Cynthia Wu

In a neuroscience elective in high school, I learned that doctors monitored epilepsy in patients using the voltage across time in EEGs. Around the same time, CTRL-Labs was prototyping wristbands to detect intent in impulses traveling through the wrist. I felt certain that in electrical engineering, I would find the window to the brain. Today, Synchron's stentrode and "brain.io" is in clinical trials, taking signals directly from blood vessels in the brain to allow paralyzed individuals to control computers. I learned of this new technology in the first year of my master's degree in electrical engineering and became convinced that not only would this field provide a window to the brain, it would become integral to supporting its functions.

With this in mind, I volunteered for Dr. Dion Khodagholy's Translational NeuroElectronics Lab at Columbia University in the second semester of my master's degree. During this time, I learned of the effects of sleep and epilepsy on memory in rats as well as the closed-loop methods used to treat it. As such, I'm deeply invested in uncovering the mysteries underlying the formation and consolidation of memory and how they present themselves as electrical measurements. Not only is the puzzle of memory intriguing, understanding it would be crucial in aiding the health and quality of life for many patients, such as those with Alzheimer's or epilepsy. In the context of human health, the study of the brain becomes extremely interdisciplinary, merging everything from electrical and mechanical engineering to biology and neuroscience to statistics and deep learning. Columbia's electrical engineering program merges all these topics in both its coursework and research labs, and this is why I am applying to this PhD program in electrical engineering.

In terms of courses, during my master's at Columbia, I have had the pleasure of taking many courses on processing signals from a variety of fields, from Dr. Aurel Lazar's class on circuits in the brain (BMEB W4020) to Dr. Nima Mesgarani's class on speech processing (ELEN E6820). This year, Dr. John Wright's class on sparse and low-dimensional models for high-dimensional data (ELEN E6001) has been enlightening for my efforts working for the Translational NeuroElectronics Lab. I hope that during a potential doctorate at Columbia, I can better understand the research I am contributing to with classes such as Dr. Ching-Yung Lin's class on big data analytics (EECS E6893) and Dr. Predrag Jelenkovic's class on statistical learning and biological and information systems (EECS E6690). I also hope to learn

about biocompatible devices which acquire bioelectronic signals from classes such as Dr. Dion Khodagholy's device nanofabrication class (ELEN E6945).

In terms of research, I plan to continue studying memory consolidation and closed-loop treatments for epilepsy at the Translational NeuroElectronics Lab. Through this lab, I aim to both further investigate analytical methods to quantify physiological and pathological signals, as well as build from the developments of new biocompatible and conformable implantable probes. During my time as a researcher, I've been captivated by the various ways to quantify the pathology of NREM signals in both the time and frequency domain, all while contributing to the development of closed-loop treatments. I hope to dedicate my potential doctorate to both further investigating explainable ways to explore sleep signals as well as to examine the application of machine learning techniques with the goal of further uncovering the information between the neocortex and the hippocampus. I'm especially curious about investigating how techniques from extreme value theory can be applied to the quantification of such communication, especially as compared to techniques using measures of center. I'm also curious about exploring whether machine learning techniques will correlate with either or both types of measures in NREM signals. But I don't just want to investigate these topics because they are interesting—I also feel that the exploration of memory as it relates to various parts of the brain is intimately tied to the human experience. *Memory* is so much of what makes us, us.

For this same reason, I also find Dr. Jennifer Gelinas' research on the connection between epilepsy and memory and the features of neurodevelopmental disorders compelling. Dr. Gelinas' research makes inquiries on how memory is disturbed by epilepsy. I'm curious about the insights into memory that treatment of said disturbance could provide. By observing and treating what is pathological, perhaps it is possible to discover patterns in the electrophysiological data which hint at what governs memory physiologically. These are all questions at the intersection of health and electrical engineering which I am excited to explore. I hope that my experience with investigating pathological and physiological NREM signals in time and frequency domains equips me to contribute to either Dr. Khodagholy's Translational NeuroElectronics Lab or Dr. Gelinas' Epilepsy and Cognition Lab.

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Both the research and coursework at Columbia represent what I've been looking for in an electrical engineering degree, touching on everything from the devices which interface with the brain to the analysis of the acquired cues. It is the culmination of what I've been looking forward to exploring since the moment I learned the brain fired electrical impulses. I look forward to discovering new windows of insight into memory and learning in the brain so that in the future, I can pursue a post-doctorate at the Zuckerman Institute or at the Friedman Brain Institute.