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Theoretical descriptions of EEG activity: application to absence seizures

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Introduction

Absence seizures are a class of primary generalized seizures, which typically affect children and young adults. Electroencephalography (EEG) recordings of patients with absence seizures display 2–4 Hz rhythmic activity, the classically observed rhythm being a discharge with a sharp spike and slow wave. However, a systematic study of data from a number of subjects with absence seizures also revealed poly-spike and wave, wave-spike or even no discernable spike-wave onset during seizure events. We present a unifying mathematical framework to study the mechanisms underlying these EEG signals.

Methods

The model we introduce is a cortico-thalamic system, used to describe the brain's electrical activity as recorded via EEG. The bifurcation structure of this model has been analyzed with the software package MATCONT. The aim of our analysis was to identify parameters that are crucial for the onset of abnormal activity, and investigate mechanisms leading to (poly)spike wave solutions.

Results

We identified regions in parameter-space where our model supports (poly)spike wave activity. Transitions into these regions occur through Hopf bifurcations, and also through bistability. Hence, our model incorporates two mechanisms to simulate the onset of seizures. Moreover, we investigate the onset of poly-spike wave oscillations; these solutions are created through inflection-points, which depend on inhibitory synaptic timescales.

Discussion

By studying the transitions in a theoretical model for EEG, using a numerical bifurcation analysis, we have identified parameters and mechanisms leading to the onset of (poly)spike wave dynamics. Future work will include a comparison between model and data, by means of parameter fitting. In addition, we aim to enhance our modelling approach by including spatial extent, physiological effects such as neurotransmitter timescales and anatomical effects such as volume conduction.