ROBERT J. & NANCY D. CARNEY
INSTITUTE FOR BRAIN SCIENCE
BROWN UNIVERSITY

Trainers for the Training Program in Computational Psychiatry

Cognitive Linguistics and Psychological Sciences

David Badre, Ph.D. is a leader in computational cognitive neuroscience, using human neuroscience methods from fMRI to ECoG to test mechanistic theories of the human mind and brain. The Badre lab focuses on the human neuroscience of cognitive control and executive function, and has made significant contributions to our understanding of the systems-level function and organization of the human frontal lobes. His approach seeks to understand these topics by deriving hypotheses from mechanistic models, including formal computational models, and testing these hypotheses using multiple, convergent human cognitive neuroscience methods, including task-based functional MRI, functional connectivity MRI, structural MRI (i.e., diffusion tractography), brain stimulation (e.g., TMS), high temporal resolution recording methods (e.g., EEG, ECoG), and the testing of patient populations. Where required, he has actively developed and published new methods to address cognitive neuroscience questions. He has, likewise, published papers on the influence of cognitive theory on neuroscience, how fMRI can inform cognitive theory, and has sought to test computational models at multiple levels using behavior, fMRI, and EEG.

Oriel Feldman Hall, Ph.D. studies the neural basis of human social behavior, with a focus on morality, altruism, and socio-emotional decision-making. She aims 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. Although she examines everyday social interactions, these processes have clear relevance to psychiatric symptomatology. She combines behavioral economics and social psychology tools with imaging and psychophysiological techniques to investigate the brain mechanisms that support these complex processes.

Michael Frank, Ph.D. directs the Lab for Neural Computation and Cognition, which develops computational models at multiple levels of description, from neural circuit implementations to higher-level algorithmic and computational levels. He uses models of motivated behavior to quantify and explain variation due to genetics and neural activity and how brain-behavior relationships are altered as a function of manipulations. He also uses ML methods for interrogating neural data to test theories and/or for classification of clinical populations and aberrant brain-behavioral relationships, helping to establish the nascent field of computational psychiatry. He and his students have also created online repositories and tutorials for using software available for the community at large, including neural models of various circuits and a hierarchical Bayesian parameter estimation toolbox ("HDDM") for exploring quantitative relationships between neural and behavioral measures, which enjoys a vibrant listserv and has been adopted by various labs internationally and used in multiple publications.

Thomas Serre, Ph.D. seeks to understand the neural computations supporting visual perception. His research focuses on both the development of computational models of the visual cortex as well as the development of computer vision and ML algorithms methods and their application for the automated analysis of neuroscience and other biology data. Serre's research is currently funded by DARPA, ONR, NSF and NIH. At Brown, Serre has designed the first of its kind fully automated high-throughput rodent behavioral testing facility (rndb.clps.brown.edu). In collaboration with Professor Dima Amso, he has developed a suite of computer vision algorithms to fully automated behavioral analysis collected through an array of sensors (depth and video cameras, portable eye tracking, skin and heart rate sensors, etc.). In a collaboration with Professor Cash at MGH, he has developed a system for automatically assessing the behavior of epileptic patients within their hospital room while simultaneously readout intent using deep learning methods from neural data toward understanding the neural basis of volitional state. He collaborated with evolutionary biologists (Professors Morand-Ferron and Chaine) to develop computer vision systems for automated analysis of bird behavior (to study cognition in the wild). In a project that just ended, he developed a deep-learning based computer vision algorithm capable of detecting tumors in pathology slides in collaboration with clinicians at the Rhode Island Hospital. Currently, his group is developing deep-learning-based architectures both as computer vision algorithms for automated analysis of images and as computational models of the visual system. Finally, they are also laying the groundwork for the development of machine-learning methods towards the development of neural prosthetics with Trainer Borton.

Amitai Shenhav, Ph.D. 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, directly relevant to this application, combines computational modeling with experimental data to examine how people determine how much cognitive effort to exert at a given time.

