Combining NMMs and compartimental modelling: insights on IEDs from neural physiology

Epilepsy is a complex pathology involving neural circuits at both local and global scales; and recent results suggests that distinct cortical populations contribute differently to the initiation and sustainment of epileptic activity [1]. Among the hallmarks of epilepsy are Interictal Epileptiform Discharges (IEDs); paroxysmal events that are ubiquitous across different forms of the disease and that are classifiable based on their EEG profile between spikes and spike-waves [2]. Investigating the neural dynamics behind these symptoms remains nevertheless challenging, as human recordings are largely restricted to mesoscale neuronal activity, often measured through electroenchephalosgraphy (EEG). A significant hurdle in modeling these network pathologies is a non-trivial connection between conventional Neural Mass Models (NMMs) and the recorded EEG signals.

To address this, we have extended a modeling framework that maintains the computational efficiency of an NMM while utilizing a multi-compartmental approach to generate biophysically grounded LFP signals [3, 4, 5, 6]. We use it to investigate the conditions to simulate different types of epileptic activity, specially the different types of IEDs. We evidentiate how the L5 pyramidal neuron morphology [7] and the synaptic targets [6] impact the generated currents and relative EEG signals, hence the IEDs cathegories: this has implications on the possible neural circuits responsable of their generation.

By linking the microscale of single-neuron morphology to the mesoscale of the cortical column, this framework facilitates the interpretation of patient measurements, the validation of theories regarding epileptic triggers, and how epileptic activity can impact the functional mechanisms required for cognitive tasks.

References

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