Enhancing rate pitch sensitivity in electric hearing by inserting extra pulses with short inter-pulse intervals

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Pitch cues are important for understanding speech, listening to music, and segregating sound sources in challenging acoustic environments. The most salient pitch cues in normal hearing arise in the temporal fine structure of acoustic signals. Envelope (ENV)-based stimulation strategies for cochlear-implants (CIs) use high carrier pulse rates to transmit speech information. At such high rates, rate pitch sensitivity is known to be very weak or absent in CI listeners. It has recently been shown that ITD sensitivity, which is affected by a similar rate limitation, can be improved by adding extra pulses with short inter-pulse intervals (SIPIs) to a high-rate (1000 pulses/s) carrier pulse train.

In the present study we tested the hypothesis that adding SIPI pulses also enhances rate pitch sensitivity in CI listeners. Based on findings from the ITD study, SIPI pulses were added at envelope peaks of the F0 period of pseudo-syllables, at either every peak (full rate, FR) or every other peak (half-rate, HR), the latter in an attempt to overcome a potential rate pitch limit if the F0 is high. Additional parameters included modulation depth (MD: 0.1, 0.3, 0.5, 0.7, and 0.9) and F0 (125 Hz and 250 Hz). A two-interval two-alternative forced choice task was used to measure the sensitivity to modulation-rate based pitch. All conditions were loudness-balanced in a formal procedure.

The data collected with five CI listeners so far show a general enhancement of sensitivity by adding SIPI pulses in the FR condition. The enhancement was, however, restricted to low MDs. In the HR condition, the effect of the SIPI pulses was less clear, showing both sensitivity deteriorations at higher MDs for the lower F0 and enhancements at low MDs for the higher F0.

Considering the typically low MDs of speech, our results suggest that strategic insertion of extra pulses in future CI stimulation strategies may enhance F0-based temporal pitch cues.