Statement of Purpose

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I am most interested in how people construct mental models of their environment and how it informs their decision making process. Some of the questions I wish to answer are in regards to how we can construct a computational model of these processes. How do prediction errors inform the state of the environment? What are the neural substrate of menal models? What role does the dopamine and the noradrenaline system play in processing error signals and updating said models? My research experience have prepared me to ask these questions through assisting in projects that investigated mental model updating and by familiarizing me with computational tools that allow me to construct behavioral experimental tasks and conduct data analysis. I believe this institution is ideal for continuing my training and research because of the faculty members who share my interest and the wealth of equipment I can utilize to answer my questions. My goal after my graduate training is to continue a career path to become a professor who is well equipped to take their research anywhere, be it in North America or back in my native country, South Korea, to contribute to a global initiative to practice cognitive science and to foster future scholars.

While my interest in the human mind started during my childhood, my research experience only started during my third undergraduate year at the University of Waterloo. Before that, I was on a two years leave to fulfill the South Korean military service requirement. I used this period as an opportunity to consider many career options (both academic and non-academic) and I invested time to read on topics ranging from military psychology, history, computer science, philosophy, behavioral economics, biology, and neuroscience. Ultimately, I decided to return to my undergraduate study with a galvanized will to continue a career path to become a scholar in the field of cognitive science. After my return, I entered Dr. Britt Andersons lab as a research assistant, and I enrolled in a directed studies course on statistics, supervised by Dr. Anna Dorfman.

In the lab, I assisted in two graduate student's projects, both involving eye-trackers (SR Eyelink) and probability learning (PL). The first project investigated whether the manipulation of involuntary spatial attention can influence voluntary spatial attention. This was done by biasing participants to a region of a display with a spatial PL task and analyzing their voluntary attention tendency using the Tse illusion. The second project investigated what eye movements can reveal about mental model updating. It involved participants learning the distribution shape of how stimuli dots appeared on the surface of an invisible circle. We monitored eye behaviors such as dwell duration (time spent fixated on a stimulus) and saccade latency (time between stimulus onset and saccade initiation) when stimuli appeared in 'low' vs 'high' probability locations and when the stimuli distribution shape was changed ('wide' $\leftrightarrow$ 'narrow').

Through a directed studies course, I strengthened my ability to work independently and I became more familiar with R programming through cleaning, mutating, visualizing and analyzing a diary data set. This data set was originally used to explore how people internalize events when writing a diary in either a self-immersed (first-person) or self-distanced (third-person) perspective. I used this data set to conduct my own exploratory analysis with my own post-hoc hypotheses. I learned to use packages to conduct quantitative discourse analysis, linear mixed effect modeling, and visualization. Along side my final write up, I created a supplementary document walking through my analysis and visualization process; which is openly accessible[1].

Currently, I am working on my undergraduate thesis project[2] under the supervision of Dr.

[1] `https://github.com/sjp117/Undergrad_Projects/tree/master/mixedEffectModelDiary`

[2] `https://github.com/sjp117/Undergrad_Projects/tree/master/mentalModelUpdatingPupil`

Britt Anderson. This project explores the relationships between changes in an internal model, confidence and pupil diameter. My participants were tasked to infer whether the shape or the color of the visual stimuli was relevant when making a decision to go 'up' or 'down', and indicate how confident they feel that one or the other factor is at play. After making their choice, they received a stochastic audio feedback where there was a small chance to be wrong regardless of making the correct choice. I manipulated the participants belief by alternating the relevant factor while I looked at their pupil responses when they made prediction errors. Of interest was comparing pupil response after experiencing an informative or an uninformative prediction error. I hypothesized that informative errors will elicit a greater pupil response. A secondary hypothesis I explored was whether confidence positively correlated with greater pupil response and belief change. This was done by manipulating the stochasticity of the feedback where, during certain blocks, the chance of an unreliable feedback was increased.

In the process of working on my thesis project, I developed a variety of technical skills. I became more skilled in the use of Python and the Psychopy library to code my experiment. I became more proficient with R programming to transform, visualize and analyze data. I applied parallelization to some of my Python codes to run tasks concurrently or to expedite a process. I learned to use an unfamiliar eye tracker (CRS LiveTrack), applying its code library and resolving bugs. And, I became more proficient working in the Unix environment and a variety of its tools to troubleshoot hardware issues and maintain a backup pipeline. I believe the skills I developed will be of value to both research and teaching assistantship. Although Im most familiar with Python and R, I am confident I can efficiently adapt to different programming languages, such as MATLAB or Julia, if there is motivation to do so.

I am most interested to work with Dr. Tobias Gerstenberg as my interest is most aligned with his. In the broadest sense, I want to investigate how the human mind is able to use internal models of the environment to make causal judgments that inform adaptive decisions. Take the example of crossing a road while chatting with a friend. How is it that, at one moment, we are attending to a conversation, than quickly evaluate whether to keep walking or to stop at the end of the sidewalk? There seems to be a gradual accumulation of evidence or error signals as the expected number of pedestrians diminish from the forward field of view or when the sound of the traffic becomes louder than expected. When all these signals pass a threshold, our mind is able to rapidly divert our attention from the conversation to the traffic and the pedestrian light to evaluate the next course of action.

From all the possible state of the world, our mind was able to intuit that we have come to the end of the sidewalk and it only focuses on select signs of danger, such as drivers, traffic lights and the self. However, it does not consider the flavor of the ice cream being sold at the sidewalk. We do not imagine that the flavor of the ice cream will cause a collision, while we do imagine a world where a negligent or malicious driver causes a collision. Thus, ice cream flavors are often not part of our mental model when crossing a road. How are these mental models formed and where do they reside? Are they updated or do we construct new ones? What role does error signals from the dopamine and noradrenaline system play in the change and choice of mental models? And how could we computationally model this function?

My questions are numerous and one could become an expert in answering just one of them. As such, I am willing to narrow down my research program and I am open to considering other research questions with suggestions from a potential mentor.