Non-Uniform Subthreshold Dynamics and Integrative Features in Dorsal Raphe Neurons

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Summary

Serotonin (5HT) neurons of the dorsal raphe nucleus (DRN), which provide the majority of the forebrain's serotonergic innervation, play a particularly important role in regulating behavioural responses to emotionally-salient stimuli. The DRN receives numerous long-range parallel inputs and it is unclear how this hub network processes this complex information stream.

To begin to address this issue, we set out to develop an experimentally-constrained computational model of raphe neurons that accurately reproduces the electrophysiological responses of individual cells to a variety of complex inputs.

We observed non-linear subthreshold dynamics in these neurons that could not be readily captured by a simplified linear model often used for cellular modelling. The addition of a minimal set of experimentally-derived conductances produced satisfactory model performance.

During the course of this work, we observed intriguing variance in the subthreshold nonlinearities of this population, and explore how these affect the integration of synaptic inputs.

Results

Figure 1: Physiology of DRN 5HT Neurons

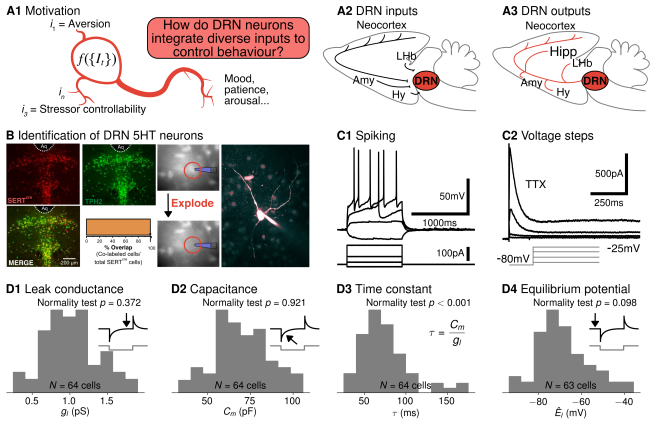


Figure 2: Simplified Neuron Model Does Not Capture Subthreshold Nonlinearities in 5HT Neurons

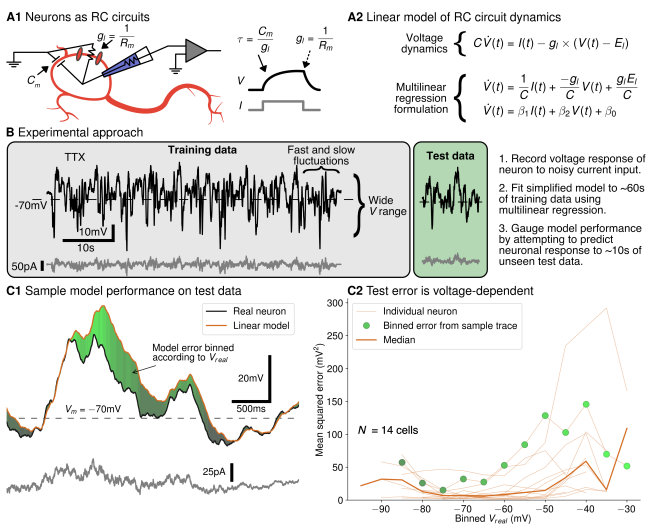


Figure 3: 5HT Neurons Express Subthreshold Nonlinearities Acting on Multiple Timescales

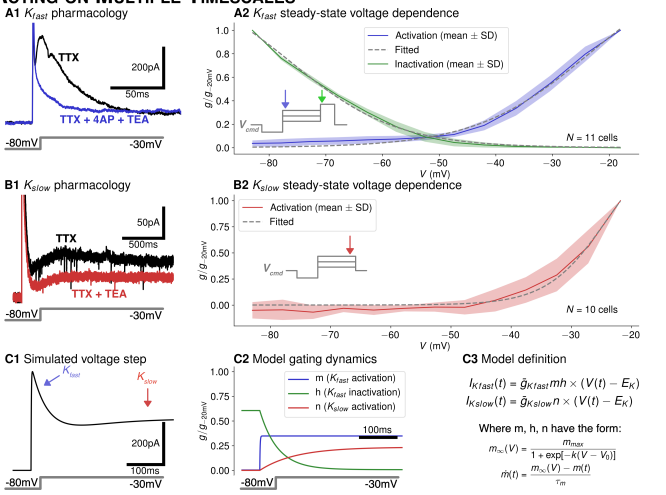


Figure 4: K_{SLOW}-augmented Linear Model Accurately Describes Subthreshold Dynamics of 5HT Neurons

