I had my first seizure on Thanksgiving 2017, collapsing out of a chair while studying for a final, trying to force myself to successfully sound out the word "the" on the page in front of me, following a week of extreme sleep deprivation, done in the name of a large class project. For a long time I tended to overload myself, making this kind of unhealthy behavior regrettably frequent, because I had a hard time turning down any opportunity that piqued my interest.

A tendency to seize chances to do exciting work and learn new things has both precipitated my epilepsy, partially, and defined my unique career, expanding a typically straight road through an electrical engineering degree into a winding trail of lucky breaks and serendipitous connections. My curiosity and open-mindedness have led me through a diverse set of research disciplines, from optical metrology to natural language processing, to my home—neurological diagnostic speech processing—an area that I find *both technologically exciting and personally important.*

My epilepsy is intimately language-linked; my seizure-preceding aura renders me unable to read, write, speak, or listen, and causes me to hear strange voices and sounds. Witnessing the terror of temporary loss of my language—and the nagging worry that every forgotten name, mispronounced word, or fleeting moment of déjà vu might herald yet another impending loss—is core to why I view helping people with neurological conditions as a personally urgent pursuit.

After completing my master's degree in Electrical and Computer Engineering, I will transition to PhD studies, working to **advance speech processing for individuals exhibiting neurological disorder symptoms.** This work sits neatly at the intersection of my technical interests and personal values; by showing you along the path I followed, I will motivate my future goals, demonstrate my intellectual merit, and present my potential to produce broad impacts in society.

My journey began in high school; a broad interest in engineering and computer science and rudimentary programming skills from robotics competitions led me to a formative opportunity, a summer internship in Dr. Hongbin Yu's lab at Arizona State University. Here I had my first exposure to real-world engineering research. I was hooked. For two summers before university I worked in his Nanoelectronics and Integration Lab, developing control and capture software for an optical thermal semiconductor strain measurement system. After enrolling in the ASU Electrical Engineering program in fall 2014, I kept working with Dr. Yu on the strain measurement system, taking over all software development for the project. My synchronous scanning and capture code drove a 10-fold increase in measurement speed as we drove precision from the μm-scale to nm-scale. This work would earn us the Best Student Interactive Paper award at ECTC in 2016.

Local competitive robotics connections led to my sophomore year recruitment as treasurer, then president, to help revitalize the flagging Sun Devil Robotics Club. I prioritized training a new base of members to serve as a strong foundation for success, organizing a series of workshops and small competitions that eventually grew to involve several on-campus engineering orgs, and rebuild the core of dedicated club members. Since then the team has kept refining its engineering practices and for the first time is ready to field a robot in this year's Mars Rover Challenge.

Itching to try out robotics research, I was thrilled at an exchange opportunity with the Social Robotics Lab at the National University of Singapore in summer 2016. Surprisingly, this internship represented a sharp bend in my trail—a first introduction to natural language processing and machine learning research. Rather than centering on robotics, my project was all about spoken dialog systems, and this area enthralled me.

My work with the robotics club and in Singapore led to my being recruited as a member for the new "Luminosity Lab," a strategic initiative devised by the ASU president's office and Dr. Sethuraman Panchanathan, to be a model for student-led skunkworks-like impact-focused interdisciplinary research. This paid position allowed me to support myself through research

activities for the first time and leave my previous job at the Engineering Tutoring Center. I would participate in the lab my junior and senior year and as a graduate research assistant for a semester during my master's. We built both technical and organizational proofs of concept for university initiatives, ranging from prototype campus escort drones to hackathons. Some projects led to formal research questions. For example, for one I led a team of lab members in a shared task submission for the AAAI-19 Workshop on Affective Content Analysis. Our semantic classification model was the runner-up in the competition, with the second highest test accuracy out of 47 submitted runs; I was invited to give an oral presentation on our model design strategy.

As time went on *I saw research as less and less a way to keep busy and get paid as a student and more and more my chief career aspiration*. Nothing could prepare me better for such a career than resuming formal academic research with professors. Leveraging my widened senior year network, I sought out opportunities to complete my undergraduate honors thesis by conducting research in speech language processing. To that end I formed my honors thesis committee with Dr. Visar Berisha, a jointly appointed professor in the Speech and Hearing Sciences and Electrical Engineering departments focusing on neurological speech processing, and Dr. Troy McDaniel, a CS research professor from Dr. Panchanathan's other lab, the Center for Cognitive Ubiquitous Computing (CUbiC), focusing on human computer interaction and assistive technologies.

From there I dove headfirst into speech processing on a hypernasality classification project. Hypernasality is a symptom of various disorders, ranging from cleft lip/palate to Parkinson's disease, caused by an inability to achieve full or consistent closure of the soft palate between the oral and nasal cavities. Hypernasality assessment has promise in tracking the early progression of neurological disease but is difficult to measure automatically.

