International Chancellor's Scholarship applicant statement
David St-Amand

Vision is the sense most central to people's experience of the world. While a lot is experimentally known about the early visual system, we are still lacking an integrative theory of how vision works and why. For my PhD, I want to tackle this problem and build coherent, testable theories that can explain and unify experimental findings in visual neuroscience.

To do so, I will draw upon my previous research experience in both visual and computational neuroscience. This experience began in the last year of my undergraduate degree in honors psychology at McGill University, where I studied how memory influences our decisions and found that episodic memory reduces the bias we naturally have against risky decisions. My resulting first-author paper, "**Modulating episodic memory alters risk preference during decision-making,**" was published in the Journal of Cognitive Neuroscience. While this initial experience sparked my interest in research, I wanted to better understand the brain at the circuit level, which led me to pursue my Master's degree in visual neuroscience under the supervision of Dr. Curtis Baker at McGill University. In my research, entitled "**Model-Based Approach Shows ON Pathway Afferents Elicit a Transient Decrease of V1 Responses,**" I built a custom machine learning algorithm to analyze how recorded primary visual cortex (V1) neurons respond differently to light and dark patches within natural images. Using these methods, we showed that V1 neurons have weaker inhibition to dark than light stimuli in their early, but not late, responses. These results demonstrate how imbalances in excitation and inhibition can give rise to response asymmetries in cortical neuron responses. I recently published this work as a first-author paper in the Journal of Neuroscience.

I am excited to now take my academic career to the next level by pursuing my PhD at Duke University under the supervision of Dr. John Pearson. I want to better understand the visual system by studying how it relates to information coding principles. Barlow (1961) suggested that sensory systems should be organized to optimize the information they process within some biological constraints (such as energy costs and a limited number of neurons). This *efficient coding* hypothesis makes testable predictions that have been verified experimentally, including center-surround receptive fields (Karklin & Simoncelli, 2011) and color-opponency (Lee, Wachtler & Sejnowski, 2002) in the retina. Another interesting characteristic of the retina is that its retinal ganglion cells (RGCs) are organized into functional types. While each of these neurons processes information in a localized region in visual space, each functional type has neurons that tile the entire visual space to form a 'mosaic' across the retina. There are over 40 functional types of retinal ganglion cells, each of which processes visual stimuli in a different way. Recently, Jun, Field and Pearson (2021) used an efficient coding model to explain characteristics of these retinal mosaics. However, these models are limited to black and white information and cannot yet make predictions about how colors are processed. It is well-known that the majority of retinal ganglion cells form a mosaic that encodes the difference between shades of red and green, while another subset of neurons form a mosaic that encodes differences between shades of blue and yellow (Dacey, 1999). In my research, I aim to explain why it is efficient to encode colors this way by expanding the efficient coding model by Jun, Field and Pearson (2021). With my strong background in both visual and computational neuroscience, I believe I am in an excellent position to utilize information theory to shed light on why the early visual system is wired the way it is.

After I complete my PhD, my goal is to become a professor in theoretical neuroscience at a top research university like Duke. To achieve this goal, there are many skills I will need to develop during my PhD. The scientific writing course I will take this fall will be an amazing opportunity for me to work on my writing skills. I will then put these new skills into practice and attempt to secure my own funding by applying to the Canadian **NSERC postgraduate scholarship** in October 2023. I will also need to develop my networking skills, which I plan to practice by participating in the Society for Neuroscience (SFN) conference in November 2023. When my research has made enough progress, I will also submit research abstracts to conferences specialized in computational neuroscience such as Cosyne and NeurIPS. To work on my teaching skills, I will likely serve as a teaching assistant for the **Quantitative approaches in Neurobiology** course in my 3rd year of graduate studies. I really look forward to honing these research skills during my PhD and eventually using this expertise to pursue theoretical neuroscience research at the postdoctoral and faculty levels.

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