

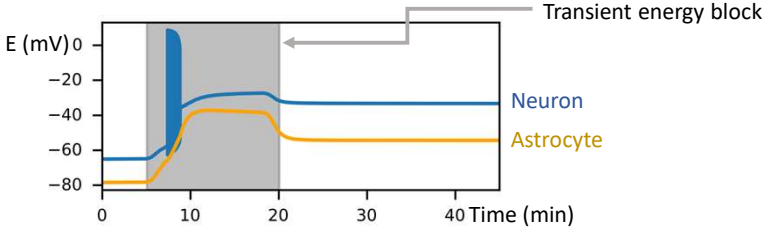
A neural mass model for the EEG in ischemia

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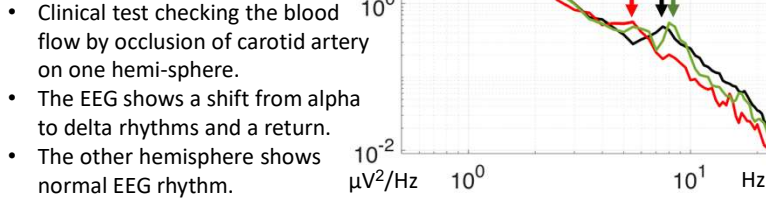
Introduction

- The Sodium-Potassium-ATPase (NKA-pump) is crucial for maintaining the neuronal membrane potential, but consumes lots of ATP.
- During a stroke, the pump no longer has energy. Then a neuron will gradually depolarize, then show a burst of action potentials (wave of death) before entering permanent depolarization block (Kalia 2021).



EEG during carotid artery clamping

- Before arterial obstruction
- During arterial obstruction
- Arterial obstruction released



- Clinical test checking the blood flow by occlusion of carotid artery on one hemi-sphere.
- The EEG shows a shift from alpha to delta rhythms and a return.
- The other hemisphere shows normal EEG rhythm.

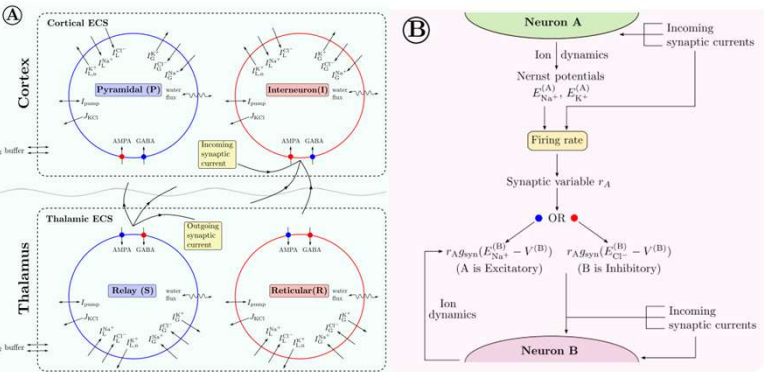
Ion Dynamics of a Neural Mass

Research Questions:

- Can we lift insights of single-cell ion dynamics to neural mass models representing EEG?
- What is the mechanism behind slowing?

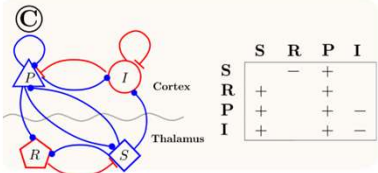
Novel Neural Mass model in terms of ion dynamics

- Most neural mass models describes the average (synaptic) activity.
- Instead we keep all ion species, average the fast gating variables and compute the resulting membrane potential for the firing rate.

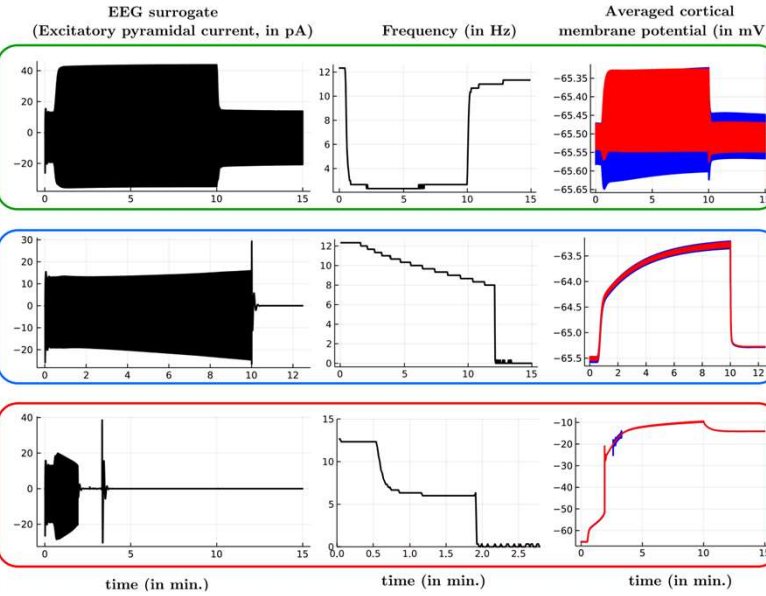
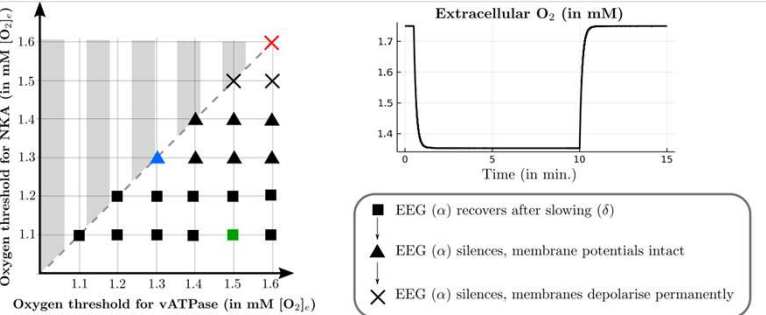


Model Components

- (A) Active and passive ion transporters for Na^+ , K^+ , Cl^- , Ca^{2+} .
- (B) Activity leads synaptic inputs and used for EEG proxy.
- (C) Connectivity involves thalamocortical loop.

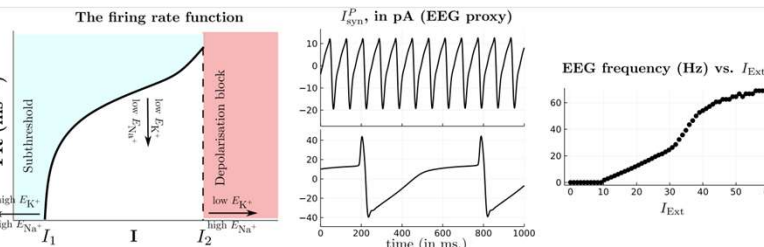


Ischemia yields gradual synaptic arrest



Ion-based Firing Rate Function

Firing rate computed for single neuron given reversal potentials and external input via a lookup table. For a heterogeneous population we convolute with a Gaussian kernel.



Conclusion & Open Questions

- Higher ATP demand of NKA-pump relative to glutamate recycling leads to synaptic arrest before cell swelling and EEG slowing.
- Excitatory thalamic input controls rhythm, weak relay-interneuron strength leads to burst-suppression upon energy deprivation.
- Physiological mechanism of slower glutamate cycle via adenosine?
- Extend modelling to energy demand signalling with neurovascular structures and buffering via astrocytes.

Reference: Ion dynamics at the energy-deprived tripartite synapse. M. Kalia, H.G.E. Meijer, S.A. van Gils, M.J.A.M. van Putten and C.R. Rose, PLoS Comp Bio (2021)