Brain Connectivity Workshop 2018

June 25-27, 2018

James H. Clark Center Auditorium
Stanford University

Organized by:
Stanford Bio-X

Sponsored by:
Stanford Bio-X
Stanford Neurosciences Institute
Stanford Neurology & Neurological Sciences
Stanford Neurosurgery

Brain Connectivity Workshop 2018

Founded in 2002, the Brain Connectivity Workshop (BCW) is an annual international meeting for in-depth discussions of all aspects of brain connectivity research. This meeting has a unique format in that it features short presentations, followed by intense discussion. The 17th edition of this workshop, taking place at Stanford University from June 25-27, 2018, begins with an educational day followed by two days devoted to presentations and discussions in multiple domains in relation to connectivity in both psychiatry and neurology.

Monday, June 25th: Educational Session

8:30 AM
Registration & Coffee
Clark Center courtyard


Jin Hyung Lee


Carla Shatz

8:45 AM
Welcome and Introduction
Jin Hyung Lee
Associate Professor of Neurology & Neurological Sciences, Bioengineering, Neurosurgery, and Electrical Engineering (Courtesy), Stanford University
with remarks from
Carla Shatz
Sapp Family Provostial Professor, Professor of Biology and Neurobiology, and David Starr Jordan Director of Stanford Bio-X

Morning Session Chair
Jin Hyung Lee
Associate Professor of Neurology & Neurological Sciences, Bioengineering, Neurosurgery, and Electrical Engineering (Courtesy), Stanford University

9:00 AM

LONG-LASTING DESYNCHRONIZATION CAUSED BY MULTICHANNEL PATTERNED STIMULATION

Peter Tass, Professor of Neurosurgery, Stanford University

PETER TASS

Abstract:

Several brain disorders are characterized by abnormal neuronal synchronization. Coordinated reset (CR) stimulation is a patterned multichannel stimulation. As shown computationally, CR primarily disrupts abnormal neuronal synchrony and, mediated by synaptic plasticity, causes long-lasting desynchronization. CR stimulation can be realized with invasive and non-invasive stimuli. CR-induced long-lasting desynchronization was validated in pre-clinical and clinical studies, e.g. with DBS or vibrotactile CR stimulation for the treatment of Parkinson's disease. Recently, a novel multichannel stimulation approach for long-term desynchronization was developed, which specifically targets synaptic plasticity and, according to computational studies (Kromer & Tass, in preparation), outperforms CR stimulation significantly.

PETRA RITTER

10:00 AM

INFERRING MULTI-SCALE NEURAL MECHANISMS WITH BRAIN NETWORK MODELLING

Petra Ritter, Professor and Chair for Brain Simulation, Department of Neurology, Charité Universitätsmedizin Berlin & Berlin Institute of Health

Abstract:

I will talk about advances of the neuroinformatics platform The Virtual Brain (thevirtualbrain.org) to integrate experimental findings with subject-specific multi-scale whole-brain network models. The Virtual Brain models enable the integration of empirical results into a biophysically based framework that allows the systematic testing of the mutual compatibility of the identified mechanisms in the context of full-brain network interaction and the prediction of system-level processes emerging from the coalescence of the individual identified mechanisms. I will demonstrate how cross-species integration may provide evidence for - possibly optimal - computational principles.

11:00 AM

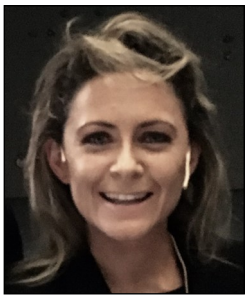
BREAK

CLARK CENTER COURTYARD

11:30 AM

DYNAMIC CAUSAL MODELS FOR NEURAL CIRCUIT ANALYSIS FROM INDUCED PLURIPOTENT STEM CELLS

Rosalyn Moran, Reader in Theoretical Neurobiology, King's College London



ROSALYN MORAN

Abstract:

Induced Pluripotent Stem Cells (iPSCs) derived directly from patients with neurological or psychiatric disorders provide a safe and rapid platform to test potential therapeutic compounds. So how should neurons derived from iPSCs be characterized? What characteristics render these cells defective and how can a treatment be deemed successful? In my talk I will argue that the ability to form effective connections, with balanced ion channel transmission at synaptic junctions is a critical and ubiquitous but disease specific feature, fit for this purpose. Using electrophysiological characteristics from multi electrode array (MEA) recordings of IPSC-derived neurons I will demonstrate how the technology behind Dynamic Causal Modeling can be harnessed for this sort of connectivity analysis.

