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Reduced compartmental Hodgkin-Huxley type models of three different cortical neuron classes

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Mazza et al. [1] constructed a large-scale model of area 3b of the primary somatosensory cortex containing reduced compartmental, Hodgkin-Huxley type models of three electrophysiological cell classes: regular spiking neurons (RSN), fast spiking neurons (FSN) and burst spiking neurons (BSN). In this work, we present modified versions of these three neuron models. They were validated against published data from *in vitro* experiments and can be used in large-scale simulations of cortical models.

The models were implemented under the GENESIS simulation environment [2]. They preserve the same morphological structures of the original models [1] but have different compartmental dimensions. As in the original models, all voltage-gated ionic currents were placed at the soma compartment of the neuron models. The ionic currents used are (the cells in which they were put are indicated within parentheses): transient sodium, Na (all models), delayed rectifier potassium, Kd (all models), transient potassium, Ka (all models), slow potassium, Ks (FSN), fast calcium-dependent potassium, Kc (RSN and BSN), slow calcium dependent potassium, Kahp (RSN and BSN), M-type potassium, Km (RSN and BSN), low threshold calcium, Cat (RSN and BSN), L-type high threshold calcium, Cal (RSN and BSN), and N-type high threshold calcium, Can (RSN and BSN). These ionic currents were modeled according to the standard Hodgkin-Huxley formalism with kinetic parameters taken from the literature. The models were submitted to tests equivalent to experiments with rat and guinea pig neocortical slices [3-5], so that characteristics like their frequency-current relations, spike amplitude, spike width at half amplitude and input resistance could be measured. The parameters of the models were adjusted using a combination of "hand-fitting" with automatic fitting procedures so that the models reproduced well the experimental results. The list with the final set of parameters is too extensive to be placed here. The tables giving their values can be seen at the Master's thesis that resulted from this work [6].

The models constructed in this work offer a better reproduction of the electrophysiological properties of the three cell classes considered than the models used in the work of Mazza et al. [1]. Furthermore, the models can be used to study transitions from a typical behavior of one electrophysiological class to a typical behavior of another electrophysiological class depending on variations of some parameters. The single-neuron modeling approach described here constitutes one out of the many possible ways of modeling neurons [7]. The neuron models constructed by us are not aimed at realistically reproducing every anatomical and physiological aspect of the neurons they model, but to capture some of their basic properties at a relatively low computational cost so that they can be used and tested in large-scale models.

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