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T36: A MODEL OF AUDITORY NERVE RESPONSES TO ELECTRICAL STIMULATION

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Cochlear implants (CI) stimulate the auditory nerve (AN) with a train of symmetric biphasic current pulses comprising of a cathodic and an anodic phase. The cathodic phase is intended to depolarize the membrane of the neuron and to initiate an action potential (AP) and the anodic phase to neutralize the charge induced during the cathodic phase. Single-neuron recordings in cat auditory nerve using monophasic electrical stimulation show, however, that both phases in isolation can generate an AP. The site of AP generation differs for both phases, being more central for the anodic phase and more peripheral for the cathodic phase. This results in an average difference of 200 μs in spike latency for AP generated by anodic vs cathodic pulses. Previous models of electrical stimulation have been developed based on AN responses to symmetric biphasic stimulation and therefore fail to predict important aspects of the observed responses to stimulation of various pulse shapes like, for example, latency differences between anodic- and cathodic first biphasic stimuli. This failure to account for these important aspects disqualifies these models to investigate temporal and binaural processing in CI listeners. Based on these premises, Joshi et al. (2015) proposed a model of the AN responses to electrical stimulation. Their model consisted of two exponential integrate-and-fire type neurons, representative of the peripheral and central sites of excitation. This model, parametrized with data for monophasic stimulation, was able to correctly predict the responses to a number of pulse shapes. Their study was only concerned with the responses to single pulse stimulation. This report extends the model proposed by Joshi et al. (2015) for the case of stimulation with pulse trains. The model is modified to include changes in excitability following either sub-threshold or supra-threshold stimulation by including a variable representing an adapting threshold. With an adaptive threshold, the model is tested for its ability to predict facilitation (increased excitability following subthreshold pre-pulse), accommodation (decreased excitability following subthreshold pre-pulse and facilitation), and adaptation (decreased excitability following a spike produced by supra-threshold pre-pulse). The model will be further tested for its ability to predict the observed responses for pulse trains by analyzing effects of stimulation rate and level on the model responses. With the ability to account for the responsiveness to electrical stimulation with pulses of various shapes, a successful model can be generalized as a framework to test various stimulation strategies and to quantify their effect on the performance of CI listeners in psychophysical tasks.

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References:

Joshi, S. N., Dau, T., Epp, B. (2015) “A model of auditory nerve responses to electrical stimulation” 38th Mid-winter meeting of the Association for Research in Otolaryngology, Baltimore, MD