

**TECHNICAL PROJECT: The Use of Acoustic Stimulation to Increase Slow-Wave Activity
in Alzheimer's Disease Patients**

**STS PROJECT: Mobility Assistive Devices, From Design Phase to Patient Interactions and
Beyond**

A Thesis Prospectus
In STS 4500
Presented to
The Faculty of the
School of Engineering and Applied Science
University of Virginia
In Partial Fulfillment of the Requirements for the Degree
Bachelor of Science in Biomedical Engineering

By

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December 15, 2022

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On my honor as a University student, I have neither given nor received unauthorized aid
on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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INTRODUCTION

How often do you meet someone and immediately forget their name after the encounter? Some people might joke about these types of situations, saying they have “short-term memory loss”, or “early-onset Alzheimer’s”. Although most of the time these comments are made in jest, we are still aware that as we get older, these symptoms become all too real. According to the Alzheimer’s Association, an estimated 6.5 million (10.7%, or 1 in 9) Americans aged 65 and older are living with Alzheimer's in 2022. This percentage of people with the disease increases with age. With the rapid growth of older Americans, barring the development of medical breakthroughs to prevent, slow, or cure Alzheimer’s disease, the number of people aged 65 and older living with the disease is projected to be around 12.7 million. There is no cure for this disease; current treatment methods are largely in the pharmaceutical field merely to help alleviate symptoms (Alzheimer’s Association, 2022). In my capstone project, we hope to implement the use of auditory stimulation to delay and/or prevent the onset of Alzheimer’s disease.

In the worst stages of Alzheimer’s Disease, symptoms interfere with most everyday activities. According to the Americans with Disabilities Act (ADA, 2022), this would be considered a disability. The ADA defines an individual with a disability as a person who has a physical or mental impairment that substantially limits one or more major life activities. According to the CDC, 61 million (26%, or 1 in 4) adults in the United States live with a disability. The focus of my STS research will be on the most common disability, physical impairment, which affects 1 in 7 people (CDC, 2020). My research will dive into the processes involved with getting mobility assistive devices from the design phase to patient interactions with the devices, and to further developments. This prospectus will define my research question, relevant social groups, methods and frameworks, and finally, key texts that will be used.

TECHNICAL PROJECT: The Use of Acoustic Stimulation to Increase Slow-Wave Activity in Alzheimer's Disease Patients

Like most things, to understand the final product/stage of something, we must first understand how it begins. In the earliest stages of degenerative Alzheimer's Disease, amyloid, plaque, and tangles (abnormal accumulations of proteins that collect inside neurons) begin to form in the brain areas involved in learning and memory as well as thinking and planning. The disease progresses in stages, with the severity of symptoms increasing over time (Alzheimer's Association, 2022). While there is no cure for the disease, current preventative studies suggest that removing these accumulations of proteins from the brain could reduce the cognitive and functional decline in people living with early Alzheimer's.

In the body, the glymphatic system is responsible for clearing the amyloid and plaque from the brain as we sleep. As the body ages, increased disruptions in the sleep cycle can cause these abnormal accumulations to build up within the brain, leading to slower connections and a loss of brain function (Han, 2021). Since current literature is unanimous about the crucial role that sleep plays in the process of memory consolidation (Salfi, 2020), sleep quality could play a major role in the ability of the brain to delay and maybe even prevent the onset of Alzheimer's disease.

There are five stages in the sleep cycle: wake, N1, N2, N3, and REM (rapid eye movement). Stages N1 to N3 are known as non-rapid eye movement (NREM) sleep, with each stage a progressively deeper sleep. A typical night's sleep consists of 4-6 sleep cycles, with a complete sleep cycle taking roughly 90 to 110 minutes. Each phase and stage of sleep includes variations in muscle tone, brain wave patterns, and eye movements; N3 (Stage 3) is also known as slow-wave sleep (SWS) and is the stage when the body repairs and grows tissues, builds bone

and muscle, and strengthens the immune system (Patel, 2022). It's characterized by slow waves between 1–4 Hz, by slow oscillations (SO) of <1 Hz, which represent the slow wave activity (SWA), and by signals with much lower frequencies and higher amplitudes, known as delta waves (Lloret, 2020). As people age, their body tends to spend less time in this slow, delta wave sleep and more time in stage 2 sleep (Patel, 2022). This reduction of SWS especially causes impairment in sleep-dependent declarative memory consolidations which is an aspect of Alzheimer's Disease.