Neuroscience

Stephanie Jones, Ph.D. 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 to develop data driven models that provide testable predictions on brain dynamics and their impact on function.

Matt Nassar, Ph.D. 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.

David Sheinberg, Ph.D. uses a combination of behavioral and neural recording methods to study the neural circuits involved in visual processing with the goal of better understanding mechanisms underlying perception including how we identify objects and events in the real world. Current projects focus on how the brain effectively integrates information from disparate sources to yield a unified perceptual experience with the hope that understanding these fundamental mechanisms can help explain how breakdown in communication between brain regions might lead to disorders in sensory and cognitive function.

Wilson Truccolo, Ph.D. 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 psychiatric disorders.

Computer Science

Stephen Bach, Ph.D. conducts research on weakly supervised machine learning, in which the goal is to train models without hand labeled data. With the advent of data-hungry representation learning techniques like deep neural networks, curating labeled training data has replaced feature engineering as the most expensive and time-consuming task in ML. Weak supervision aims to overcome this bottleneck and is directly relevant to electronic health record data abstraction projects.

Carsten Eickhoff, Ph.D. specializes in mining, representation and retrieval of large-scale natural language resources with applications ranging from forecasting complications in intensive care to speeding up biobanks and automated patient-centric literature retrieval. He is a mentor on a DPHB K award application on which he brings his expertise on developing data-driven computational methods for improving individual health and experience employing ML to develop idiographic models of internet search history.

Sorin Istrail, Ph.D. was Head of Informatics Research at Celera Genomics, where his group played a central role in the construction of the Sequence of the Human Genome; they co-authored the 2001 Science paper "The Sequence of the Human Genome," which, with over 12,000 citations to date, is one of the most cited scientific papers. Istrail is the former Director of the Center for Computational Molecular Biology at Brown. His research focuses on computational molecular biology, human genetics and genome-wide associations studies, medical bioinformatics of autism, multiple sclerosis, HIV, preterm labor and viral immunology, algorithms and computational complexity, and statistical physics.

George Konidaris, Ph.D. aims to understand the fundamental mathematical properties of the algorithms and representations that are necessary to reason about, and act in, an uncertain world. Principled mathematical tools have been used to develop basic, foundational reinforcement learning methods as well as principled mathematical and computational tools to develop algorithms that enable artificial agents to match the capabilities of humans, and which in turn suggest concrete and specific hypotheses about human learning.

David Laidlaw, Ph.D. 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, Ph.D. focuses on computational reinforcement learning, developing algorithms that learn from interaction with an environment or person to maximize a given reward function. In ongoing collaborations with cognitive scientists, he looks at how norms and other forms of prosocial behavior can be learned. He also leads the Humanity-Centered Robotics Initiative at Brown.

Ellie Pavlick, Ph.D. studies Natural Language Processing (NLP), specifically computational models of semantics and pragmatics. She has expertise in ML methods for analyzing informal text and social media data. She is a mentor on a DPHB K award examining social media and its association with adolescent suicidal behavior.

Biostatistics

Ani Eloyan, Ph.D. 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. She has worked extensively on statistical modeling approaches for brain connectivity analysis of people with Autism Spectrum Disorder.

Applied Mathematics

Matthew Harrison, Ph.D. works with neuroscientists on the development of a 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, Ph.D. studies stochastic multiscale modeling of physical and biological systems, including blood flow dynamics in health and disease and neurovascular coupling. His current focus is on developing ML tools for biophysical systems.

Engineering

David Borton, Ph.D. studies*:* i) characterization of neural activity during unconstrained, complex, and natural behavior; (ii) realization of fully implanted neural recording and modulation technologies to aid 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, M.D., Ph.D. leads the BrainGate pilot clinical trials and the Laboratory for Restorative Neurotechnology. 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.

