbers of neurons. In principle, these collective dynamics can be of almost arbitrarily high dimension, with many independent degrees of freedom—and this may reflect powerful capacities for general computing or information. In practice, neural datasets reveal a range of outcomes, including collective dynamics of much lower dimension—and this may reflect other desiderata for neural codes. For what networks does each case occur? We will introduce the underlying concepts from scratch and then discuss two recent sets of contributions to the answer. The first are "bottom-up" mechanistic ideas that link tractable statistical properties of network connectivity with the dimension of the activity that they produce. The second are "top-down" computational ideas that describe how features of connectivity and dynamics that impact dimension arise as networks learn to perform basic tasks.

Sara Solla

Professor, Physiology and Weinberg College of Arts and Sciences, Northwestern University

1982, PhD, University of Washington

Research Interests

Dr. Solla's research interests lie in the application of statistical mechanics to the analysis of complex systems. Her research has led her to the study of neural networks, which are theoretical models that incorporate "fuzzy logic" and are thought to be in some aspects analogous to the way the human brain stores and processes information. She has used spin-glass models (originally developed to explain magnetism in amorphous materials) to describe associative memory, worked on a statistical description of supervised learning, investigated the emergence of generalization abilities in adaptive systems, and studied the dynamics of incremental learning algorithms. Dr. Solla has also helped develop constrained neural networks for pattern-recognition tasks, along with descriptions of the computational capabilities of neural networks and learning algorithms for the design of neural network controllers.

Lecture topic: Models for Unsupervised and Supervised Learning

Hang Zhang

2014-Present, Principal Investigator, Department of Psychology, PKU-IDG/McGovern Institute for Brain Research, and Peking-Tsinghua Center for Life Sciences, Peking University

2008-2014, Postdoctoral Fellow, Department of Psychology, New York University

2008, PhD in Cognitive Psychology, Institute of Psychology, Chinese Academy of Sciences

2002, BS in Engineering Physics, Tsinghua University

Lecture topic: Decision theoretic modeling of perception and cognition

In the past three decades, a decision-theoretic approach has been widely applied to understanding human perception and cognition, which models humans as Bayesian ideal observers who maximize expected gain under their own sensorimotor and cognitive limitations. It addresses the WHY question in Marr’s term, that is, the goal of the brain’s computations. This normative framework not only captures human behavioral patterns in many (though not all) tasks, but also provides rational explanations for some pervasive perceptual and cognitive biases. In this lecture, I will walk you through the development of the decision-theoretic approach in perception and cognition, including a boom of Bayesian ideal observer models at the turn of the century, the following criticism and introspection, and its recent marriage with efficient coding. I will not aim for a complete review, but will instead focus on a few examples to illustrate the significance and power of the decision-theoretic approach.

Kechen Zhang

Associate Professor, Department of Biomedical Engineering, Johns Hopkins University

Postdoctoral Fellow, Computational Neurobiology, Salk Institute

Ph.D., Cognitive Science, University of California, San Diego

M.S., Neurobiology, Peking University

B.S., Biophysics and Physiology, Peking University

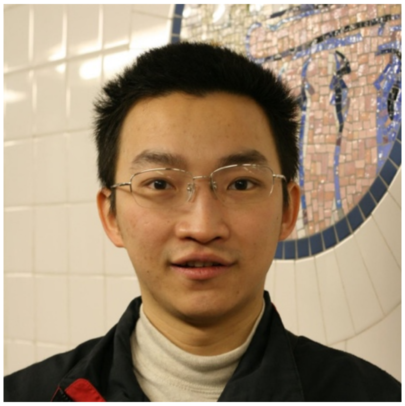
Research Interests:

Dr. Zhang's research interest is in theoretical and computational neuroscience. In his early work, he proposed to use continuous attractor models to explain the spatial activities of head-direction cells and showed how to extend the idea to hippocampal place cells. He made contribution to several problems in computational and theoretical neuroscience, including methods for decoding from neural activity with applications to hippocampal place cells, population coding theory, and neocortical grey matter and white matter scaling theory. His research projects at Johns Hopkins University have been focused on two broad themes: dynamic neural computation in the circuits related to the hippocampus and associated areas, and sensory representations by neural populations, especially the visual and auditory systems. He has also devoted much efforts to collaborative research projects to promote interactions between computational modeling and neurophysiological experiments.

Lecture topic: Dynamical models of spatial representations in the hippocampal system

Several types of space-related cells have been found in the hippocampal system of the mammalian brains, with well-known examples including place cells, head direction cells, and grid cells. These neurons represent spatial information by combining both self-motion signals and landmark cues. This lecture provides an overview of the leading computational models of such neurons, with a focus on the attractor networks which allow a continuum of stable equilibrium states to represent spatial variables, and this spatial framework can readily accommodate nonspatial information from a complex environment. We will compare the theoretical models with the data from multiple animal species.

Douglas Zhou



Douglas Zhou is a professor of Institute of Natural Sciences and School of Mathematics at Shanghai Jiao Tong University, Shanghai, China. He obtained his B.S. and Ph.D. at Peking University, Beijing, China. Then he did his postdoctoral research in the Courant Institute of Mathematical Sciences at New York University, New York, NY, USA. After that, he joined the Institute of Natural Sciences and School of Mathematics at Shanghai Jiao Tong University, first as a Distinguished Research Fellow in 2010, then became a professor in 2016.

Research Interests

Douglas Zhou's research interests focus on mathematical modeling and scientific computation for scientific problems arising from neuroscience. In particular, he is interested in understanding of the relation between structures and functions of biological neuronal network dynamics, development of new efficient computational methods for modeling large-scale cortical networks, discovery of potential mechanisms underlying information processing in the brain, and investigation of new mathematical structures and tools to extract useful information from neurophysiological data measured in experiment. For more information, please visit his personal website: http://ins.sjtu.edu.cn/people/zdz/.

Lecture topic: Modeling and analysis of balanced state in neuronal networks

The idea of a balanced state is that the excitatory and inhibitory components of inputs nearly cancel each other, and the neural firing activity is driven by strong fluctuations that intermittently interrupt this cancellation and give rise to the irregularity of neural spikes. Consistent with the hypothesized scenario, balanced synaptic inputs have been observed in experiment. Previous theoretical and computational works proposed a mechanism to understand the emergence of the balanced state in homogeneous networks and have shown that small perturbations of the balanced state in a network with binary neurons grow exponentially, indicating the chaotic nature of the balanced activity. However, there are several issues that remain to be clarified. First, whether the chaotic dynamics is the underlying mechanism for the irregularity of neural activity in a balanced network. Second, whether a balanced state can exist in heterogeneous networks and how it differs from the balanced state in homogeneous networks. We address these issues through modeling, analysis and simulations in this lecture. In addition, we investigate the implications of the balanced state for the network connectivity reconstruction and the information coding.