Sensory Decoding within the Mouse Visual Cortex

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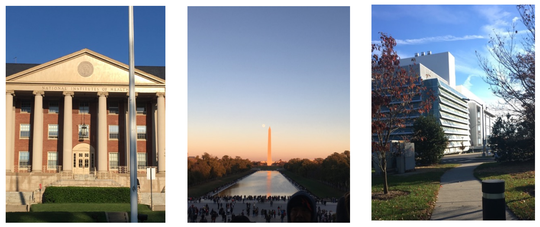
Introduction

For my final co-op, I had the opportunity to work at the National Institutes of Health (NIH) under the guidance of Mark Histed, Ph.D. The NIH is the nation's top medical research agency and aims to pave the way for breakthrough scientific discoveries within a wide variety of disciplines. The agency is made up of 27 institutes and each has its own research agenda and focus. During my time there, I was in the National Institute of Mental Health (NIMH) and our unit focused on neural computation and behavior. Our main goal was to understand how the brain interprets the activity of neurons and subsequently how it decodes this information to make decisions and actions.

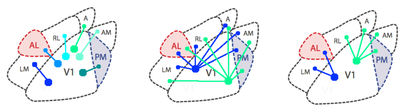


The NIH campus is located in Bethesda, MD, and only a few miles down the road from Washington, D.C.

Research Focus

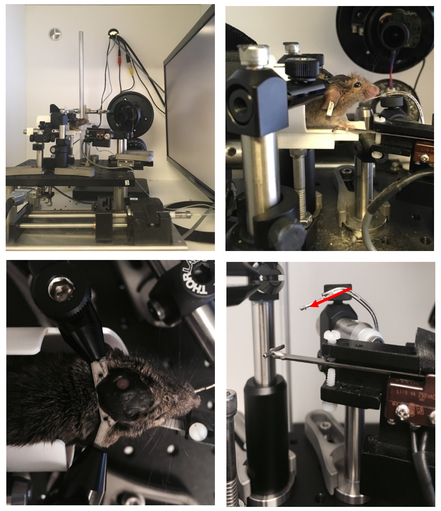
The Porter Neuroscience Center on campus and our behavioral room!

The Histed Lab utilizes psychophysical behavioral assays, in vivo electrophysiology, optogenetics, and two photon imaging, to understand how the brain interprets the activity of neurons within the visual system. During the presentation of a single visual stimulus, thousands of neurons are recruited to code, process and perceive the visual input. Our main research question aims at understanding how the brain interprets this stimulus and subsequently decodes this information to make informed decisions and actions. Research has demonstrated the presence of higher order visual areas that the mouse visual cortex (V1) targets for downstream visual processing[1,2]. The Histed Lab aims to understand how this processing is occurring through elucidating the circuit based mechanisms mediating the perception of visual input. Understanding a simple neural network such as that of the mouse visual system will aid in understanding how circuits change behavior in diseases such as schizophrenia and autism spectrum disorder.



Possible Circuit models from mouse visual cortex to the higher visual areas

Activity

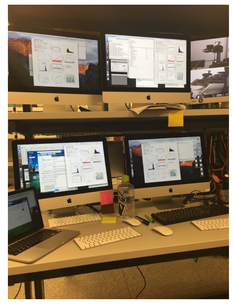


The behavioral equipment that we use to run our experiments!

Starting in a recently established lab, I had a wide array of responsibilities as a research fellow. For the first several months of my co-op, I was responsible for designing and fabricating the electronic and optomechanical parts used in our behavioral training. I acquired a variety of technical skills in materials engineering and was able to use these skills to optimize the behavioral reward delivery system. I was also responsible for all of the data collection and psychophysical behavioral assays conducted within the lab. My prior co-op experience at Duke University allowed me to aid the Histed Lab in troubleshooting surgical and optogenetic roadblocks.

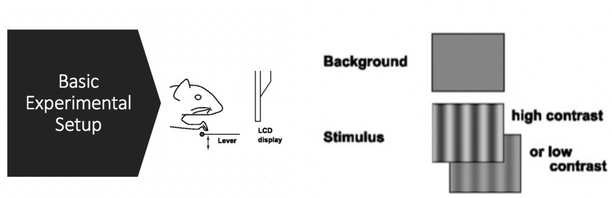
One of the first programs I wrote!

