Personal Motivation: I remember clearly the moment my best friend disclosed she had an eating disorder. It was autumn and we had just started high school. I remember the question that came to me in that moment: *how can I understand what is happening in your mind?* Though I have tried my hardest since then to find out, ten years later I still have no answer.

Despite tremendous progress in psychology and neuroscience, we are far from being able to offer a complete account of the cognitive operations responsible for how we learn and make decisions in our everyday lives. Unsurprisingly then, we are further still from understanding how these processes go awry in psychiatric illness. Though I was initially drawn to psychology by clinical aspirations, I quickly realized that without a rigorous, mechanistic account of how we learn to navigate our world, we are profoundly handicapped in any attempt to understand mental illness. Thus, for the last eight years I have dedicated myself to research advancing our understanding of learning and decision making. My ultimate goal is to develop rigorous computational models of these processes in order to understand how they operate in our everyday lives and how they break down in psychopathology.

Intellectual merit: My training in psychology and neuroscience began as an undergraduate at Johns Hopkins University (JHU). However, my start in computational methods came in my junior year when I was selected as the 2012-2013 Visiting Undergraduate Research Fellow in Cognitive Science at Indiana University. I applied because the fellowship afforded a rare opportunity to engage in full-time research while still an undergraduate. At Indiana, I studied under Professor John Kruschke, an expert in computational models of learning and Bayesian statistics, and completed his year-long graduate seminar in Bayesian modelling and statistics. At the same time, I began research investigating mechanistic models of human counterfactual reasoning. Using what I had learned in class, I devised competing models of how humans might use prospective and retrospective counterfactuals to resolve credit assignment problems. I then compared these models' predictions to actual human behavior collected from several hundred participants. My time with Professor Kruschke (which culminated in my senior thesis[1]) gave me a solid foundation in computational methods that would serve me in all my future research.

Returning to JHU to complete my degree, I sought additional research opportunities in order to challenge and refine my newfound computational abilities. With Professor Marc Boulay, I joined a team of epidemiologists, clinicians, and statisticians studying the effects of social network structure on risky decision making and HIV transmission in Nigeria. Using egocentric network models, we found that seroconcordancy predicted decreased risky decision making and HIV transmission rates even after controlling for individual-level variables.[2] In separate research with Dr. Jared Lorince, I studied models of belief formation in a sample of two million users of a Wikipedia-like website. Specifically, I developed statistical methods for identifying "expert" users and quantified their outsized influence on communal knowledge.[3,4] Though unrelated, these projects not only expanded my computational repertoire but also challenged me to learn how to communicate and collaborate with researchers with vastly different backgrounds and expertise.

Though I enjoyed these experiences, I realized I next wanted to work on research investigating how cognitive processes like reasoning and decision making were instantiated in the brain. Thus, following graduation, I became a research assistant with the Massachusetts General Hospital (MGH) TRANSFORM-DBS program: a DARPA-funded project to develop closed-loop deep brain stimulation (DBS) for patients suffering from severe psychiatric illness. For three years, I worked with a team of neuroscientists, neurosurgeons, psychiatrists, and engineers all working to develop this revolutionary therapeutic technology. At MGH, my primary responsibilities were the collection and analysis of EEG and fMRI data. Despite never previously working with either modality, I quickly rose to the challenge and was thereby able to make many analytic contributions to the team's research. As a result, I co-authored five publications[5-10] and three first-author posters presented at major scientific conferences.[11-13]

Of my research at MGH, I am most proud of two accomplishments. First is my work investigating the effects of DBS on executive control in patients with severe depression.[10] In a study of DBS patients, we found that DBS improved patients' performance on a Stroop-like task, and this improvement was correlated with enhanced prefrontal cortex theta oscillations as measured by EEG. Most importantly, the degree of theta oscillation increase was predictive of patients' clinical response to DBS. These results provided preliminary evidence for a more mechanistic approach to DBS therapy, based on tuning stimulation to optimize neurophysiologic phenomena. Second is my work modeling approach-avoidance decision making in a sample of healthy controls.[13] In this work, I devised a novel hierarchical Bayesian model that estimated trial-by-trial decision conflict from reaction times and choice behavior. Using these estimates as regressors in model-based fMRI analysis, I found that conflict modulates the hemodynamic response, and that accounting for these changes allows for more robust detection of neural activity in the salience and executive control brain networks during approach-avoidance conflict.