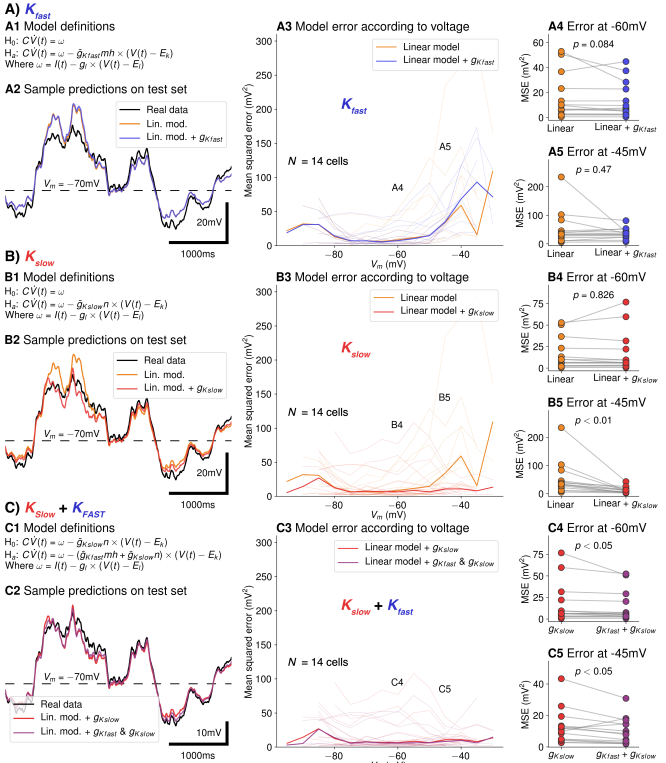


Figure 5: Augmented Model Accurately Estimates Passive Membrane Properties

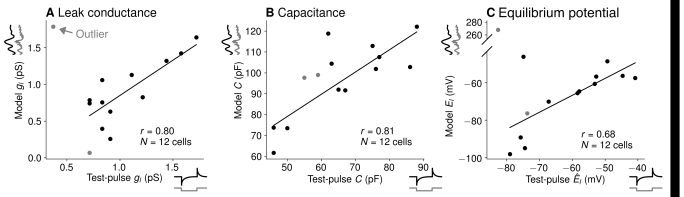


Figure 6: Skewed Distribution of K_{SLOW} Predicts DRN Populations with Distinct Voltage-Dependent Filtering Properties

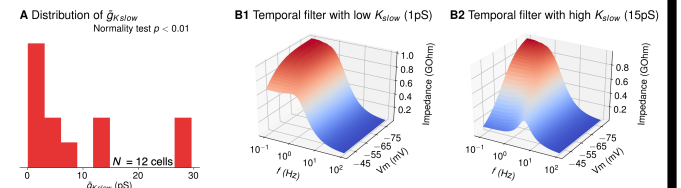
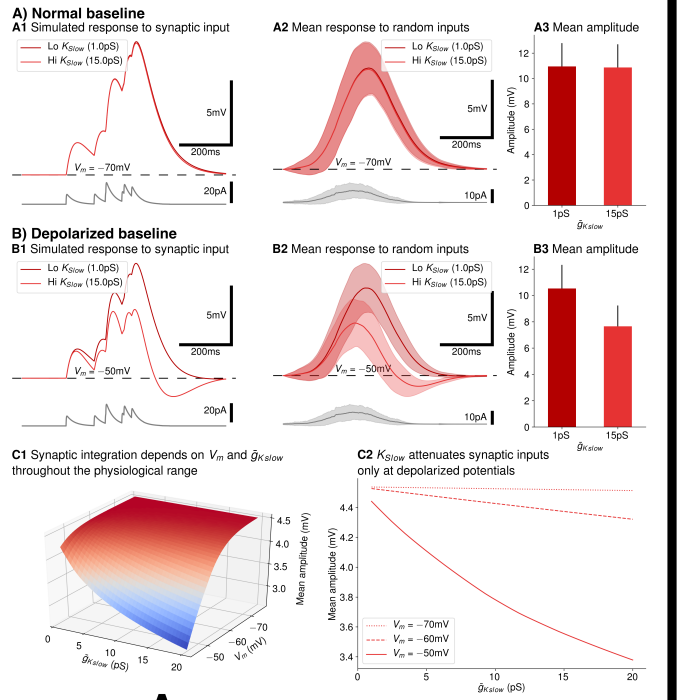


Figure 7: Low- and High-K_{SLOW} Model Neurons Exhibit Differential Voltage-Dependent Integration of Synaptic Input



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