Department of Psychiatry and Human Behavior

Michael Armey, Ph.D. is an expert in the use of EMA to better understand how both between- and within-person variability in affect, behavior, and cognition (including suicidal ideation) influence suicidal- and non-suicidal self-harm behavior. He works closely with Jennifer Primack, Ph.D., a psychologist at the Veterans Administration, who has a comparable data set with Veterans. Armey also collects laboratory-based behavioral and psychophysiological data that can be fused with EMA data to enhance suicide prediction. These rich, multimodal and multi-dimensional, data sets would be excellent sources of data for a computational fellow using ML approaches to devise a research question on digital phenotyping. For example, behavior-based assessments of emotional reactivity may inform intensive longitudinal models using EMA data to provide both between- and within-subjects measures of emotion reactivity to stressful situations. Armey currently has EMA, behavioral, psychophysiological (i.e., EDA, ECG, EDA, and eye-tracking), audio-recorded speech, and genetic data available for future analysis.

Jennifer Barredo, Ph.D. has a VA Clinical Science R&D Career Development award to collect structural, functional, and diffusion MRI scans from veterans scanned after hospitalization for severe ideation or a suicide attempt. She has also applied for access to the Human Connectome and ABCD databases to conduct some exploratory studies of the relationship between impulsivity and sleep and later risk for suicide and/or mood and anxiety disorders.

Linda Carpenter, M.D. has a large EEG dataset from depressed patients who received a 6-week course of Transcranial Magnetic Stimulation for pharmacoresistant major depressive disorder. These patients had EEG recording 64 channels at rest prior to stimulation, recording throughout a 37- minute rTMS protocol (4 sec trains and 26 second intertrain rest intervals), and again at rest at the end of the stimulation session. For the majority of patients, this TMS-EEG recording protocol was repeated after the final session after the course of treatment. She also has systematically measured clinical outcomes for these patients as well as resting MRI data at baseline for a subset. In addition, for a subset, she has collected EEG recordings over multiple years, capturing within-patient data at times when the individual was severely depressed, then in remission, and again at the time of the next severe depressive episode relapse and again after return to remission after repeat courses of TMS therapy. This unique dataset of patients cycling through severe depressive illness and remitted states would provide an excellent source for a computational fellow using ML approaches to elucidate EEG biomarkers and connectivity patterns that reflect fundamental oscillatory and connectivity pathology underlying depression. All of these TMS-EEG data are associated with meticulously captured symptom assessments on rating scales that are available at the individual item-level for analysis to fellows who might be interested in analyses to elucidate endophenotypes of depression associated with specific oscillatory signatures. This line of work offers great promise for informing future work where they are used to guide neurostimulation targeting and parameterization.

Daniel Moreno DeLuca, M.D. is working with Eric Morrow M.D., PhD., Director of the Center for Translational Research at Brown and an expert in the functional genomics of rare variants in autism and schizophrenia. Moreno DeLuca is conducting remote research on digital phenotyping of behavior and facial morphology, as well as neuroimaging persons with rare genetic changes associated with autism. Because of the low frequency of rare genetic changes in the general population, he is working closely with several collaborators and datasets to increase sample sizes, including the Psychiatric Genetics Consortium, the Simons Foundation, the Autism Sequencing Consortium, the 17q12 Foundation, deCODE genetics, and the UK biobank. These datasets would be excellent sources for a computational fellow to focus on NLP to obtain phenotypic information from medical records, or AI approaches to integrate multiple streams of data.

Benjamin Greenberg, M.D., Ph.D. leads two related lines of research focusing on the development of brain circuit-based treatments in neuropsychiatry. At Butler Hospital, Brown's adult psychiatric 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 NIGMS Cobre Center, of which he is the PI. 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 **Trainer Jones**.

Sarah Garnaat, Ph.D. is working with DPHB senior faculty Rasmussen and Greenberg to examine cognitive control and related networks in OCD using fMRI, and using a single session of TMS to try to acutely modulate brain networks of interest (frontal-striatal networks) before putting people back in the scanner. Opportunities for individualized network modeling are also possible in this dataset.

