Development and in vitro Validation of a Functional Neuroacoustic Modulation System for Neurodegenerative Diseases

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Every 3 seconds, a new case of dementia is diagnosed worldwide, and more than 55 million people live with dementia, underscoring the need for innovative, accessible complementary strategies for neurodegenerative diseases. In Brazil, Alzheimer's disease (AD) affects about 2.7 million older adults, increasing care demands. The high socioeconomic burden of dementia and the limited efficacy of current pharmacological treatments further support the search for alternative interventions. Binaural beats are auditory stimuli generated by presenting two slightly different frequencies to each ear and have been associated with neural synchronization and modulation of brain activity, supporting their investigation as a promising complementary intervention. In this study, acoustic simulation was performed to predict the absorption and reflection of binaural beats in nervous tissues. Next, interactome analysis identified modules associated with synaptic function, neuroinflammation, and ionic homeostasis. Subsequently, changes in APP, MAPT, and BACE expression were evaluated in H4 cells exposed to 12 Hz binaural beats. Finally, a web-based prototype was developed to support future translational studies. The acoustic simulation indicated high absorption and low reflection. The interactome identified APP and BACE1 as hubs and PIEZO1 and TRPV4 as bottlenecks, suggesting links between mechanotransduction and the amyloid-tau axis. After exposure, H4 cells showed a 2% reduction in APP, 11% in BACE, and 48% in MAPT. These findings provide initial biophysical, in silico, and in vitro evidence that binaural-beat stimulation may offer a complementary strategy for AD research and future pre-clinical investigation. Next steps include EEG-based human studies and expanded molecular analyses.

Awards Won:
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