Lucy Lai
Stanford Neuroscience PhD Statement of Purpose

As a neuroscientist and future professor, I plan to combine experiments and theory to elucidate the neural principles underlying sensorimotor function in health and disease. By pursuing a Ph.D. in Neuroscience, I seek to acquire the tools necessary to conduct rigorous experimental investigations of neural circuits and to discover the computational principles that govern circuit function in complex behaviors.

Inspired by my thirteen years of training as a classical pianist, I became fascinated with how the brain processes complex perceptual scenes and learns sophisticated motor sequences. Curious as to how our brains guided our interactions with the world, I declared a major in Cognitive Sciences and joined Dr. Jeffrey Yau's lab at Baylor College of Medicine (BCM) in my freshman year to investigate how brains processed sensory information. In the Yau Lab, I designed and implemented a psychophysical experiment where human subjects made duration judgements on multisensory stimuli to investigate how the brain uses context to inform multisensory perception. I found that the same multisensory cues produced different percepts depending on the context in which they were presented. With data in hand, I recognized the need to gain experience in computational modeling of behavior, as no previous model in the multisensory literature could explain the pattern of interactions that we had observed.

Seeking an opportunity to learn more about computational neuroscience, I applied to and was awarded a travel grant to attend the 2016 Computational and Systems Neuroscience (Cosyne) conference in my sophomore year. Inspired by the collaborative work of theorists and experimentalists and convinced that theory unified principles of neural computation, I began adding quantitative courses in mathematics, statistics, and computer science to my curriculum in hopes of applying theoretical approaches to my research.

At Cosyne I met Dr. Mehrdad Jazayeri, whose work blended behavior and computational modeling to characterize the brain processes underlying sensorimotor timing. The summer after my sophomore year, I joined Dr. Jazayeri's lab at the Massachusetts Institute of Technology (MIT) as part of the Center for Sensorimotor Neural Engineering's (CSNE) NSF-REU program to investigate how timing is represented in memory. I designed and implemented a psychophysical experiment where human subjects recalled and produced time intervals from memory and developed a Bayesian inference model that could explain subjects' bias and variance in interval timing. I presented my work as a poster and talk at the CSNE in Seattle, and have continued working with Dr. Jazayeri to prepare a first-authored manuscript of my work. With the skills I gained from MIT, I was better equipped to engage my research back in the Yau Lab.

During my junior year, I resumed my exploration of multisensory perception in the Yau Lab. After nearly a year of trial-and-error, I developed a Bayesian observer model that explained our behavioral data and predicted conditions under which the same sensory inputs can be flexibly interpreted. With the support of a Rice Undergraduate Scholar grant, I presented posters of my work at Society for Neuroscience in 2016, International Multisensory Research Forum in 2017, and Cognitive Computational Neuroscience in 2017. Additionally, I wrote my Neuroscience honors thesis on this research, and am about to submit a first-authored manuscript of my work to a peer-reviewed journal.

Behavioral psychophysics and computational modeling provide methods to study perception and sensorimotor action in humans. However, I also wanted to understand the underlying neural mechanisms that drive complex behaviors. Seeking to learn neurophysiology, I joined Dr. Joshua Dudman's lab at Janelia Research Campus (JRC) as part of the Janelia Undergraduate Scholars program to probe the neural representations underlying action selection. By recording extracellularly from neurons in the motor cortex and striatum of mice performing a directional reaching task, I found that while both motor cortex and striatum represented action choice, striatum showed more sensitivity to the kinematic parameters, such as velocity, of the action. At Janelia, I was exposed to state-of-the-art technologies in recording and imaging, and discovered the beauty of hearing neurons fire in an awake, behaving animal. Excited by the types of questions that could be answered by physiology, I left Janelia with a greater appreciation of the various levels of explanation that neuroscientists operate at and how one level can inform discovery in another. At the end of the summer, I presented my work as a poster and talk to the JRC community, and am now preparing a figure of data from my neural recordings to be incorporated into a manuscript.

My experiences at BCM, MIT, and JRC equipped me with the skills necessary to articulate my research questions and to design robust experiments to answer them. More fundamentally, I have learned that research is both challenging and fulfilling. Despite the reality of failed experiments and the levels of persistence and patience required in research, I remain driven by the satisfaction that comes from inquiry and discovery. I seek to continue pursuing my curiosities in Stanford's Neuroscience PhD program, where I plan to build a broad, interdisciplinary skillset for conducting neuroscience research at different levels of explanation.

Vibrant labs within the Stanford Interdepartmental Neurosciences Program provide exceptional environments for the kind of graduate training I seek. In particular, Dr. Shaul Druckmann's research resonates with my interest in understanding and modelling the neural circuit computations underlying sensorimotor behaviors. I am interested also in Dr. Jennifer Raymond's research on understanding the neural principles underlying cerebellar learning in the VOR system. Additionally, I find Dr. Krishna Shenoy's research on understanding the neural circuit dynamics and computations underlying motor control to be particularly intriguing. Finally, I am interested in Dr. Surya Ganguli's research on extracting meaningful representations from high dimensional data and on understanding the neural dynamics and network computations underlying complex behaviors. Should I be accepted to Stanford, I plan to rotate through these labs; to this end, I have already communicated with Drs. Druckmann and Raymond regarding our mutual research interests in building computational models that are biologically plausible and experimentally tractable to test theories of circuit function in sensorimotor behaviors.

By bringing together faculty in molecular biology, physics, psychology, and engineering under an interdepartmental program, Stanford's Neuroscience Institute is uniquely positioned to provide interdisciplinary training and opportunities for collaboration. I intend to make the most of this enriching environment by collaborating with experimentalists and theorists across disciplines. As my next step in training, Stanford's Neuroscience PhD program will equip me with the skills and resources to conduct rigorous investigations of nervous system function that will reveal how the brain gives rise to behavior, and how knowledge of the underlying mechanisms can be leveraged to improve human experiences compromised by disease.