Andrea Goldschmidt, Ph.D. has EMA protocols assessing mood, eating-related constructs, interpersonal functioning, shape/weight concerns, and environmental factors in obese children as well as daily actigraphy data and 24-hour computerized, self-guided dietary recalls. A novel simulated food restriction paradigm, an emotion regulation paradigm, and a food-cue working memory task are being studied in the scanner. She is working with **Trainer Shenhav** on the latter study who is seeking to elucidate neural underpinnings of self-control and decision-making loss of control eating

Nicole McLaughlin, Ph.D. has behavioral and neuroimaging data on tasks examining inhibitory control and cognitive interference in a variety of studies related to OCD, including cross-sectional and longitudinal (post-intervention) designs. These data allow for the examination of different types of cognitive control pre- and post- various interventions, including tDCS, TMS, and ablative neurosurgery. Potential questions of interest include predictors of response to OCD treatments based on task performance and neural correlates. She also has collaborations with **Trainers Badre and Borton.**

Nicole Nugent, Ph.D. conducts research focused on the interplay of biomarkers and social context as related to development of stress-sensitive outcomes such as posttraumatic stress disorder, depression, substance abuse, and suicidal thoughts and behaviors. Two currently funded digital phenotyping investigations involve intensively sampled ecological data and biomarkers. One study involves an innovative combination of ecological methods, including time stamped data streams from the EAR (electronically activated recorder; periodic 30 second audio capture that has been coded for environment, participant language, interactions), EMA of affect as well as suicidal thoughts and behaviors, and online social media (OSM). Participants also provide blood samples for interrogation of genomics (DNA, DNA methylation, gene expression). For the second study, adolescent injury patients are recruited in the emergency department and are sent home with a healthtracker watch and a smartphone; heart rate (HR) and skin conductance data are continuously streamed to and stored on the smartphone. Also loaded on the smartphone is the EAR, which collects 30 second audio samples every 12 minutes coded later for social interactions, and references to pain, affect, references to trauma or post-trauma symptoms. In addition, the app has been configured such that physiological reactivity (defined as an increase in HR) triggers additional audio assessments. Follow-up in-person evaluations include completion of a startle and a fear conditioning paradigm as well as assessments of attention bias.

Hwamee Oh, Ph.D. conducts multimodal neuroimaging approaches including amyloid and tau PET, structural and functional MRI (resting state as well as task-based fMRI), and behavioral measurements. Dr. Oh investigates the neurotoxic effects of beta-amyloid (Ab) plaque pathology on cognition and brain circuits among clinically intact older adults. In addition, in collaboration with **Trainer Nassar**, she plans to collect EEG and fMRI data during decision making to further examine the effects of Ab pathology on brain circuits underlying decision making, such as medial frontal cortex. These studies fit well with computational methods to link neural dynamics at the circuit level defined by molecular (Ab plaques) data to EEG, fMRI, and behavioral performance for cognitive control and decision making subserved by the prefrontal circuits. Dr. Oh is also working with **Trainer Badre** to investigate individual differences in cognitive aging trajectories utilizing behavioral measures, neuroimaging, and Alzheimer's disease biomarkers in a longitudinal birth cohort followed for 60 years. In addition, Drs. Oh and Professor Song in CLPS have collaborated on a project on sensory and motor function in aging and early Alzheimer's disease using behavioral and neuroimaging methods.

Noah Philip, M.D. uses functional neuroimaging with TMS, low-current stimulation and low intensity ultrasound in combination with network-based resting state functional connectivity, and virtual reality, to understand and treat serious psychiatric disorders, such as major depressive disorder and PTSD. Large data sets with ongoing data collection range from first-in-human studies of novel stimulation devices, rational development of individualized stimulation parameters, and multimodal imaging assessments on how trauma and negative mood states affect brain responses to stimulation.

