The importance of model selection when studying gap junctions: A cautionary tale

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Abstract

Gap junctions are widely recognised for their crucial role in synchronising neuronal populations, contributing to the generation of both normal and pathological brain rhythms. Unlike coupling through chemical synapses, gap junctions enable ion and molecule exchange between cells both pre-threshold and during an action potential. Hence, the subthreshold dynamics and the shape of the action potential will affect the dynamics of gap junction coupled cells. As modellers, we often explore the sensitivity of our model results to changes in parameters (e.g., firing threshold, resting potential, etc.), but we do not typically explore the robustness of our results to changes in the neuron model itself. As we develop more detailed models and computational tools to simulate gap junction coupled neurons, it is useful to step back and fully understand how the choice of neuron model may influence the results. In this work, we compare the dynamics of gap junction coupled neurons using four different models: Hodgkin-Huxley, leaky integrate-and-fire, Morris Lecar and Izhikevich. Matching their subthreshold activity, we find distinct differences in the gap junction transmission for dynamically changing inputs and in post-threshold spiking regimes. We then explore how these differences affect network-level dynamics, specifically synchrony and the frequency of oscillation.