Dynamic causal models utilize generative models of cells to build a comparative building block against which real brains can be compared. In other words, in DCM, model parameters can be 'fit' to empirical data to estimate the strength of synaptic networks from patient data. To date these datasets have comprised M/EEG and ECoG recordings from patients. In my talk I will show how these models can be adapted to investigate the synaptic formations of IPSC-derived neurons in a dish.

I will present data from collaborators at the EU StemBANCC where DCM analyses have yielded initial results and a proof of principle.

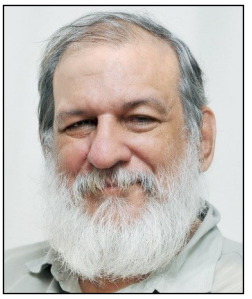
12:30 PM
LUNCH
NEXUS CAFÉ PATIO

AFTERNOON SESSION CHAIR
Hadi Hosseini
Assistant Professor of Psychiatry & Behavioral Sciences, Stanford University

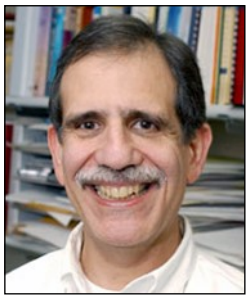

MICHAEL BREAKSPEAR

2:00 PM
FAILURE TO EXCITE THE SECOND MODE! INCOMPLETE CORTICAL STATE TRANSITIONS DURING SLEEP IN PRETERM NEONATES
Michael Breakspear, Group Leader, Systems Neuroscience Group, QIMR Berghofer Medical Research Institute
Abstract:
Fluctuations between sleep and vigilance are a key indicator of future brain health in neonates. Using multichannel EEG acquired from sleeping babies at term equivalent age, we find whole brain differences in source -reconstructed functional connectivity between preterm and full-term babies. Transitions between active and quiet sleep are characterised by an intriguing half brain (front-back) pattern, the strength of which is diminished in the preterm group and pre-empts cognitive development at 2 years. There is a striking match between this pattern of functional connectivity and the second mode of a spatiotemporal eigen-decomposition of cortical activity. These results suggest that transitions between active and quiet sleep in neonates reflect a fundamental reorganization of large-scale brain states that is muted following preterm birth. I will use this work to provoke discussion about a network/node versus wave/mode "duality" in neuroscience, in metaphor to the wave-particle duality of matter.

3:00 PM
DATA DRIVEN VERSUS MODEL DRIVEN IDENTIFICATION OF NONLINEAR BRAIN NETWORKS
Pedro Valdés-Sosa, Director Joint China/Cuba Laboratory for Translational Neurotechnology, The Clinical Hospital of Chengdu Brain Science Institute, MOE Key Lab for Neuroinformation, University of Electronic Science and Technology of China
Abstract:
Whereas model driven modelling of brain networks has relied on ordinary or partial random differential equations, data driven approaches till now have been based on discrete time series analysis. Recent developments in data driven discovery of differential equations, based on applications of Koopman Operator theory, now allows comparison of neural mass and neural field models with their data driven counterparts. We summarize the current state of the art and identify research opportunities. The methods developed are illustrated with ECoG data from a macaque in different states of consciousness.


PEDRO VALDÉS-SOSA

4:00 PM
BREAK
CLARK CENTER COURTYARD



Barry Horwitz

4:30 PM

The Kötter Lecture: Using Neural Network Modeling and Functional Neuroimaging Data to Understand the Neural Basis of Human Cognition

Barry Horwitz, Scientist Emeritus, NIH

Abstract:

"No man is an island entire of itself; every man is a piece of the continent, a part of the main." So said the poet John Donne of man, and now so says the neuroscience research community of brain areas. The importance of the neural network framework led Rolf Kötter to co-organize the first of the Brain Connectivity Workshops in 2002, a yearly meeting that has continued to this day. From the beginning, it was apparent to all that various kinds of computational modeling would be required to understand neural network behavior. Here, I will provide an overview of my lab's efforts at developing large-scale neural networks that can simulate neural, neuroimaging, and task performance data for multiple cognitive tasks.

