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Glial network modulation of neuronal network synchrony

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Extensive research over the past three decades have been revolutionary by conceptualizing a neuron-glia paradigm which aims at describing the mutual dependence between glial and neuronal processes at multiple spatiotemporal scales. However, glial contributions to large-scale functional neuronal network organization remain mysterious due to the lack of empirical and theoretical frameworks elaborating on neuron-glia interaction mechanisms at a macroscopic scale.

Here, we developed a biophysical neuron-glia mass network modeling approach to explore how variations in glial network activity could reshape emergent brain-wide neuronal functional connectivity patterns.

Our model explains local dynamics by coupling bilaterally neuronal and glial activity through the modulation of extracellular glutamate and GABA concentrations. In addition, our model assumes that glial masses interconnect only to their first neighbors along the cortical mantle, while neuronal masses interconnect through white matter tracts as empirically derived from diffusion magnetic resonance imaging tractography.

By tuning model parameters that control the relative contributions of glial network activity in inducing glutamate and GABA neuronal release by acting on presynaptic neurons, we simulated multiple whole brain activity with distinct spatiotemporal signatures. We used phase-locking value to quantify the synchrony patterns between neuronal populations thereby providing neuronal functional connectomes, and we used graph theoretical indices to describe the topological properties of these connectomes.

We report a non-trivial dependence between glial network induced changes in excitatory and inhibitory synaptic transmission and neuronal functional connectivity. Importantly, we provide a new perspective of functional organization and operation of neural networks, inclusive of glial processes.

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