BMC Neuroscience

ORAL PRESENTATION Open Access

Role of active dendritic conductances in subthreshold input integration

Michiel Remme[1*], John Rinzel[1,2]

From Nineteenth Annual Computational Neuroscience Meeting: CNS*2010
San Antonio, TX, USA. 24-30 July 2010

A large body of data has demonstrated the presence of voltage-dependent conductances in the dendrites of many types of neurons. A subset of these conductances are active at subthreshold membrane potentials and can greatly affect the integration of synaptic inputs. To understand the computations neurons perform it is key to understand the role of active dendrites in subthreshold input processing. Here, we examine how active dendritic conductances affect postsynaptic potentials that propagate along dendrites and the interaction between such signals. We focus in particular on coincidence detection, one of the most basic operations a neuron can perform, in which a neuron needs to detect the occurrence of two or more EPSPs in a short time interval (e.g. down to ~10 μs in auditory brainstem).

To systematically study the effects of active dendritic conductances on synaptic inputs, we make use of the so-called quasi-active description of dendritic cables [1], an extension of classical passive cable theory, which relies on linearizing the voltage-dependent conductances. Though the linearized description does not capture the full dynamics of the active currents, the results can serve as a solid reference for the effects of active dendritic currents on propagating EPSPs. This approach allows us to categorize active dendritic currents into two types: restorative currents (e.g. I_h), which function as a negative feedback and counteract changes of the membrane potential, and regenerative currents (e.g. I_{NaP}), which act as a positive feedback and amplify membrane potential changes.

The two types have qualitatively different effects on subthreshold EPSP propagation and interaction. Compared to a passive cable's response, the EPSP halfwidth is decreased by restorative currents and increased by regenerative currents. Moreover, these effects increase as the EPSP propagates along the active cable. Interestingly, restorative dendritic currents can maintain a constant EPSP halfwidth or even gradually narrow the EPSP as it moves along a dendrite. We find there is an optimal activation time constant of the active dendritic currents to exert their maximal effect on the EPSP halfwidth. Finally, since narrow EPSPs will only summate on short intervals, coincidence detection of dendritic inputs is enhanced by restorative currents: the coincidence window is narrower and is less dependent on the exact locations of the inputs along the dendrite. Conversely, coincidence detection is less precise when the dendrites have regenerative currents, which cause a wider coincidence window and stronger dependence of the window on input locations.

Author details
[1]Center for Neural Science, New York University, New York, NY 10003, USA . [2]Courant Institute of Mathematical Sciences, New York University, New York, NY 10003, USA.

Published: 20 July 2010

Reference

1. Koch C: Cable theory in neurons with active, linearized membranes. *Biol Cybern* 1984, **50**:15-33.

doi:10.1186/1471-2202-11-S1-O13
Cite this article as: Remme and Rinzel: Role of active dendritic conductances in subthreshold input integration. *BMC Neuroscience* 2010 **11**(Suppl 1):O13.

* Correspondence: michiel.remme@nyu.edu
[1]Center for Neural Science, New York University, New York, NY 10003, USA