5:30 PM

Closing Remarks

Dr. Heideh Fattaey

Stanford Bio-X Executive Director of Operations & Programs, Member of Executive Committee, Scientific Leadership Council, and Seed Grant Committee

and

Cici Huber

Program Manager, Stanford Bio-X

5:45 PM

Welcome Reception

Nexus Café Patio

Tuesday, June 26th

8:30 AM

Registration & Coffee

Clark Center Courtyard

William Newsome

8:45 AM

Welcome and Introduction

William Newsome

Harman Family Provostial Professor, Vincent V. C. Woo Director of the Stanford Neurosciences Institute, and Professor of Neurobiology and, by courtesy, of Psychology, Stanford University

Morning Session Chair

Michael Lin

Associate Professor of Neurobiology and of Bioengineering, Stanford University

9:00 AM

Linking real-time activity with detailed anatomy at cellular resolution across the vertebrate brain

Karl Deisseroth

Karl Deisseroth, D. H. Chen Professor and Professor of Bioengineering and of Psychiatry & Behavioral Sciences, Stanford University

Abstract:

Diverse cells underlie basic drives and actions essential for animal survival, including behaviors such as those related to thirst, hunger, and sleep. Cell-type-specific activity signals that underlie these animal behaviors have been elucidated, interestingly, using channelrhodopsin proteins essential for plant behaviors. Here we will present our structure-guided tool designs and briefly review our prior application of these tools to uncover basic hypothalamic mechanisms underlying thirst, feeding, sleep, and other fundamental drives, via identification of internal cellular-resolution brain states. And we will present in detail a new general method for identifying the cellular manifestation of internal states by integrating brain-wide single-cell activity imaging and control with hydrogel-tissue chemistry for high-content cellular-resolution molecular phenotyping. Together, these experiments have established an approach for unbiased discovery of cellular elements underlying behavior, and have revealed an evolutionarily-conserved set of diverse cellular systems that collectively govern survival drive-related internal states.

Viren Jain

10:00 AM

Automated reconstruction of synaptic-resolution neural wiring diagrams using very large scale computation and machine learning

Viren Jain, research scientist, Google

Abstract:

The large-scale reconstruction of synaptic-level wiring diagrams remains an attractive target for achieving greater understanding of nervous systems in health and disease. Progress has been severely limited due to technical issues involved in the imaging and analysis of nanometer-resolution brain imaging data. In this talk, we will discuss recent advances in using new machine learning techniques and very large scale computation and storage capabilities in order to drive order-of-magnitude progress in automated analysis of 3d electron microscopy data. We will also discuss some of the biology that these projects are enabling in fly, mouse, bird, and human brains, and prospects for making these tools and techniques widely available to neuroinformatics researchers.

11:00 AM

BREAK

CLARK CENTER COURTYARD

11:30 AM

THE MAMMALIAN PRION PROTEIN IN HEALTH AND DISEASE

Adriano Aguzzi, Professor and Director of the Institute of Neuropathy, University Hospital Zurich

ADRIANO AGUZZI

Abstract:

Prion diseases are a group of neurodegenerative diseases involving the conversion of the cellular prion protein, PrPC, into a disease-associated form termed PrPSc. In my lecture I will focus on the normal function of PrPC, on its role in prion diseases, and on how these two aspects might be related. Although numerous functions have been attributed to PrPC, many of these were subsequently debunked as artifactual. In my opinion, only two phenotypes have been stringently validated in PrPC deficient mice: peripheral demyelinating neuropathy and defective hippocampal slow afterhyperpolarization. Both phenotypes are related to the interaction of PrPC with G protein-coupled receptors. I will elaborate on the implications of these findings for human disease.

12:30 PM

LUNCH

NEXUS CAFÉ PATIO

AFTERNOON SESSION CHAIR

Xiaoke Chen

Assistant Professor of Biology, Stanford University

DANIEL TOPGAARD

2:00 PM

MAPPING FIBERS IN HETEROGENEOUS BRAIN TISSUES

Daniel Topgaard, Professor in Physical Chemistry, Lund University

Abstract:

Fiber tracking based on conventional diffusion MRI faces problems in heterogeneous white matter regions containing not only myelinated axons but also unknown amounts of gray matter, cerebrospinal fluid, or tumor tissue. Using principles from solid-state NMR spectroscopy, we design new MRI acquisition and processing methods to quantify the composition of each voxel of the image as a nonparametric relaxation-diffusion tensor distribution where the fiber signals are cleanly resolved from other tissue components. Additionally, values of relaxation rates and diffusivities are estimated for each distinct fiber bundle, potentially giving tract-specific information on chemical composition and microstructure.

