A Combined Analytical and Computational Approach to Multiscale Modeling of Temperature Effects on Neural Dynamics

Kufel, Dominik (School: Centro de Estudios Tecnológicos del Mar 08)

It was previously reported, that temperature may significantly influence neural dynamics on different levels of brain modeling. Therefore, in computational neuroscience, we would like to construct models scalable for wide-range of various brain temperatures. However, because of an absence of analytical model describing temperature influence on synapses, it is currently not possible to include this effects in modeling of huge neural networks and reproduction of local field potentials. In this paper, I propose first step to deal with this problem: by a combination of analytical and computational approach, new model of temperature-sensitive AMPA-type synaptic conductance for low-frequency stimulation was created. It is based on a Markov model description of AMPA receptor kinetics and simplifications motivated both empirically and from Monte Carlo simulation of synaptic transmission. The synaptic model was successfully validated with computational and experimental data both on relative occupancy of different states of AMPA receptor and the physiological dynamics of AMPA conductance. On the basis of the synaptic model, for the first time, a computational link between experimental results of temperature influence on single ion channels and local field recordings was found. The local field potential reproduction was recorded in a small network of biologically real pyramidal neurons. It turned out, that increased temperature led to bigger amplitude in neural sub-threshold oscillations. The accuracy and efficiency of the synaptic model suggest that may be used in large scale neural network simulations. This in fact, opens wide-range of new possibilities for researching an influence of temperature on such neurological disorders like autism, traumatic brain injury or epilepsy.