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Modeling action potential initiation using voltage-gated ion-channels kinetics from L5 pyramidal neurons of the rat cortex

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Trans-membrane protein mechanisms such as ion-channels and their activity are at the essence of neuronal transmission. The most accurate method, so far, for determining ion-channel kinetic mechanisms is single-channel recording and analysis. Nevertheless, single-channel recordings carry several hold-ups and complexities, especially when dealing with voltage-gated channels. We have previously developed a method for fitting cell-attached and whole-cell voltage-clamp data to kinetic models of ion channels using genetic search algorithms (GAs). Several newly conceptualized kinetic schemes for voltage-gated sodium and potassium channels were tested using somatic and dendritic cell-attached and nucleated patch-clamp recordings from layer 5 pyramidal neurons of the rat cortex.

Out of more than a dozen models, the best simplified Markov schemes of both channel types were then combined to simulate a somatic action potential (AP). Adding the dendritic mechanisms, we proceeded to simulate back-propagating action potentials along the apical dendrite of L5 pyramidal neurons. Our results therefore constitute yet another step towards a novel paradigm for AP initiation and propagation in cortical neurons that may be more physiologically relevant than previously suggested kinetic schemes.