Steven Rasmussen, M.D. conducts research focused on understanding the role of frontostriatal circuitry in the etiology of OCD and the use of this understanding to develop novel circuit-based interventions for the illness. Current projects with suitable data sets for computational analyses include: 1) the use of neuroimaging (functional and structural connectivity), cognitive tasks and clinical assessments to test a structural equation model of two core clinical features, harm avoidance and incompleteness, as drivers of symptoms of OCD and related disorders, and 2) the development of invasive and noninvasive closed loop neuromodulatory circuit based treatments for OCD. He has been a key investigator of a program project focused on the neurocircuitry of OCD and is co-PI of one of the projects with Trainer Shenav who in turn is co-PI of the computational core with MPI Frank of the overall project. He has worked collaboratively on internally funded projects over the last two years with MPI Frank and Teresa Desrochers that involve computational modeling of frontostriatal circuitry and tasks exploring uncertainty and information seeking and sequential learning in OCD.

Heather Schatten, Ph.D. has speech data samples from suicidal patients as part of a large study examining risk factors for suicidal behavior. To date, she has over 800 hours of speech data collected from personal phone calls. The primary aim of the grant is to predict changes in suicide risk based on changes in speech. The cleaned data will potentially be available for a TPCP fellow who would be interested in conducting additional analyses on acoustic properties that might be related to associated psychiatric symptomatology.

Mohamed Sharif, M.D., Ph.D., a newly recruited junior faculty member to the DPHB, uses computational techniques to understand microcircuit mechanisms underlying psychiatric disorders and their treatment, with a focus on schizophrenia, MDD, and OCD. To elucidate the microcircuit alterations in various psychiatric disorders, he utilizes cortical computer models to interpret resting-state EEG/MEG and ERPs in patients. He also studies how such microcircuit changes affect cortical functioning. In addition, he uses EEG data to study mechanisms of action of breakthrough treatments, like ketamine, in treatment-resistant depression.

Stephen Sheinkopf, Ph.D. is the Director of the Rhode Island Consortium for Autism Research and Treatment. Multilevel data amenable to computational approaches includes studies on: 1) visual attention to social information in young children with ASD using static and dynamic scenes, and 2) identification of subgroups that differ in cognitive and language functioning in the RI-CART data registry, and 3) a recent RO1 using voice recognition technology to explore abnormal separation cries as an biomarker of autism.

Laura Stroud, Ph.D. directs the Maternal-Infant Studies Laboratory and the Child and Adolescent Stress Laboratory in the DPHB. Her research involves a life course framework incorporating both neurobiological and behavioral markers of risk and a focus on novel neurobehavioral and stress response paradigms. She has a large data set of (epi)genomic biomarkers of prenatal exposures (such as depression, substance use, stress) as well as genomic predictors of fetal behavioral data and infant development that are available for questions that might benefit from a computational psychiatry approach.

Elizabeth Thompson, Ph.D.*,* is planning a study to explore associations between psychosis-spectrum experiences that may be indicative of emerging psychotic disorders in adolescents, including specific acoustic characteristics (e.g., increased proportion of pauses, increased pitch, decreased pitch variability, and decreased percentage of spoken time) and linguistic properties (e.g., decreased semantic coherence, lower semantic density, and lower syntactic complexity).

Amin Zand Vakil, M.D., Ph.D. is a psychiatrist with training and experience in electrophysiology and neuroscience. He has closely collaborated with **Trainer Jones**. A similar, large scale dataset is currently being collected as part of a collaboration between DPHB senior faculty member **Philip** with frequent multi-channel EEG recordings through the course of TMS treatment in patients with depression and PTSD. These data are amenable to computational psychiatry approaches aimed at better understanding disease neurobiology as well as refining and individualizing TMS treatment based on EEG recordings. He has also worked with DPHB junior faculty member **Barredo** and **MPI Frank** to link patient PTSD symptom severity to their brain functional imaging (fMRI). Using a novel ML algorithm, they identified networks of functionally connected brain regions where distinct patterns of regional communication differed based on patients' PTSD symptom profiles.