OPEN ACCESS
ARVO Annual Meeting Abstract | July 2019

Dendritic voltage-gated K^+ currents stabilize response amplitude and speed on a computational model of the rod-driven ON bipolar cell

Kae Leopoldo; Maarten Kamermans; Christina Joselevitch

Author Affiliations & Notes

Kae Leopoldo
Psicologia Experimental, Instituto de Psicologia da Universidade de São Paulo, São Paulo, Brazil
Núcleo de Neurociências e Comportamento, Universidade de São Paulo, São Paulo, Brazil

Maarten Kamermans
Retinal Signal Processing, The Netherlands Institute for Neuroscience, Netherlands

Christina Joselevitch
Psicologia Experimental, Instituto de Psicologia da Universidade de São Paulo, São Paulo, Brazil
Núcleo de Neurociências e Comportamento, Universidade de São Paulo, São Paulo, Brazil

Footnotes

Commercial Relationships **Kae Leopoldo**, None; **Maarten Kamermans**, None; **Christina Joselevitch**, None

Support CAPES; FAPESP (2010/16469-0); CNPq (469797/2014-2 and 830608/1999-0)

Investigative Ophthalmology & Visual Science July 2019, Vol.60, 574. doi:

Abstract

Purpose : As the eye grows, rod-driven ON bipolar cells (ON rBCs) extend their dendrites laterally and make new synapses with rods. We investigated how this addition of membrane area and synapses impacts the integration of rod-driven signals.

Methods : We modeled an ON rBC using NEURON; biophysical and morphological data were gathered from literature.The model cell was connected to a variable number of rods to analyze the effect of synaptic convergence onto the response properties of ON rBCs. The length of the dendrites was then gradually increased to study the effects of neuronal growth onto ON rBC responses. Finally, a voltage-gated potassium current (I_{KV}) was inserted on the dendritic tips of the model cell, and the interactions of this conductance with rod-driven responses were investigated.

Results : Without I_{KV}, a ten-fold increase in rod convergence depolarized the resting membrane potential (V_{rest}) of the model ON rBC by 31-35 mV (depending on the size of the dendritic arbor implemented), whereas increasing its dendritic length 10 times hyperpolarized V_{rest} by 5 to 9 mV (depending on the number of rods projecting to the model cell). These changes in V_{rest} impacted rod-driven responses of ON rBCs: dendritic growth increased response amplitudes, whereas large rod convergences decreased response amplitudes. Synaptogenesis, but not dendritic growth, increased the gain of the rod:ON rBC synapse by steepening the slope of the rod:ON rBC input/output relation in the absence of active dendritic conductances. On the other hand, dendritic growth led to a substantial decrease in response speed. Insertion of I_{KV} hyperpolarized V_{rest} and stabilized response amplitudes for all convergences and dendrite lengths tested. Activation of I_{KV} during rod-driven depolarizations also sped up ON rBC responses, stabilized time-to-peak, and prevented the gain of the rod:ON rBC input/output relation to change with growth and/or synaptogenesis.

Conclusions : These results suggest that (a) both dendritic growth and the degree of synaptic convergence influence ON rBC response amplitudes, sensitivity and speed and (b) dendritic I_{KV} stabilizes ON rBC responses throughout growth. Dendritic voltage-gated K^+ channels could enable ON rBCs to transmit a stable and coherent message to ganglion cells as the retina expands.

This abstract was presented at the 2019 ARVO Annual Meeting, held in Vancouver, Canada, April 28 - May 2, 2019.