# Inferring microscale parameters from macroscale eeg-data with the help of simulation-based inference


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# Abstract

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# Declaration

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# Acknowledgements

I want to thank...

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# Introduction

Understanding how macroscale signals evolve from microscale parameters is an interesting question in many domains, e.g. in research about global climate, gene expression or brain phenomena like the signal coming from an electroencephalography (EEG). The later is an example for a macroscale signal of the brain that evolves through the activation of many neurons that fire in parallel. To specify, it measures the intracellular current flow in the long and spatially-aligned pyramidal neuron dendrites (Neymotin et al., 2020). While macroscale signals are the product out of the combination of many signals, we are often interested in the origins of these signals - the underlying mechanisms. These mechanisms can be described by a so called mechanistic model that meets assumptions about e.g. the information flow circuits, the morphology of the cells in the brain or the weights between different neurons. The more parameters this mechanistic model has, the more difficult it gets to infer the underlying processes that have caused the output of an EEG signal. One approach to find the underlying parameters of a macroscale signal is to simulate lots of different parameter settings with the help of a simulator that captures the met assumptions of a certain mechanistic model.

The Human Neocorical Neurosolver (HNN), developed by Neymotin et al. (2020), is an example of such a simulator and was used in this work to gain thousands of simulations to later work with and infer a posterior density of the parameters of interest.

HNN is based on a model that tries to represent the neocortical circuits of pyramidal neurons and interneurons. The model has a 3-layered structure with pyramidal neurons and inhibitory interneuons in a 3-to-1 ratio of pyramidal to inhibitory cells (Neymotin et al., 2020). The 3 layers that are modeled are Layer 2/3 (also referred to as supragranual layer), Layer 4 and Layer 5 (also referred to as infragranular layer).

The HNN model distinguishes between so called proximal drives, coming from

the thalamus and signaling to the supragranular layers of the cortex, and so called distal drives, representing cortical-cortical inputs or non-lemniscal thalamic drive that signals directly into the supragranual layers and from there further downwards to the infragranular layers. The timing and duration of these drives can be adjusted (Neymotin et al., 2020).
For each evoked drive, there are up to 7 parameters that can be tuned like the onset of the drive, the number of spikes and the weights of synaptic inputs to the specific layers (see (Neymotin et al., 2020) for further details)
Besides, tonic inputs can be modeled and describe somatic current clamps that can change the resting membrane potential in both ways, specifically get it closer or further from firing (Neymotin et al., 2020).

HNN is based on the NEURON environment. Taken on from NEURON, membrane voltages are based on Hodgkin-Huxley equations and current flow between compartments is modeled by cable theory.
Further, the model captures different ion channels like Na, K, Km, KCa and others and codes the thresholds for these Neymotin et al. (2020).

# Bibliography

Neymotin, Samuel A, Dylan S Daniels, Blake Caldwell, Robert A McDougal, Nicholas T Carnevale, Mainak Jas, Christopher I Moore, Michael L Hines, Matti Hämäläinen, and Stephanie R Jones (2020), "Human neocortical neurosolver (hnn), a new software tool for interpreting the cellular and network origin of human meg/eeg data." *Elife*, 9, e51214.