My experiences at MGH reaffirmed my belief that only through advances in our mechanistic understanding of learning and decision making will we be able to make significant progress in understanding psychiatric illness. As such, I am incredibly excited to be pursuing my doctoral studies at the Princeton Neuroscience Institute (PNI). After completing my research rotations this past summer, I joined the labs of Professors Yael Niv and Nathaniel Daw, two leading experts in the psychology and neuroscience of learning and decision making. Under their guidance, I have started several lines of research developing computational models of complex learning processes. With Professor Daw, I am currently writing a first-author manuscript summarizing a series of experiments that formalize the construct of controllability in reinforcement learning. With Professor Niv, I am using Bayesian hierarchical models to analyze data collected as part of a series of experiments investigating the interactions between attention, decision making, and learning. I am confident that, with the expertise and guidance of Professors Niv and Daw and my extensive background in computational research, I will be able to successfully carry out the proposed research during my doctoral studies.

Broader impacts: In line with my goals, it is important to me to be able to communicate my research to non-scientists, especially mental health practitioners and patient populations. As such, I have been involved with mental health volunteering for many years. At JHU, I completed certificates in peer counseling and crisis intervention and volunteered with the Counseling Center for three years. At MGH, I shadowed psychiatrists in order to hear from patients and better understand their experiences. Beyond informing my research vision, these experiences make me unique in my ability to communicate psychological and neuroscientific research to the groups most impacted by it in a language most meaningful to them. In recognition of these efforts, I was recently admitted to the prestigious Alda Center Workshop for Communicating Science. With this additional training, I intend to continue my outreach to clinicians, patients, and the general public to communicate psychological research and its importance for advancing clinical research.

I am also passionate about improving the reproducibility and transparency of scientific practices. In an effort to improve the transparency of my own research, I am committed to making available all data and code from my previous and ongoing research.[14] Similarly, I have also been involved in efforts to improve the reproducibility of computational science. For example, this past summer, I was accepted to and attended NeuroHackademy, a workshop on open source software and reproducible analysis of neuroscience data. Using the skills I learned there, I am developing software for the standardized analysis of eye-tracking and pupillometry data.[15] This software, used recently by the Niv lab to analyze a quarter-million eye fixations, is freely available to the scientific community and will help to standardize the analysis of these very important types of data. Moving forward, it is my intention to continue weaving reproducible and transparent practices into my work so as to maximize the rigor of my own studies and foster the growth of new ideas through open collaboration.

Finally, I am committed to training the next generation of scientists through teaching, mentoring, and service. I have actively sought opportunities to practice teaching and have lectured on neuroscience and computational methods at Harvard Medical School, Columbia University, and Princeton. As the graduate student representative to the PNI curriculum committee, I am also directly involved in the planning of the courses offered to both undergraduate and graduate neuroscience students at Princeton. At JHU, I was the chair of the Cognitive Science Honors Society. As chair, I helped other students navigate the cognitive science program and find research opportunities. At MGH, I mentored undergraduate interns through the Harvard Summer Student Research Program. I mentored one particular student, KL, for two consecutive summers. Working with KL taught me how to support the growth of someone new to computational research. Together we worked on several projects (one of which we published[6]) and she is now continuing computational research at the Allen Institute. Watching KL become an impressive researcher in her own right has been one of my most rewarding academic experiences and I look forward to continuing mentoring students at Princeton.

Career Aspirations: My long-term goal is to become a professor of cognitive science with my own lab specializing in computational cognitive research. Specifically, I want to use computational methods to develop mechanistic models of learning and decision making and use these to augment treatments for mental illness. Given the scope and complexity of this goal, it will be imperative to build diverse collaborations with other researchers across varying fields. Support from the NSF GRFP would be immensely beneficial in pursuing these goals. (1) The NSF GRFP will support my training in computational methods by allowing me to attend additional workshops. (2) It will also allow me to attend diverse academic conferences and patient outreach events, helping me build collaborations and communicate my science. (3) Finally, the NSF GRFP will also help me to give back to the scientific community by making it possible for me to continue developing robust open source software and mentoring new students.

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