ICoN - Interdisciplinary Training in Computational, Cognitive, and Systems Neuroscience Trainers

ICoN includes 33 trainers from six academic departments and two clinical departments at Brown University.

Cognitive, Linguistic, and Psychological Sciences (CLPS)

Dima Amso – Amso's research broadly examines the cognitive and neural development of visual attention, cognitive control, and learning and memory processes and from infancy through adulthood. Her lab uses a combined-methods approach including data from eye tracking, Near Infrared Spectroscopy, fMRI, and genetic and experiential variables to understand developmental change. Her combined-methods interdisciplinary approach is on the cutting-edge of science and training and has relevance to a wide range of developmental disorders, such as autism, as well as understanding the influence of environmental factors, such as socio- economic status, on mental health and development.

Kevin Bath – Dr. Bath's laboratory studies the effects of early life stress (ELS) on neural and behavioral development in a mouse model. Specifically, the lab is focused on understanding the mechanisms by which ELS enhances the risk for developing both cognitive and affective pathology, and why sex differences exist in these debilitating disorders. The focus on cognitive outcomes following early adversity, and the neural underpinnings underlying these effects, will provide ample training for students in topics that are highly relevant to the overarching goals of this training grant.

Rebecca Burwell – The Burwell laboratory uses optogenetics, electrophysiology, neuroanatomy, and experimental lesions in the rodent to study the structure and function of the cortical regions that surround the hippocampus. The lab is currently incorporating new single-unit, local field potential, and ensemble analyses of multi-site recordings in behaving animals in order to better understand and model brain circuits involved in memory and associative learning.

Oriel FeldmanHall – The FeldmanHall lab studies the neural basis of human social behavior, with a focus on morality, altruism, and socio-emotional decision-making. They aim to understand how the brain detects, values and assesses these conflicting reward and punishment contingencies, and to examine the role of emotion and its operational power in shaping these social interactions. They combine behavioral economics and social psychology tools with imaging and psychophysiological techniques to investigate the brain mechanisms that support these complex processes.

Yuka Sasaki – Dr. Sasaki is interested in neural mechanisms of visual perceptual learning and roles of sleep in visual perceptual learning in human adults. She uses psychophysics and noninvasive neuroimaging techniques including functional magnetic resonance imaging, diffusion tensor imaging, and magnetic resonance spectroscopy, as well as polysomnography. She is also interested in how aging affects neural mechanisms of visual perceptual learning.

Thomas Serre – Serre's lab seeks to understand the neural computations supporting visual perception. There is little doubt that even a partial solution to the question of which computations are carried out by the visual cortex would be a major breakthrough: it would begin to explain one of our most amazing abilities, vision; and it would open doors to other aspects of intelligence such as language, planning or reasoning. It would also help connect neurobiology and mathematics, making it possible to develop computer algorithms that follow the information processing principles used by biological organisms and honed by natural evolution.

Amitai Shenhav – The Shenhav lab studies how decision-making and cognitive control systems interact, with a particular interest in how people choose to engage in cognitively effortful activities and why some individuals have more trouble with this than others (e.g., those with anxiety disorders, major depression, and ADHD). One line of research seeks to elucidate the motivational obstacles to engaging in certain cognitive tasks, by examining the subjective costs associated with overcoming choice conflict and engaging inhibitory control. A second line of research combines computational modeling with experimental data to examine how people determine how much cognitive effort to exert at a given time.

William Warren – Dr. Warren's current research investigates the visual control of locomotion and spatial navigation, using human experiments in virtual reality, dynamical systems modeling, and agent-based simulation. The main project aims to build a vision-based "pedestrian model" that accounts for steering, obstacle avoidance, pedestrian interactions, and how these interactions generate the collective behavior of human crowds. A related line of research investigates longer-range navigation, including the process of path integration, the geometry of spatial knowledge, and how such knowledge is used to guide wayfinding. This research has broad applications to mobile robotics, computer simulation, evacuation planning, urban and architectural design, and assistive technology for people with visual-motor impairments.

Takeo Watanabe – Dr. Watanabe's research examines visual and cognitive learning and the underlying plasticity. His lab has used multiple brain imaging methods including fMRI, MRS and DTI as well as psychophysics. His long-term goal is to understand learning and plasticity in the whole brain.

Neuroscience

Carlos Aizenmann – Dr. Aizenman's laboratory focuses on the development of the visual system and the role of experience in shaping how the immature visual system becomes properly wired. They are interested in the adaptations, both cellular and at the circuit level, that the developing Xenopus visual system undergoes to function stably and robustly while remaining sufficiently flexible to allow for growth and rewiring. They are also interested in using

Xenopus as a model organism to understand psychiatric and neurological disorders such as autism and epilepsy. The lab uses an integrative approach drawing from diverse fields such as cellular biophysics, genetics, neural circuits, imaging, behavior and computational modeling.

