Preserving axosomatic spiking features despite diverse dendritic morphology

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Abstract:

Throughout the nervous system, cells belonging to a certain electrical class (e-class) sharing high similarity in firing response properties may nevertheless have widely variable dendritic morphologies. To quantify the effect of this morphological variability on the firing of layer 5 thick-tufted pyramidal cells (TTCs), a detailed conductance-based model was constructed for a three-dimensional reconstructed exemplar TTC. The model exhibited spike initiation in the axon and reproduced the characteristic features of individual spikes, as well as of the firing properties at the soma, as recorded in a population of TTCs in young Wistar rats. When using these model parameters over the population of 28 three-dimensional reconstructed TTCs, both axonal and somatic ion channel densities had to be scaled linearly with the conductance load imposed on each of these compartments. Otherwise, the firing of model cells deviated, sometimes very significantly, from the experimental variability of the TTC e-class. The study provides experimentally testable predictions regarding the coregulation of axosomatic membrane ion channels density for cells with different dendritic conductance load, together with a simple and systematic method for generating reliable conductance-based models for the whole population of modeled neurons belonging to a particular e-class, with variable morphology as found experimentally.

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