3:00 PM

ANATOMICAL, PHYSIOLOGICAL, AND FUNCTIONAL HETEROGENEITY OF THE DORSAL RAPHE SEROTONIN SYSTEM

Liqun Luo, Ann and Bill Swindells Professor in the School of Humanities and Sciences and Professor, by courtesy, of Neurobiology, Stanford University

LIQUN LUO

Abstract:

The dorsal raphe (DR) constitutes a major serotonergic input to the forebrain, and modulates diverse functions and brain states including mood, anxiety, and sensory and motor functions. Most functional studies to date have treated DR serotonin neurons as a single, homogeneous population. Using viral-genetic methods, we found that subcortical- vs. cortical-projecting serotonin neurons have distinct cell body distributions within the DR. Further, the amygdala- and frontal cortex-projecting DR serotonin neurons have largely complementary whole-brain collateralization patterns, receive biased inputs from presynaptic partners, and exhibit opposite responses to aversive stimuli. Perturbation experiments suggest that amygdala-projecting DR serotonin neurons promote anxiety-like behavior, whereas frontal cortex-projecting neurons promote active coping in face of challenge. These results provide compelling evidence that the DR serotonin system contains parallel sub-systems that differ in input and output connectivity, physiological response properties, and behavioral functions.

4:00 PM

BREAK

CLARK CENTER COURTYARD

JIN HYUNG LEE

4:30 PM

ILLUMINATING NEURAL CIRCUITS: FROM MOLECULES TO MRI FOR PRECISION BRAIN HEALTH

Jin Hyung Lee, Associate Professor of Neurology, of Neurosurgery and of Bioengineering and, by courtesy, of Electrical Engineering, Stanford University

Abstract:

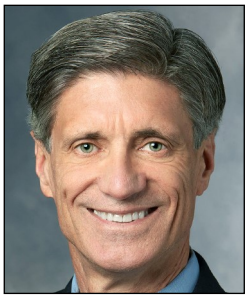
Starting from the first observations of neurons, neuroscientists have strived to understand how the neurons are connected and communicate with each other. Owing to astonishing technological advancements, we are now able to measure multiple aspects of neuronal organization including their molecular pathways, electrical activity, and large-scale functional changes. However, we still lack a comprehensive understanding that can concretely describe how any particular behavior is controlled. Beyond the lack of understanding, this also means that when abnormal behavior arise in neurological disease such as tremors, neuropsychiatric disorders, or memory loss, it is impossible to figure out exactly how the function should be restored. In this talk, we demonstrate an approach putting the puzzle together by an intelligent, systematic combination of brain function signal measurements, manipulations, and modeling, starting from MRI scale going down to single unit recordings and molecular mechanisms with the goal of treating neurological disease.

5:30 PM

CLOSING REMARKS

Frank M. Longo

George E. and Lucy Becker Professor in Medicine and Professor, by courtesy, of Neurosurgery, Stanford University



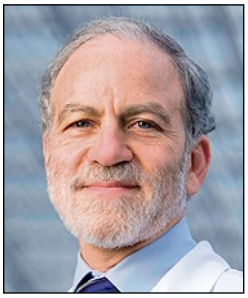
FRANK LONGO

Wednesday, June 27th

8:30 AM

Registration & Coffee

Clark Center Courtyard



Gary Steinberg

8:45 AM

Welcome and Introduction

Gary K. Steinberg

Bernard and Ronni Lacroute-William Randolph Hearst Professor in Neurosurgery and Neurosciences and Professor, by courtesy, of Neurology

Morning Session Chair

Sui Wang

Assistant Professor of Ophthalmology, Stanford University

9:00 AM

Volume imaging of activity, plasticity, and degeneration in the intact brain and embryo

Eliza Adams, Ph.D. Student, Marc Tessier-Lavigne's lab, Stanford University

Abstract:

Diverse recent advances in volumetric imaging methods have enabled the interrogation of neural circuit structure and function in the mammalian brain in 3D. Our lab has developed a tissue clearing and analysis pipeline (iDISCO+/ ClearMap) for the mapping of molecular markers across the intact brain with single cell resolution and automated registration to the Allen Brain Atlas. We have leveraged these methods to study neurodegeneration in the developing embryo, plasticity in the adult, and to identify new brain regions that are differentially active in freely behaving animals.

Eliza Adams

Edward Bullmore

10:00 AM

Development of connectomes

Edward Bullmore, Professor of Psychiatry and Head of the Department of Psychiatry, University of Cambridge

Abstract:

Efforts to map the post-natal, mainly adolescent, development of human brain connectivity and connectomes will be reviewed. What do we know for sure about how human brain networks mature and decline as a function of age? What are some of the residual challenges that need to be addressed to progress to a clearer account of developmental connectomics in future? These questions will be addressed mainly in the context of multi-parameter micro-structural MRI and resting state multi-echo fMRI data from an accelerated longitudinal cohort (N~300, aged 14-25 years).

