Sensitivity to interaural time differences in temporal fine-structure, onset, and offset in bilateral electrical hearing

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Interaural time differences (ITDs) are essential for understanding speech in noise and localizing sound sources. The normal auditory system encodes ITD information both in the phase and in the amplitude envelope. Bilateral cochlear implant (CI) listeners currently use stimulation strategies which transmit ITD via the envelope, but not through the carrier (so-called fine structure) due to the constant phase in the electrical pulse train. To determine the benefit to be expected from transmitting fine structure ITD in CI systems, the effects of different ITD types have to be separated.

The relative contributions of fine structure, onset, and offset ITD to lateralization discrimination were studied for unmodulated pulse trains. Bilateral CI listeners and normal hearing (NH) subjects listening to acoustic simulations of CI stimulation were tested. In experiment I, lateralization discrimination (2AFC task) was measured using trains of four pulses at four different pulse rates. The ITD was presented in the fine structure, the onset and/or offset, or the entire signal. The CI listeners showed high sensitivity to ITD in the fine structure at low pulse rates and decreasing relative weight of fine structure ITD with increasing pulse rate, as opposed to increasing relative weight of onset ITD. In experiment II, stimuli of experiment I were presented monaurally in a 3AFC (oddity) task to verify that lateralization discrimination was not influenced by monaural cues such as periodicity pitch or timbre. None of the test conditions exceeded chance level performance, indicating that the lateralization scores of experiment I were achieved using binaural information. Experiment III measured the effect of pulse number on the relative weighting of fine structure and onset/offset ITD at a rate of 100 pulses per second. For longer stimuli (containing more than 8 to 16 pulses, depending on the subject) the just noticeable differences were determined almost entirely by fine structure ITD. Overall, the results indicate that bilateral CI listeners are most sensitive to ITD in the fine structure at lower pulse rates. The results of the NH subjects showed close agreement with those of the CI listeners, suggesting that CI performance can be predicted from experiments with NH listeners.