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**Research Statement**

My long-term goal is to become a professor in theoretical neuroscience at a top University like Duke. For this, I joined the Duke Neurobiology Graduate Program and the lab of John Pearson, where I investigate how our visual system works.

In principle, there are three explanatory processes that underlie scientific explanation: Descriptive (what), mechanistic (how), and normative (why) explanations1. The latter have been much less developed in neuroscience. When theories are successful, they unify experimental findings and generate predictions about how brain cells are connected and function to process information. My goal is to develop such normative explanations. The visual system is one of the best understood neural systems, making it a great field for building normative explanations.

For this, I studied visual neuroscience under the supervision of Dr. Curtis Baker for my Master’s degree at McGill University. In that work, I used machine learning to model recorded responses of the primary visual cortex to natural images. I showed that the involved neurons respond more to dark than light stimuli. This research resulted in a first-author paper in the *Journal of Neuroscience*. Thus, my Master’s degree provided me with a solid foundation for understanding the visual system.

My current research focuses on efficient coding, which is a mathematical framework for understanding how neurons *should* encode information. This framework provides results that can be directly compared to experimental data. Efficient coding has been especially successful in the visual system. However, efficient coding frameworks are mostly limited to static black-and-white images. We still lack efficient coding predictions for how the retina processes many complex features of the visual world such as color and motion. For example, we do not understand why most cells in the retina process the differences between red and green color. We also do not understand why some neurons encode motion in one of the four cardinal directions. My work will tackle these problems, by using machine learning to train a population of model neurons to efficiently encode natural images. This model will provide testable predictions that we will compare with experimental data. Importantly, our collaborator, Dr. Greg Field at UCLA, is generating experimental data I can directly use to test the framework I am developing. Altogether, this work will reveal fundamental principles of how the visual system works. In addition, this work will train my theoretical and computational skills, which are essential for successful modern-day neuroscientists.

I also have the ambition to use my knowledge to train the computational skills of other students, which are becoming more and more important in neuroscience. In the past, I tutored undergraduate students in statistics and formally taught programming in workshops on the programming languages R and Python. In the future, I plan to serve as a Teaching Assistant for the graduate-level course Quantitative Neurobiology, and to help teach a bi-weekly methods workshop for Duke neuroscientists. Altogether, these activities will not only support my community, but also prepare me for my long-term career goal of being a professor.

After completing my PhD in Neurobiology, I want to continue my training as a postdoctoral fellow and expand my work to the entire brain. My previous training in experimental neuroscience and my current training in computational methods, will put me in a perfect position to do this. Receiving the Myra and Bonne fellowship will allow me to pursue the above-described research project and training, which I will be able to fully dedicate myself to since I will have completed my training requirements for Neurobiology next fall. Doing so will get me closer to my goal of becoming a professor in theoretical neuroscience. I hope that by developing better theories, I can help us understand the essence of what neurons do and accomplish one of the biggest challenges in science: Understanding how the brain works.

**Bibliography**

1. Levenstein, D., et al., *On the role of theory and modeling in neuroscience.* Journal of Neuroscience, 2023. **43**(7): p. 1074-1088.