Auditory stimulation during sleep is a promising therapy as it has been shown to increase SWA in older adults with mild cognitive impairment (CDC, 2020). The goal of the technical project is to design a device capable of monitoring a patient's brain waves and other physiological signs during sleep, as well as producing auditory stimulation to increase SWA. This fall semester was mostly focused on researching and learning the literature in the field and brainstorming form factors of the device and its software components. We used CAD to design our ideas and will need to come up with more alternatives so we have more options. Our design must be easy for the older population to use as they will be the primary target. Long term, we hope this device will be useful in increasing slow-wave sleep activity enough to clear the amyloid-beta plaques that contribute to Alzheimer's disease. The success of our project could prove to be a powerful tool not only in combating this disease but also in allowing families to stay together longer without the burden of caring for loved ones who are unable to perform their everyday activities.

STS PROJECT: Mobility Assistive Devices, From Design Phase to Patient Interactions and Beyond

“Wheelchairs are amazing and that’s really precious, and at the same time, it’s a machine. I’m subject to its frailties like any machine, so it makes me feel pretty vulnerable” (Brashear, 2013, 0:29:17). This comment was made by Patty Berne, a disability justice educator, in the documentary *Fixed: The Science/Fiction of Human Enhancement* as she expressed her frustrations that financial priorities are geared towards emerging technologies rather than making improvements to existing mobility assistive devices (e.g., making wheelchairs waterproof).

Research Question

There are processes involved in the designing of these mobility assistive devices, patients receiving and using them, and if there is the continued development of these devices. I want to investigate what these processes are, as well as the interactions that people have with their assistive devices. These interactions might include their frustrations, hindrances, and even their hopes for the future.

According to the World Health Organization (WHO), more than 2.5 billion people are in need of one or more assistive products such as wheelchairs, hearing aids, or apps that support communication and cognition. Unfortunately, nearly one billion of them are denied access, particularly in low- and middle-income countries, where access can be as low as 3% of the need for these life-changing products (WHO, 2022). WHO Director-General, Dr Tedros Adhanom Ghebreyesus describes assistive technology as being a life changer which opens doors to education for children with impairments, employment and social interaction for adults living with disabilities, and an independent life of dignity for older persons. He continues on by declaring the denial of access to these life-changing tools is an infringement of human rights. As

UNICEF (United Nations Children’s Fund) Executive Director Catherine Russell says, without access to the proper assistive technology, children with disabilities will continue to be subjected to stigma and discrimination, undermining their confidence and wellbeing (WHO, 2022). To begin addressing these difficult issues, we must look at the processes in place for getting these assistive devices to the people and the impact they have on the lives of those who rely on them.

Relevant Social Groups

For the sake of this paper, I will limit my social groups to people with physical disabilities who use assistive technology and the people directly involved in getting devices from the design phase to the patient's use. Those included in the latter group could consist of designers, engineers, physicians, technicians, insurance companies, and more. Some of these are still a little vague and broad since I have not immersed myself in the literature to be able to better define them yet.

Methods/frameworks

Disability studies will be the most useful framework to use. There are many sources on the topic so I should be able to use them to dive into the complexities of the disability world and the interactions between those who are physically disabled and the technology that is supposedly designed for them. Looking at public policy will also be useful in understanding the laws, regulatory measures, and funding priorities concerning disability technology. The Actor-Network Theory will be a useful framework as it is an approach to understanding humans and their interactions with inanimate objects. Since I hope to also look at both the processes involved with designing assistive devices and the interactions between the physically disabled and their devices, this could be a good framework to help demonstrate that both the processes and the technology are important to the interactions.

Key Texts

Bess Williamson's *Electric Moms and Quad Drivers: People with Disabilities Buying, Making, and Using Technology in Postwar America* shares the story of Ida Brinkman's life as an "Electric Mom" after becoming paralyzed in her arms, legs, and abdomen from contracting polio in the late 1950s. Her experience would provide a very specific outlook on the processes of getting various assistive devices, as well as her interactions with them.

Leah Lakshmi Piepzna-Samarasinha's *Care Work: Dreaming Disability Justice* discusses the politics and realities of disability justice. Leah advocates for the rights of the disabled on subjects such as collective access and accessible spaces. Insight might be provided into the experiences and voices of the disabled on the topic of disability justice.

Nedi Atanasoski and Kalindi Vora's *Surrogate Humanity* shows "how liberal structures of anti-blackness, settler colonialism, and patriarchy are fundamental to human-machine interactions, as well as the very definition of the human" (Atanasoski, 2019). This might prove to be useful when looking at how mobility assistive devices are developed, the possible biases involved in the processes, and the future of these technologies.

Corbett O'Toole's *Fading Scars* is a collection of essays that together form a collection of significant disability rights history. This is from the author's point of view which means it is open to bias and inaccurate information. However, this will provide an important perspective of someone with a disability and her story as it relates to historical events.

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