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**Research statement**

There are three explanatory processes that underlie scientific explanation: Descriptive (what), mechanistic (how) and normative (why) explanations19. Neuroscience is a relatively new field, which is why most of its efforts have been focused on descriptive and mechanistic explanations. Neuroscience currently lacks normative explanations, which are conceptual frameworks of what the brain does. Such frameworks would allow us to understand what objective function the system is trying to optimize, which in turn allows us to make predictions about what computations a system performs. My goal as a researcher is to bridge that gap and develop better theories to explain neuroscience phenomena. For that purpose, I am currently doing theoretical work in the retina under the supervision of John Pearson at Duke University. My long-term goal is to become a professor in theoretical neuroscience at a top University like Duke. I personally believe that it is only a matter of time before we develop general theories that explain how the brain functions, and I would love to dedicate my career to help push theoretical neuroscience to the next level.

Mechanistic explanations are a pre-requisite to normative explanations, in that we need to first understand how a system works before trying to explain why it works that way. There is a lot of work in experimental neuroscience to understand the mechanisms of a system, and this endeavor has been more successful for some systems than others. The early visual system is one of the neural systems we understand best, making it a great foundation for building normative explanations of how neural systems function. This became apparent to me at the end of my undergraduate studies, which is why I chose to research visual neuroscience under the supervision of Dr. Curtis Baker for my Master’s at McGill University. In this work, I used machine learning to predict recorded responses from the primary visual cortex to natural images. We showed that primary visual cortex neurons have weaker inhibition to dark than light stimuli in their early, but not late, responses. This research granted me a first-author paper in the Journal of Neuroscience, entitled **“Model-based approach shows ON pathway afferents elicit a transient decrease of V1 responses”**. My Master’s granted me a lot of expertise and knowledge in visual neuroscience, which I now want to use for theoretical work.

For this reason, I started my PhD in Neurobiology at Duke University under the supervision of John Pearson. I study efficient coding, which is one of the most successful theories in neuroscience. This theory provides us with a mathematical framework to understand how neurons *should* encode information, which can then be experimentally tested against how neurons *actually* do so. Over the past 60 years, efficient coding has successfully explained many experimental findings in different sensory modalities such as vision, audition and touch. This hypothesis has been especially successful in the retina, where it can explain many features of retinal encoding such as center-surround receptive fields and ON-OFF pathways. However, we still lack efficient coding predictions for how the retina processes many complex features of the visual world such as color. More specifically, we don’t know why most retinal ganglion cells (RGCs) in the fovea (the center of the retina) are midget cells, which process the difference between red and green stimuli. My work will tackle this problem by providing a theoretical account of how the retina integrates redundant inputs across different color channels. We will do so by building an efficient coding model that optimizes the mutual information between the natural images and model RGC responses. My lab has previously been successful at building such models, which were used to explain why ON-OFF mosaics in the retina are anti-aligned. Completion of this project will result in testable predictions for efficient coding of motion in natural images, which we will be able to compare to experimental data from the Field Lab at UCLA. This training will teach me how to do research in theoretical neuroscience, and will be the first step towards my goal of building better normative explanations in neuroscience.

My interest in computational approaches led me to develop multiple computational skills during my undergraduate and graduate studies. Not everyone has this chance, which is why I want to help the communities I participate in to develop their computational skills. I was able to help undergraduate students understand statistics better by being a private tutor for McGill students for about 2 years. Back at McGill’s, I also hosted a programming workshop in R for graduate students, and was a TA for another workshop in python. I would like to keep helping the community at Duke during my PhD. I intend to do so by being a TA for the programming class in Neurobiology next year. People from my lab also host bi-weekly methods workshop for neuroscientists, which is definitely something I would like to help with as well. These opportunities are great teaching experience that will prepare me to become a professor in the future.

After I complete my graduate training at Duke, I want to pursue a post-doc with the goal of becoming a professor in theoretical neuroscience at a top university like Duke. I want to develop theories of how the brain works that not only apply to the retina, but to the brain as a whole. I am especially interested in studying computational models of inhibition and synaptic plasticity, and use such models to explain how systems (e.g. vision) process information. Combined with my current rigorous training in computational methods, my previous training in experimental neuroscience would make me the perfect candidate to collaborate with experimentalists and build theoretical models from their data. Since I will have completed completed the required courses for Neurobiology next fall, I will be able to fully dedicate myself to my research. Receiving the Myra and Bonne fellowship will allow me to complete the above-mentioned research project, 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 and develop better normative explanations of neural systems.