

124. Investigating Cellular-Level Effects of Neurostimulation Therapies with a Partial Differential Equation Based Mathematical Model

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Neurostimulation therapies have demonstrated success in mitigating symptoms of neurodegenerative diseases, but the cellular-level impacts of these treatments remain elusive. We have implemented a mathematical model that integrates the Poisson-Nernst-Planck system of PDEs and Hodgkin-Huxley based ODEs to model the effects of this neurotherapy on transmembrane voltage, ion channel gating, and ionic mobility. The PDEs are solved using the finite element method on a biologically inspired discretized domain. Our results suggest two possible mechanisms by which neurostimulation achieves therapeutic success. First, neurostimulation polarizes the cell membrane, elevating resting membrane potential to facilitate action potential firing. Second, a neurostimulation-induced calcium influx alters cytosolic calcium concentrations, which is essential for proper neurotransmitter secretion and its dyshomeostasis is a known associate of neurodegenerative diseases. We also compare the effects of two different types of neurostimulation (transcranial electrical stimulation and deep brain stimulation) showcasing cellular-level differences resulting from these distinct forms of electrical therapy.