During my time in lab, I was given the opportunity to take a 14 -week long Python coding course! This was my first experience attempting to learn computer programming and required dedication and diligence. Following the completion of the course, I was able to write simple programs for the lab! Each week I would also attend seminars and journal clubs within the various institutes at the NIH.



4 out of the 8 behavioral stations in the behavior room

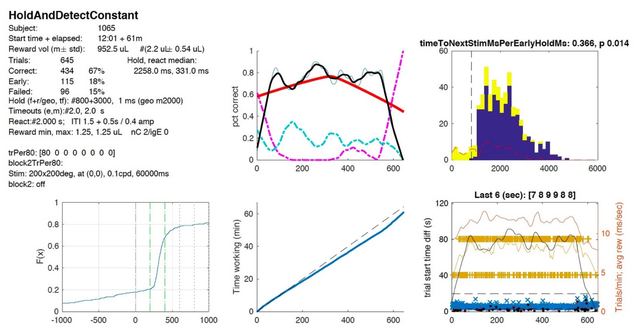
Outcomes



Behavioral Task

Visual behavioral task: We train the mice to respond to a drifting grating visual stimulus using operant conditioning[3]. The mouse is head-fixed with a chronic cranial window and positioned over a lever. The goal is to train the mice to release the lever upon the presentation of a visual stimulus within a specific react time window. They are trained to detect changes in contrast increments. Once they are trained to psychophysical threshold, they are then transferred and used for 1-photon imaging, 2-photon imaging, and in-vivo electrophysiology.

Each day we would collect a multitude of metrics from each behavior animal to assess their performance and overall progress (6 days a week, 90 minutes a day). In this behavioral paradigm, animals report contrast changes and receive juice rewards based upon a correct response. Each animal would take approximately 2-3 months to reach psychophysical threshold. During my time in the lab, we had to troubleshoot various training practices and reward delivery systems in order to optimize training. We were able to get several animals to perform training under 1-photon and 2-photon stimulation after several weeks of trouble shooting! Behavior was the most important part of our lab because many of our experiments were based upon perturbations to the trained behavioral response.



Example of a few behavioral graphs generated daily

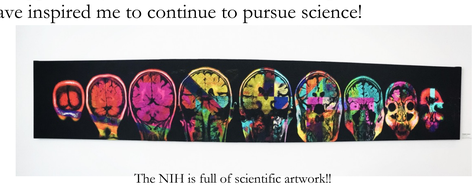
Literature cited

1. Wang, Q., Burkhalter, A. Area Map of Mouse Visual Cortex. *The Journal of Comparative Neurology* . **502:**339-257 (2007)
2. Andermann, M.L. et al. Functional Specialization of Mouse Higher Visual Cortical Areas. *Neuron.* **72**, 1025-1039 (2011)
3. Histed, M., Carvalho, L., Maunsell, J. Psychophysical measurement of contrast sensitivity in the behaving mouse. *Journal of Neurophysiology.* **107:** 758-765 (2012)

Reflection

Representing Northeastern University Triathlon Team at the Nation's Triathlon and the Marine Corps Marathon

My time spent at the NIH served as the perfect way to finish my undergraduate research career. The NIH fosters an amazing sense of community and strives to provide students with the tools needed to grow as a scientist and individual. Over the span of 7 months, I learned how to be independent, confident and resourceful. My lab provided me with an immense amount of support and mentorship and challenged me to think outside the box. I was able to grow as a scientist and used my experiences to shape my education. Aside from the technical skills I acquired, I was also able to learn a lot about myself. My co-ops at the NIH and Duke University taught me how to move beyond my comfort zone and adapt to new surroundings. Both of these experiences allowed me to further my independence and gave me the opportunity to live in some pretty amazing places! Science is challenging, frustrating and complicated. Fortunately, I have had the opportunity to work with some amazing individuals who have inspired me to continue to pursue science!



The NIH is full of scientific artwork!!

Acknowledgments

I would like to thank Mark Histed for allowing me the opportunity to be a member of the lab and continue my development within the neuroscience research community. I thank Lindsey Glickfeld for also giving me the opportunity to conduct research with her lab at Duke University Medical School, which enabled me to acquire the skills to work at the NIH. Thank you to the Histed and Glickfeld labs for your guidance, and thank you to Michelle Israel for your continuous support!

The Histed Lab!

Further information

Upon graduation I will be returning to the NIH to start a research fellowship with Ariel Levine M.D., Ph.D., within the National Institute of Neurological Disorders and Strokes. Our lab will focus on studying plasticity and learning within the spinal cord!