A model of auditory nerve responses to electrical stimulation

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A model of auditory nerve responses to electrical stimulation
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Model Structure

This study introduces a phenomenological model of the AN cell for electrical stimulation. The model consists of two exponential integrate-and-fire type point-neurons, representing peripheral and central nodes of the AN cell. A cathodic pulse depolarizes the ‘peripheral’ neuron and anodic pulse depolarizes the ‘central’ neuron. Both the neurons simultaneously, but independently, integrate the electric charge imposed by the stimulus. A first spike produced by either neuron causes the node to the absolute refractory period, during which no spike can be fired. Both the ‘peripheral’ and the ‘central’ neurons are parameterized based on responses to monophasic stimulation in cat AN. The model is tested for its ability to predict responses to various pulse shapes.

Monophasic stimulation

The model is evaluated for stimulation with monophasic and charge-balanced biphasic pulses of various shapes. Model is run at the sampling rate of 101, and probabilities are obtained by running the model 10000 times at each stimulus level.

Biphasic stimulation

Fig. 5 Data and corresponding model responses to change in threshold of catho-monophasic stimulation with biphasic pulses (anodic-cathodic). Model predicts large differences between anodic-cathodic and cathodic-anodic pulses at high pulse durations.

Further Evaluation

Fig. 8 Miller et al. 2001 presented comparison of response statistics for monophasic cathodic vs biphasic stimulation of AN of cat. The data from their study is shown as the density kernel with mean of the data at the center of groups. Corresponding model responses are shown with red squares.

Discussion

• In this model, the strict threshold voltage criterion has been replaced by a more realistic smooth spike initiation zone, during which inhibitory input can cancel the spike initiation.
• Model fails to predict reduction in spike jitter with increasing level as reported by Miller et al. 1999.
• Model predicts shorter latencies for biphasic stimulation than observed.
• Model over estimates the interaction between pulse phase duration and interpulse phase duration compared to data reported by Ramekers et al. 2014. However the differences may be due to species specific variability (guinea pig in their study).
• This study shows that a model parameterized based on very few data points for monophasic stimulation can qualitatively predict the responses to biphasic pulses of various shapes. Data fit to larger datasets for monophasic stimulation may improve the predictive power of the model significantly.
• It may be possible to fit the model to individual human CI listeners using response statistics derived from ECAP recordings.