Session/Poster# Presenter

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Multiscale Models of Motor and Somatosensory Thalamocortical Circuits to Study Brain Function and Disease

Primary motor cortex (M1) and primary somatosensory cortex (S1), together with their corresponding thalamic circuits, play a critical role in sensorimotor behavior. However, the biophysical cellular and circuit mechanisms underlying this function are not yet well understood. Understanding cortical function requires studying its components and interactions at different scales: molecular, cellular, circuit, system and behavior. Biophysically detailed modeling provides a tool to integrate, organize and interpret experimental data at multiple scales and translate isolated knowledge into an understanding of brain function. We developed detailed biophysical models of rodent M1 and S1 thalamocortical circuits, each with approximately ~15k detailed neurons and ~30M synapses. The model neuronal densities, classes, morphology, biophysics, and connectivity were derived from experimental data. The models were validated against in vivo firing rate and local field potential data under different behaviors and experimental conditions. The M1 model generated predictions about the long-range and neuromodulatory inputs underlying behavioral changes, and their multiscale effects across specific layers and cell types. The S1 model predicted how thalamocortical interactions generate different oscillatory patterns. These detailed models also provided insights into the biophysical underpinnings of different brain diseases and disorders, including Parkinson's, dystonia, schizophrenia and epilepsy. Our models integrate previously isolated experimental data at multiple scales into a unified simulation that can be progressively extended as new data become available. This provides a quantitative theoretical framework for researchers to evaluate hypotheses, make predictions and guide the design of new experiments. Unraveling the non-intuitive multiscale interactions in thalamocortical circuits can help us understand disease mechanisms and develop new treatments for brain disorders.