IGERT Integrative Graduate Education and Research Traineeship

Neuroengineering: From Cells to Systems

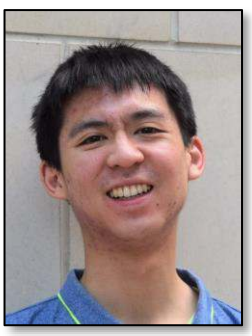
PI: Robert M. Raphael, PhD, Bioengineering, Rice University

neuroigert.rice.edu

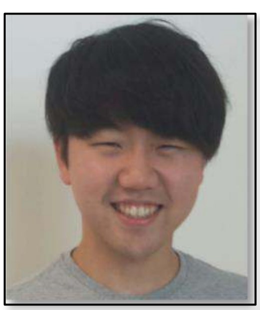
Meet the Trainees

Cohort 3, Appointed September 1, 2016 – August 31, 2018 (expected)

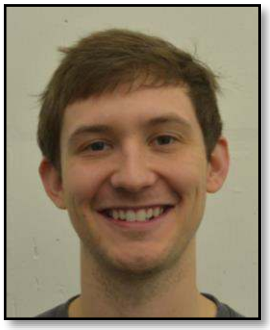
Krishna Badhiwala
Bioengineering, Rice University
Mentor: Jacob Robinson
Scalable Microdevices for Neuroscience with Small Organisms
Small organisms such as Hydra provide a useful model for studying the nervous system. These transparent invertebrates can be manipulated in microfluidic chambers to image almost every neuron. Neuronal calcium imaging combined with electrophysiology provide the resolution needed to identify single action potential events and the individual neurons associated with observed animal behavior. This project aims to study the neural processes underlying animal behavior using small model organisms in a microfluidic platform.



Joshua Chu
Electrical & Computer Engineering, Rice University
Mentor: Caleb Kemere
Probing Mechanisms of Working Memory and Decision Making Through Manipulation of Hippocampal Circuits
My research will investigate the incorporation of information from hippocampal replay into working memory and decision making. Real time decoding of replay events and content-based perturbation of associated sharp wave ripples (SWRs) will help deepen our understanding of the contribution of replay to learning and memory processes. This study may have translational impact by revealing strategies for treatment of depression or posttraumatic stress disorder via selective replay suppressions that do not interfere with recall of other memories.



Hamin Jeon
Bioengineering, Rice University
Mentor: Tomasz Tkaczyk
Minimally Invasive High Resolution Imaging of Auditory Neurons Inside a Living Cochlea
I propose to develop a minimally invasive cochlear-imaging device, based on the fast Image Mapping Spectrometer (IMS). Overall, the proposed research plan will involve development of innovative tool that can shed more light onto the elaborate workings of hair cells and auditory neurons in cochlea and, ultimately, the mechanisms of sound transduction. This may lead to the development of new treatments for hearing loss, or improvement of existing treatment technologies such as cochlear implant.



Matthew Evan Pezent
Mechanical Engineering, Rice U
Mentor: Marcia O'Malley
Design and Control of a Robotic Exoskeletal Device for Hand-Wrist Rehabilitation
Robot-augmented therapy is a clinically verified path forward to improving rehabilitation outcomes for several neuromuscular conditions, such as stroke and spinal cord injuries. Robotic rehabilitative devices enable the high intensity, long duration interventions needed for regaining motor function, and quantitative metrics for tracking therapeutic outcomes. I am developing a combined hand-wrist robotic exoskeleton to research passive dynamics in the hand and wrist during grasping and manipulation, and then mimic such properties in collaboration with stroke rehabilitation clinicians.

Dan Sazer
Bioengineering, Rice University
Mentor: Jordan Miller
Title: Spatially Controlled Photo-Patterning of Multi-Material Sensory Organ Mimics
The histological architectures of mammalian sensory organs are complex and heterogeneous. Integration of discrete cellular layers allows these tissue systems to reliably sense and relay environmental stimuli, but there does not currently exist a fabrication platform that is capable of recapitulating and probing these heterogeneous organs in vitro. The central objective of this study is to use projection stereolithography (PSL) to pattern multi-material, cell-laden hydrogel constructs that mimic the heterogeneous organization of sensory tissue systems such as the retina and cochlear stria vascularis. I am developing a novel 3D printer that implements PSL for cyto-compatible, multi-material integration, and with this system I intend to fabricate sensory organ mimics for various functional and pathological assays.

