Asynchronous Stimulation for Cochlear Implants

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Introduction

- Cochlear Implants (CI) restore some sensation of hearing to the profoundly deaf by stimulating the auditory nerve through implanted electrodes (Fig 1).
- The current sound processing standard, Continuous Interleaved Sampling, stimulates all electrode channels with current pulses at a constant rate.
- Success in CI users is limited to speech recognition. Finer temporal patterns such as speech intonation are lost when neurons are stimulated synchronously.
- Asynchronous stimulation allows each channel’s stimulation rate to adapt to the input stimulus, potentially conveying both sound frequency and phase (Fig 2) to the CI user.
- This experiment implemented asynchronous stimulation in two CI users and measured their success in understanding phase cues.

Psychoacoustic Experiment

Schroeder Phase Discrimination (SPD) Test
- ACE (a version of CIS) and AIS were used to process the Schroeder signals with \( f_0 = 15 \text{ Hz}, 25 \text{ Hz}, 50 \text{ Hz}, 100 \text{ Hz}, 200 \text{ Hz}, 400 \text{ Hz} \).
- Schr+ and Schr- were delivered to CI users using both ACE and AIS. Subjects were asked to discriminate between the two phase signals, with a 50% chance of being correct if they were simply guessing.

Results

- Trial 1
  - False spectral cue led to improved SPD with AIS at higher \( f_0 \).
  - This unexpected cue was conveyed to user and confounded results.
- Trial 2
  - Lower \( f_0 \) exaggerates temporal info.
  - At 50 Hz, subject could detect AIS temporal cue of signal ramp.
- Trial 3
  - Tested a variety of AIS parameter settings, finding little difference.
  - No significant difference is apparent between ACE and AIS.

Conclusions & Future Work

- The finer temporal shape of a stimulation pattern may not be detectable by CI users since neural populations are shared between electrode stimulation sites.
- CI users can detect temporal cues, such as a ramp window applied to the edges of a signal.
- A “winner-take-some” strategy adjustment may allow weaker channels a better chance at participation.
- Future improvements in presenting temporal information improves understanding of speech intonation and tonal languages like Mandarin Chinese.

References