E I N L A D U N G

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"TEMPORAL PRECISION OF SPEECH CODED INTO NERVE-ACTION POTENTIALS"

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For both normal hearing subjects and cochlear implant patients the most drastic step of sound coding for neuronal processing is when the analog signal is converted into discrete nerve-action potentials. As any information lost during this process is no longer available for neural processing, it is important to understand the underlying principles of sound coding in the intact auditory system and the limitations in the case of artificial stimulation of the auditory nerve. We have therefore developed a detailed model of auditory processing based on physiological and psychoacoustic measurements, which codes sound signals into spike-trains of the auditory nerve. We also investigate detailed models of cochlear nucleus neurons, which are driven by auditory nerve spike-trains. We analyze the quality of coding with the framework of automatic speech recognition and the methods of information theory. With information theory, we analyzed the transmitted information rate coded in neural spike trains of modeled neurons in the cochlear nucleus for vowels. We found that at least onset neurons are able to code temporal information with sub-millisecond precision (<0.02 ms) across a wide range of characteristic frequencies. Temporal information is coded by precisely timed spikes per se, not only temporal fine structure. Moreover, the major portion of information (60%) is coded with a temporal precision from 0.2 to 4 ms. Enhancing the temporal resolution from 10 ms to 3 ms and from 3 ms to 0.3 ms is expected to increase the transmitted information by approximately twofold and 2.5 fold, respectively. In summary, our results provide quantitative insight into temporal processing strategies of neuronal speech processing. We conclude that coding of information in the time domain might be essential to complement the rate-place code for robust speech discrimination in noise.