Theresa Desrochers – Dr. Desrochers seeks to understand how we plan, monitor, and carry out sequential tasks that unfold in time. Though these tasks are central to our everyday lives, the ability to carry out a complex sequential task effectively is disrupted in a wide range of psychiatric and neurological disorders. It is at the basis of real world executive dysfunction. However, we have very little understanding of how the brain accomplishes these sequential tasks. The Desrochers lab seeks to understand how habits, sequential motor function, and serial attention are organized by combining animal and human experimental models.

John Donoghue – Dr. Donoghue has a strong track record of contribution in basic neuroscience in the areas of plasticity, cortical function and information processing, and in applied neuroscience in the area of neurotechnology, particularly brain-computer interfaces. His lab's fundamental research question has always been to understand how the cerebral neocortex accounts for flexible behavior, their model has always been the motor cortex, and they have always sought ways to translate their findings into useful human clinical applications. Dr. Donoghue's multidisciplinary knowledge has grown from teaching neuroscience courses at all levels, including clinicians, medical students, undergraduate, and graduate neuroscience students.

Stephanie Jones – Dr. Jones' laboratory integrates human electrophysiological brain imaging (Magneto- and Electro-encephalography MEG/EEG) and biophysically principled computational neural models to study thalamocortical dynamics of healthy brain function and disease. She has used this integrated approach to study the cellular and circuit level dynamics underlying sensory evoked and spontaneous rhythmic activity in human MEG/EEG recordings and their modulation with perception, attention, practice, and healthy aging. She works closely with clinicians and animal electrophysiologists to develop data driven models that provide testable predictions on brain dynamics and their impact on function.

Karla Kaun – Dr. Kaun's laboratory uses the powerful molecular and genetic tools available in the fruit fly Drosophila melanogaster to investigate the neural substrates of memory, reward, and addiction at the molecular and cellular level. The basic circuit motifs underlying reward responses are remarkably similar across phyla, from flies to primates. The lab uses the extremely well characterized mushroom body memory circuit in Drosophila, to understand the neural dynamics underlying appetitive behavioral decisions. Combined with the close inter-departmental collaborations at Brown, the Kaun lab's participation in this training grant provides an ideal interface for using computational approaches to integrate the circuit principles uncovered in behaving Drosophila into a more complex neural platform relevant to human behavior.

Matt Nassar – Dr. Nassar investigates how neural mechanisms of information processing impact decisions and afford complex behavior. His research relies on computational models to link behavior to their neural mechanisms, often by using indirect measures of neural activity (e.g. fMRI, MRS, EEG, and pupillometry) to distinguish between potential neural mechanisms. This integrative computational approach allows him to use experimental results from different levels of analysis (e.g. single neurons, population summaries, behavior) to inform a multi-level understanding of information processing and decision making.

David Sheinberg – Work in the Sheinberg Lab aims to understand how the brain makes sense of the constant barrage of sensory information that is picked up by our peripheral senses. By combining behavioral and neurophysiological studies in non-human primates, they ask how the activity of single neurons working together in the brain empowers the visual system to explore complex environments and recognize objects, scenes, and actions. A central question they study is how experience affects these processes and how information from more than one source can be integrated to give rise to the impression of an object.

Wilson Truccolo-Filho – The Truccolo lab develops data-driven stochastic models of neuronal network dynamics with the following goals: (a) to understand how collective dynamics in neuronal ensembles distributed across different brain areas contribute to behavior and cognition; (b) to develop neural decoding and closed-loop control approaches for brain-machine interfaces designed to assist people with neurological disorders (e.g. paralysis, epilepsy), and (c) to predict, detect and control pathological events in Alzheimer's, epilepsy, Parkinson's, and other psychiatric and neurological diseases and disorders.
Computer Science

George Konidaris – The Intelligent Robot Laboratory develops algorithms that enable robots to generate goal- directed behavior in unstructured environments, and in real-time. They focus on learning hierarchies that represent behaviors and world knowledge using various levels of abstraction, to enable robots to reason and problem-solve maximally efficiently. They also develop reinforcement learning and motion planning algorithms.

David Laidlaw – David Laidlaw's lab studies visualization and modeling applications of computer graphics and computer science to other scientific disciplines. The lab is working with researchers in, for example, developmental neuroscience, medical imaging, neuropathology, and cognitive science to develop new computational applications and to understand their strengths and weaknesses. Research problems of particular interest are visualization of multivalued multidimensional neuroimaging data, comparisons of virtual and nonvirtual environments for scientific tasks, and applications of perception and cognition to visualization.

Michael Littman – Littman's lab focuses on computational reinforcement learning, developing algorithms that learn from interaction with an environment or person to maximize a given reward function. They also study how people can specify tasks and how learning systems can acquire task specifications from interaction. Finally, in ongoing collaborations with cognitive scientists, they look at how norms and other forms of pro-social behavior can be learned. He also leads the Humanity-Centered Robotics Initiative at Brown. Littman is funded by NSF and has organized and coordinated several reinforcement learning competitions and challenges.

