

Nonlinear interaction between shunting and adaptation controls a switch between integration and coincidence detection in pyramidal neurons

Steven A. Prescott¹, Stéphanie Ratté², Yves De Koninck³, and Terrence J. Sejnowski^{1,4}

¹*Computational Neurobiology Laboratory, Howard Hughes Medical Institute, Salk Institute, La Jolla, CA 92037*

²*Département de physiologie, Université de Montréal, Montréal, Québec, Canada H3C 3J7*

³*Division de Neurobiologie Cellulaire, Centre de Recherche Université Laval Robert-Giffard, Québec, Québec, Canada G1J 2G3, and Department of Pharmacology and Therapeutics, McGill University, Montréal, Québec, Canada H3A 1Y6*

⁴*Division of Biological Sciences, University of California, San Diego, La Jolla, CA 92093*

The membrane conductance of a pyramidal neuron *in vivo* is substantially increased by background synaptic input. Increased membrane conductance, or shunting, does not simply reduce neuronal excitability. Recordings from hippocampal pyramidal neurons revealed that adaptation caused complete cessation of spiking in the high conductance state, whereas repetitive spiking could persist despite adaptation in the low conductance state. This behavior was reproduced in a phase plane model and was explained by an increase in voltage threshold caused by shunting. Increase in threshold allows greater adaptation to be induced at subthreshold potentials and reduces the minimum adaptation required to stabilize the system. Because this phenomenon depends on adaptation's activation curve, it occurs with M current-mediated adaptation but not with AHP current-mediated adaptation. The nonlinear interaction between shunting and the M current has other important consequences. First, timing of spikes elicited by brief stimuli is more precise when background spikes elicited by sustained input are prohibited, as occurs exclusively with M current-mediated adaptation in the high conductance state. Second, activation of the M current at subthreshold potentials, which is increased in the high conductance state, hyperpolarizes average membrane potential away from voltage threshold, allowing only large, rapid fluctuations to reach threshold and elicit spikes. These results suggest that the shift from a low to high conductance state in a pyramidal neuron is accompanied by a switch from encoding DC input with firing rate to encoding transient inputs with precisely timed spikes, in effect, switching the operational mode from integration to coincidence detection.

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