

Data-driven Multiscale Model of Macaque Auditory Thalamocortical Circuits Reproduces In Vivo Dynamics

We developed a biophysically-detailed model of the macaque auditory thalamocortical circuit using the NEURON simulator and NetPyNE modeling tool. The simulated structures included medial geniculate body (MGB), thalamic reticular nuclei (TRN), and a 6-layered A1 cortical column of 2000 μm depth and 200 μm diameter, containing over 12k neurons and 30M synapses. Cell population types, densities, locations, biophysics, and connectivity at the long-range, local and dendritic scales were derived from experimental data. The A1 column contained multiple neuron populations which were reciprocally connected to the thalamus (MGB and TRN), mimicking anatomical connectivity. The MGB included core and matrix thalamocortical neurons with layer-specific projection patterns to A1, as well as locally-projecting thalamic interneurons. The cochlear auditory nerve and the inferior colliculus were simulated using phenomenological models, which were capable of taking auditory stimuli as input and outputting firing patterns which served as input to MGB. Here we compared spontaneous activity in this model to spontaneous activity recorded in vivo in macaque A1. We found that the model generated cell-type and layer-specific firing rates consistent with overall ranged observed experimentally. It also accurately simulated the corresponding local field potentials, current source density (CSD), and electroencephalogram signals. Physiological oscillations emerged spontaneously across frequency bands, without external rhythmic inputs, and were comparable to those recorded in vivo. We used the model to examine the contributions of distinct neuronal populations to the CSD signal during oscillation events to explore the cell- and layer-specific dynamics underlying these events. Overall, this model provides a framework to integrate multiscale experimental data, and constitutes a powerful tool to make predictions about the cellular and network mechanisms underlying common experimental measurements.