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Spike timing control in retinal prosthetic[1]

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To restore meaningful vision to blind patients requires a retinal prosthetic device that can generate precise spiking patterns in retinal ganglion cells. We sought to develop a stimulus protocol that could reliably elicit one ganglion cell spike for every stimulation pulse over a broad frequency range. Small tipped platinum-iridium epiretinal electrodes were used to deliver biphasic cathodal electrical stimulus pulses at frequencies ranging from 10 to 125 Hz. We measured spiking responses with on-cell patch clamp from ganglion cells in the flat mount rabbit retina, identified by light response and morphology. Single electrical 30 pA cathodal pulses of 1 msec duration elicited both by direct electrical activation of ganglion cells and synaptic excitation and inhibition. Direct activation elicited a single spike that followed the onset of the cathodic pulse by about 100 μsec; presynaptic activation typically elicited multiple spikes which began after 10 msec and could persist for more than 50 ms depending on pulse amplitude levels. Limiting the pulse duration to 100 μsec eliminated all presynaptic activity: only ganglion cells were driven. Each pulse elicited a single pike for stimulation frequencies tested from 10 to125 Hz. Our ability to elicit one spike per pulse provides many important advantages: This protocol can be used to generate temporal patterns of activity in ganglion cells with precision. We can now mimic normal light evoked responses for either transient or sustained cells, and we can modulate spike frequency to simulate changes in intensity, contrast, motion and other essential cues in the visual environment.

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