Abstract:
Although modern cochlear implants (CI) are able to restore speech perception to a high degree there is still a large potential for improvements e.g. in music perception and speech discrimination in noise. To evaluate and optimize novel coding strategies, we have developed a toolbox which codes sound signals into spike-trains of the auditory nerve. We have previously developed a model of the intact inner ear, which we have complemented with detailed models of a CI speech processor, the channel crosstalk and spiral ganglion neuron models. Here we use a model of spiral ganglion type I neurons with Hodgkin-Huxley type ion channels, which are also found in cochlear nucleus neurons (HPAC, Kht, Klt). Their large time constants might be responsible to explain adaptation to electrical stimulation (Negem & Bruce 2008). We corrected conductances and time-constants to a body temperature of 37°C and solved the differential equations in the time domain with an exponential Euler rule. Depending on the task, we model the neurons at different levels of detail. The electrode was modeled as an array of 12 current point sources at a distance of 0.5 mm from the spiral ganglion neurons. The coupling between electrode and excitation of the neuron was described by the activation function (second derivative of the extracellular potential with respect to the neuron's path). Cannel cross-talk was implemented by a convolution of the activation function with a spread function (symmetric, slope: 1dB/mm). With our toolbox we present qualitative comparisons of neurograms elicited by different coding strategies with the situation in the healthy inner ear. Moreover, we conducted qualitative evaluations using two methods: with the framework of automatic speech recognition we evaluated speech discrimination using a noisy database. With the methods of information theory we are
able to quantify the transmitted information coded in neuronal spike trains, which allows us to evaluate especially well how well temporal information is coded. The major advantage of our approach is that we are able to evaluate both spectral- and temporal aspects of novel coding strategies before we conduct long-lasting clinical studies. Supported by the Munich Bernstein Center for Computational Neuroscience by the German Federal Ministry of Education and Research (reference number 01GQ1004B and MED-EL Innsbruck).

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