Thesis Project Portfolio

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

(Technical Report)

Analyzing Racial and Socioeconomic Differences in the Treatment and Outcomes of Adults with Alzheimer's Disease

(STS Research Paper)

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Sociotechnical Synthesis

Alzheimer's disease is a degenerative brain disease that progressively degrades a patient's memory, thinking, and behavior over time. It affects 6.7 million Americans over the age of 65 (Alzheimer's Disease Facts and Figures, n.d.). There is no cure for the disease, but there are treatments that exist to slow the progression of the disease. However, these medications stop working over time, as they are cholinesterase inhibitors, which prevent the breakdown of acetylcholine to preserve memory. As the disease progresses, acetylcholine production greatly diminishes, and these drugs lose their effects, so there is a demand for more effective and long lasting treatment methods(How Is Alzheimer's Disease Treated?, n.d.).

The technical project will focus on using sleep and the brain's natural cleaning system to slow the progression of Alzheimer's disease. The glymphatic system is a clearance system that uses cerebrospinal fluid flow through perivascular channels to remove soluble proteins and plaques in the brain (Jessen et al., 2015). Alzheimer's disease is characterized by the buildup of amyloid-β plaques in the brain, which can clump together and disrupt cell function(What Happens to the Brain in Alzheimer's Disease?, n.d.). The goal of the technical project is to increase glymphatic activity in the brain to clear the plaques that build up in the early stages of the disease. This can be done during sleep, by enhancing slow wave sleep. Slow wave sleep is the deepest phase of non-rapid eye movement (NREM) sleep. It is characterized by delta waves, as well as the appearance of spindles on EEGs (Slow-Wave Sleep - Latest Research and News | Nature, n.d.). Studies have shown that slow wave sleep can be enhanced using acoustic stimulation, specifically with pink noise, which is a constant, low frequency tone (Papalambros et al., 2017).

The proposed technology for the technical project is a device that houses electrodes that will collect and monitor brain activity during sleep.The electroencephalogram (EEG) will be read and interpreted through a program and the sleep stage that the patient is in will be determined by analyzing delta waves and sleep spindles. The user, which will be an adult with mild cognitive impairment (MCI), a characteristic of early stages Alzheimer's Disease, will wear the device as they sleep, and it will deliver appropriate acoustic stimulation to get the patient to and keep them in slow wave sleep. By increasing the time that patients spend in this phase, their glymphatic activity should increase, and plaque buildup in the brain should decrease.

For this capstone project, the main focus was creating a housing component for electrodes that can be comfortably worn during sleep while keeping the electrodes in the correct position. To do this, the group did market discovery through questionnaires and interviews with caregivers of older adults. This allowed us to understand technological use, sleep habits, and preferences of older adults with MCI. We then used this data to inform a series of different prototypes for housing components. The prototypes were designed in AutoDesk software, refined and rendered for modeling, and then 3D printed. After printing, we assembled the prototypes using fabrics, foams, and other materials, and then tested the fit and comfortability of the different prototypes. The devices were altered and improved based on these factors, and the steps of this project are to conduct interviews with outside sources to better understand the ease of use.

Alzheimer's disease raises a series of important considerations about bias in the medical system. In my STS component of the paper, I applied Actor-Network Theory to better understand how interactions between human and non-human actors in the network contribute to bias. Biases in the medical system can lead to Black patients having their symptoms ignored, and

thus, they are less likely to be diagnosed with Alzheimer's after their initial visit to a physician than white patients (Data Shows Racial Disparities in Alzheimer's Disease Diagnosis between Black and White Research Study Participants, n.d.). Because it is a progressive disease, it is important that patients are diagnosed as quickly as possible so measures can be taken to slow the progression of the disease. Overall, this component of the thesis portfolio will highlight the racial biases that exist within the medical system, as these must be taken into account when trying to understand and address a disease such as Alzheimer's Disease.