Biostatistics

Ani Eloyan – Dr. Eloyan's work focuses on computational analysis of neuroimaging data including functional and structural image processing and statistical analysis. She developed computational methods for dimension reduction specifically focusing on matrix decompositions for analyzing functional magnetic resonance imaging data. Dr. Eloyan worked extensively on statistical modeling approaches for brain connectivity analysis of people with Autism Spectrum Disorder. She developed and taught several courses in statistical methodology and in computational neuroimaging. Her expertise in statistical methodology development and teaching imaging statistics methods will add to the aims of this proposal.

Zheng Zhang – Dr. Zhang is an assistant professor of biostatistics and an affiliated faculty with the Brown Data Science Initiative. She is interested in developing novel statistical methodologies for evaluating the performance of biomarkers and imaging modalities in advancing personalized medicine and health data analytics. Her research made contributions to clinical trial methodology, decision making methods, biomarker analysis, and statistical machine learning. Her expertise in study design and statistical machine learning will greatly aid the success of the proposed training program.

Applied Mathematics

Matthew Harrison – A large component of Dr. Harrison's work involves collaborative research with neuroscientists and the development of statistical methodology for brain science data. He has been especially interested in rigorous statistical techniques that allow neuroscientists to explore the structure of their data without burdensome modeling efforts and unrealistic assumptions. He has also worked on novel algorithms for neural decoding, including applications for closed-loop cursor control using brain-computer interfaces.

George Karniadakis – Dr. Karniadakis' interests concern stochastic multiscale modeling of physical and biological systems, including blood flow dynamics in health and disease and neuro-vascular coupling. His current focus is on developing machine learning tools for biophysical systems. He has supervised more than 45 PhD students and more than 20 postdocs.

Engineering

David Borton – Dr. Borton's laboratory engages engineers, neuroscientists, mathematicians, and clinicians to create and apply state-of-the-art neural interfaces, kinematic sensors, and biochemical sensors to study neurological disease and injury in humans and relevant animal models. Their main research goals include (i) characterization of neural activity during unconstrained, complex, and natural behavior; (ii) realization of fully implanted neural recording and modulation technologies to aide in rehabilitation, augmentation, and replacement of lost neurological function; and (iii) leverage biophysical, computational, and behavioral models to predict the effects of neuromodulation on behavior.

Leigh Hochberg – Dr. Hochberg leads the BrainGate pilot clinical trials and the Laboratory for Restorative Neurotechnology at Brown University. His research enables the real-time decoding of human motor cortical neuronal ensemble activity, with single-neuron resolution, toward the control of external devices by people with tetraplegia. A variety of computational neuroscience techniques are employed not only to decode most efficiently the intended movement of a participant's limb, but to better understand the information encoded in high-resolution human cortical activity and the dynamic nature of this activity.

Neurosurgery

Wael Asaad – Dr. Asaad's laboratory studies the neuronal basis of visual-motor learning, decision-making and motor function across the prefrontal cortex, basal ganglia and thalamus. Embracing the interactionist approach, they undertake systems neuroscience projects in humans and nonhuman primates, focusing on recording neurophysiology during the performance of psychophysical tasks to study adaptive behavior. Their ultimate goals are to understand and harness the mechanisms of learning to augment neural plasticity in the setting of obsessive compulsive disorder (OCD), brain injury, stroke and other psychiatric and neurological illnesses, and to design new methods of advanced neuromodulation.

Psychiatry and Human Behavior

Benjamin Greenberg – Dr. Greenberg leads two related lines of research focusing on development of brain circuit-based treatments in neuropsychiatry. At Butler Hospital, his group works on the neurocircuitry of noninvasive brain stimulation in OCD, using transcranial neuromodulation and neuroimaging. This occurs in the context of an NIMH-funded P50 translational Conte Center, which he co-Directs. At the Center for Neurorestoration and Neurotechnology (CfNN) at the Providence VA Medical Center, where Dr. Greenberg is Associate Director, the research team focuses on studying effectiveness and predictors and mechanisms of action of neuromodulation for depression, posttraumatic stress disorder (PTSD), and the affective dimension of chronic pain. The latter work uses computational approaches, in collaboration with Dr. Stephanie Jones.

Noah Philip – Dr. Philip's lab uses cutting edge technology to understand and treat serious psychiatric disorders, such as major depressive disorder and PTSD. They use noninvasive brain stimulation and functional neuroimaging, including transcranial magnetic stimulation, low-current stimulation, network-based resting state functional connectivity and virtual reality. Active studies in the Philip lab range from first-in-human studies of novel stimulation devices, rational development of individualized stimulation parameters, and multimodal imaging assessments how trauma and negative affect impact brain responses to stimulation.

Steven Rasmussen – Dr. Rasmussen's research team focuses on understanding the role of frontostriatal circuitry in the etiology of OCD and the use of this understanding to develop novel circuit base interventions for the illness. Current projects are focused on 1) the use of neuroimaging, cognitive tasks and clinical assessments to test a structural equation model of two core features of anxiety/OC spectrum disorders and 2) the development of invasive and noninvasive closed loop neuromodulatory circuit-based treatments for OCD.