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Model for a cortical circuit associated with childhood absence epilepsy

Childhood absence epilepsy is a pediatric epilepsy disorder characterized by brief episodes of impaired consciousness. The thalamocortical circuit is considered to play an important role in the pathophysiology of absence seizures, exhibiting the ability to generate oscillations of different frequencies and a range of synchrony. The purpose of our investigation was to explore of the same of the factors that alter the function of individual neurons in the cerebral cortex, giving rise to an epileptic network. In particular, we investigated the consequence of these alterations on neuronal network activity associated with this disorder. In this regard, we created a small network consisting of deep layer cortical pyramidal neurons and an interneuron, each described by a single-compartment Hodgkin-Huxley style model. We investigated factors that convert a normal network into a hyperexcitable one, including impairment of $GABA_A$ synapses and sodium channel defects resulting from mutations in Scn genes. Our model agrees with experimental results indicating the role of GABA impairment in generating a hyperexcitable network. In particular, our cortical network is capable of generating its own spike-and-wave oscillations analogous to those in a thalamocortical network. Our results also suggest that the co-existence of multiple Na^+-channel mutations alters individual neuronal function to increase or decrease the likelihood of the network exhibiting seizure-like behaviour.