Sudha Yellapantula

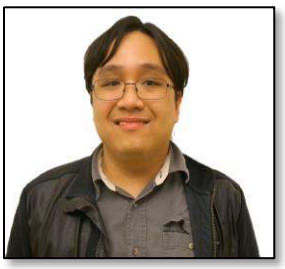
Electrical & Computer Engineering, Rice U
Mentor: Behnaam Aazhang
Reverse Aphasia in Permanently Impaired Adults, by Mapping Human Language Networks in the brain using ECoG data.
Reversal of aphasia is based on the hypothesis that the brain develops a certain functionality based on the various inputs it receives. It has been shown that the brain can adapt to changing input, and re-wire itself, so aphasia could be reversed if we create an implant that would redirect the inputs originally entering the lesioned area of the brain, into downstream areas, that would adapt to this new input and recreate the lost functionality. The goal of this project is to first understand the inputs and outputs associated with lesions in the brain causing specific aphasias. This knowledge will be gleaned by analyzing lesion databases, along with analysis of ECoG data obtained from various language experiments done in epileptic patients. This model can be validated if it can predict which patients would recover from a stroke that causes aphasia, and which patients would not.

Cohort 2, Appointed September 1, 2015 – August 31, 2017

Elizabeth Halfen
Neuroscience, Baylor College of Medicine
Mentor: David Ress
Multisensory Integration in Human Superior Colliculus (SC)
I plan to study multisensory integration in human superior colliculus (SC) using functional MRI. And optimize imaging and depth-mapping analysis protocols for human midbrain. I am currently finishing a study, in Dr. David Ress' lab, that maps visual stimulus representation in terms of eccentricity in the SC. Testing different sequences or changing the parameters, specifically the echo time (TE),

of the sequence we used in the study could help us recover signal quality in the middle of SC. Computational analysis of how sequence types and parameters affect functional data acquisition in midbrain structures would be useful not only in my own work but also in the work of other researchers who want to image small or subcortical structures. For this project, I would continue to work with Dr. Ress, who has a background in electrical engineering and physics and is an expert in MRI.

Eric Lewis
Electrical & Computer Engineering, Rice University
Mentor: Caleb Kemere
Deep Brain Stimulation (DBS) therapy and the reduction of symptoms associated with Parkinson's Disease (PD)
The effectiveness of DBS has not been thoroughly studied as a means of early therapy in PD due to the risks of surgery in human patients and lack of adequate animal models for progression of PD. I hypothesize that stimulation during the loss of dopaminergic neurons in animal models will slow the advancement of PD in the animal. I propose using Pink-1 knockout rats to test for neuroprotective benefits of DBS. All rats will be implanted with electrodes in the motor cortex (M1), STN, GPe, and SNc to record spiking and local field potentials (LFP) weekly to provide effective characterization of firing patterns. This study will indicate if DBS provides neuroprotective benefits to the progression of PD.



Minh Tan Nguyen
Electrical & Computer Engineering, Rice University
Mentor: Richard Baraniuk
Understanding the brain mechanisms underlying perception
The goal of my research project is to understand how the brain performs computations in certain key inference tasks, such as object and face recognition. I plan to organize my research around the following three Specific Aims (SAs). SA 1: Develop Neurally Plausible Models for Solving Visual Perception Problems I will develop new mathematical models for solving perceptual inference problems that A) are neurally plausible, B) offer good performance in complicated inference tasks, and C) have a strong mathematical foundation. Perceptual inference tasks are hard. The key factor complicating such tasks is the presence of numerous nuisance variation in the sensory data, for instance, the unknown object position, orientation, and scale in object recognition.

Amanda Wickens
Applied Physics, Rice University
Mentor: Jacob Robinson
Magnetoelectric Nanomaterials for Neural Modulation
Specifically my current interests in neuroengineering lie at the cellular level working in novel methods to modulate and record neural activity. Magnetoelectric materials represent a novel method for extracellular neural interface and modulation which is the primary motivation for this project. This project will first focus on the use of magnetoelectric thin film laminate composites composed of PVDF (a piezoelectric polymer) and Metglas (a magnetostricitve alloy). Currently, composites such as these are easily fabricated and well characterized in terms of their magnetoelectric properties. However, they have never before been used for applications in neuroengineering. This project will develop methods to culture neurons on the top electrodes of these films and modulate their activity using an external magnetic field. This project will also develop a method to model the magnetoelectric stimulation using an equivalent circuit.

The IGERT program is Administered by the:
Gulf Coast Consortia
QUANTITATIVE BIOMEDICAL SCIENCES

www.gulfcoastconsortia.org
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The GCC is a collaboration of:
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University of Texas Medical Branch at Galveston
University of Texas MD Anderson Cancer Center
Institute of Biosciences & Technology at Texas A&M Health Science Center