Creating better automatic measures of hypernasality became the core focus of my research. For my honors thesis I evaluated the existing "goodness of pronunciation" algorithm for this purpose. Building off this existing work I created a novel metric called nasal cognate distinctiveness that closely models the perceptual changes to specific plosive phonemes under hypernasality, which I presented at ICASSP in 2019. Additionally, I brought my honors thesis work together with a colleague's work on voiced phone nasalization modelling to produce a model that achieves state-of-the-art performance in estimating clinician hypernasality ratings in a disorder-agnostic manner, then turned this work into a manuscript for the IEEE Journal of Selected Topics in Signal Processing Special Issue on Automatic Assessment of Health Disorders Based on Voice, Speech and Language Processing, where it is currently in review.

Concurrently, I took a lead role in my senior design capstone project team. I was excited to once again work with Dr. Yu in this capacity and his newly formed NSF Center for Efficient Vehicles and Sustainable Transportation Systems site. He provided me with REU support in return for further efforts on the project. I took software lead on our project characterizing the performance of LiDAR systems using video comparison. I continue to assist conceptually and technically with the group's ongoing work on neural architectures for processing LiDAR data.

My involvement with CUbiC opened many more paths to explore. Through Dr. McDaniel I was selected as the first ASU student to be sent on a research exchange program with Hiroshima University, working on computer vision and affective computing in Summer 2018. This year I helped Meredith Moore, another speech-focused CUbiC student, with neural network code development and manuscript writing to complete an Interspeech submission on characterizing the performance of ASR systems on dysarthric speech, and estimating them using neural networks. She was invited to present this work in an oral session. With Dr. McDaniel I am participating in

exciting work with haptic interfaces and affective computing, making social assistive technologies for the visually impaired, through which I have learned how to design and conduct user studies.

Along this winding trail of pursuits, I have produced useful insights and deliverables for my collaborators and derived valuable growth and understanding of my goals. My zeal for learning and desire to make the most of my time in college kept me motivated through the busyness, while being continuously employed as a student worker (tutor, then researcher) or intern to support myself throughout. These qualities also led me to partake in multiple research groups and jobs at a time, enroll in a course overload of 19 credit hours almost every semester, complete 42 hours of coursework beyond that required for my EE degree, collect a minor in Mathematics, and learn about comparative foreign policy, and about archeological analysis of the evolution of metallurgy, and how to prove the security of RSA, and how to introduce myself in Japanese. On Thanksgiving of my senior year, this tendency to overload caught up with me when my seizures began.

At this point I knew that my epilepsy was in part triggered by sleep deprivation and stress. I needed to change my relationship with work, lest I risk worsening it. Upon beginning my MS in Computer Engineering in Fall 2018, I committed myself more fully to my own research, and took on a more manageable number of courses, building in credit hours for my research work. Since then I have published, gotten higher grades, and felt much less stressed. Exciting opportunities to work in the private sector in my research area arose, and I worked for Aural Analytics, a speech-based brain health assessment startup for 6 months, and with Amazon as an Applied Scientist Intern developing end-to-end neural spoken language understanding models for Alexa.

A core problem I have faced in my work is the **scarcity of disordered speech training data**. Large corpora of such speech with which the most sophisticated deep learning algorithms can be trained is scarce. This is unfortunate, as such algorithms have driven significant advancements in other speech processing domains. I will work to apply existing work in neural transfer learning to speech processing and produce novel transfer learning methods as well; in so doing I will continue creating high-performance models trained on healthy speech and applying them to disordered speech. This work is crucial now, as it will ensure the inclusion of individuals with less intelligible dysarthric speech in burgeoning neural speech interfaces and will drive the development of ever-better metrics with which neurologically linked biomarkers in speech may be assessed.

My PhD study plan is interdisciplinary and doubtless filled with bends I cannot yet envision, very much in line with the nontraditional, interdisciplinary path I've followed so far. *The GRFP will give me the freedom to pursue my research with the focus it deserves, without the stresses of other funding sources. With this grant, I will ensure that my journey continues to be fruitful.*

Intellectual Merit: My broad experiences demonstrate my zeal for learning, willingness to explore, and ability to dive deep. I have juggled many competing projects and produced results. I attribute my success in this to my technical competence, with which I can quickly iterate through ideas, and an ability to independently craft my research direction.

Broader Impacts: I am driven by a desire to apply my interest in speech technologies to help others with neurological conditions like me who have things much worse, and perhaps one day this work will even enable seizure prediction. Having seen firsthand the development of cutting-edge voice interfaces at Amazon, enabling participation in voice interface technology for persons with disabilities matters to me. Having seen firsthand the promise of speech technologies in clinical applications, in my own research and in my work with Aural Analytics, improving well-being for individuals with neurological conditions in society through early assessment diagnosis in speech matters to me. Finally, my network of connections in both industrial and academic groups centered on both of those impacts will ensure that my work brings together academia and industry.