11:00 AM

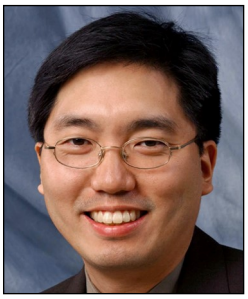
Break

Clark Center courtyard

11:30 AM

DECODING AND PREDICTING ATTENTION

Marvin Chun, Dean of Yale College and Richard M. Colgate Professor of Psychology, Neuroscience, and Cognitive Science, Yale University



MARVIN CHUN

Abstract:

Major advances in functional magnetic resonance imaging (fMRI) have given psychologists and neuroscientists unprecedented access to the workings of the human mind. Incorporating tools from machine learning and computational vision, we are using fMRI to decode from natural scene viewing where people attend and look (O'Connell et al., in prep). In a separate project to quantify attention, functional network analyses of whole brain functional connectivity allow us to fingerprint individual differences in sustained attention tasks (Finn et al., 2015; Rosenberg et al., 2015). Our models also show potential as neuromarkers to predict ADHD symptoms and the effects of attention-enhancing drugs such as Ritalin. fMRI can decode and predict behavior with increasing power and sophistication.

12:30 PM

LUNCH

NEXUS CAFÉ PATIO

AFTERNOON SESSION CHAIR

Kathleen Poston

Associate Professor of Neurology, Stanford University

RUSSELL POLDRACK

2:00 PM

NETWORK INTEGRATION AND ITS RELATION TO COGNITIVE FUNCTION

Russell Poldrack, Albert Ray Lang Professor of Psychology and Professor, by courtesy, of Computer Science, Stanford University

Abstract:

The question of integration versus segregation in the brain is nearly as old as neuroscience itself. I will discuss recent work that has used dynamic network analyses to identify fluctuations in network integration and relate these to cognitive function. I will also outline modeling work that provides a link between network integration and neural gain, demonstrating how changes at the neuronal level can ramify in large-scale brain dynamics at the network level.

3:00 PM

MODELING AND MEASURING FLOWS BETWEEN COGNITIVE AND NEURAL PROCESSES

Randy McIntosh, Senior Scientist, Rotman Research Institute, Baycrest Centre, and Professor of Psychology, University of Toronto

RANDY MCINTOSH

Abstract:

Mental processes have a temporal flow that is captured in the theory of structured flows on manifolds, wherein these processes are considered as the moment-by-moment evolution of brain network interactions. This evolution, or flow, is constrained by brain's structural architecture, but within this space, the number of potential networks is a direct link to the emerging mental processes. We can study such flows by having behaviour measures that change over time, such as tracking emotional responses as one listens to music, and then relate the flow of music, the personal emotional response, and the measured brain activity. The helps define a connection between the "where" and "when" in the brain and the perceptual and emotional response to music. This approach moves our perspective of brain and cognition as the orchestration of networks, whose temporal evolution brings richness to our experience.

4:00 PM

BREAK

CLARK CENTER COURTYARD

VIKTOR JIRSA

4:30 PM

ON THE SLOW VARIABLE IN BRAIN NETWORK DYNAMICS

Viktor Jirsa, Director INS Inserm (Institut de Neuroscience des Systèmes)

Abstract:

Slow processes organize the brain network dynamics on scales of seconds to minutes, allowing to change brain states and behaviors, as well as transient dysfunctions such as seizures, which are disruptions of normal brain activity present across a vast range of species, diseases, and conditions. Their underlying mechanisms remain mostly unknown. Mathematical considerations on time scale separations and nonlinear dynamic system theory allow principled reflections on conceptual frameworks to characterize and understand how brain states are created, evolve and terminate. We discuss the implications for epilepsy and provide the first objective taxonomy of seizures based on analysis of the electrographic data. Analyzing a cohort of over 2000 focal-onset seizures recorded from 7 epilepsy centers on 5 continents, we find evidence of the predicted 16 dynamic classes of seizures. The theory enables drawing a map of brain dynamics that includes most of the seizure classes and status epilepticus. We demonstrate that patients navigate the map via slow processes, and verify key predictions of the theory. This form of epidynamics not only provides a way to stratify patients in complement to present practical classifications, but also guides biophysically based mechanistic approaches. Epilepsy and intracranial encephalographic signatures are beautiful entry points for testing the theory of slow processes, the predictions, however, generalize beyond epileptic disorders and suggest to be physiological.

5:30 PM

CLOSING REMARKS

Petra Ritter

Professor and Chair for Brain Simulation, Department of Neurology, Charité Universitätsmedizin Berlin & Berlin Institute of Health

and

Jin Hyung Lee

Associate Professor of Neurology & Neurological Sciences, Bioengineering, Neurosurgery, and Electrical Engineering (Courtesy), Stanford University

PETRA RITTER

JIN HYUNG LEE

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