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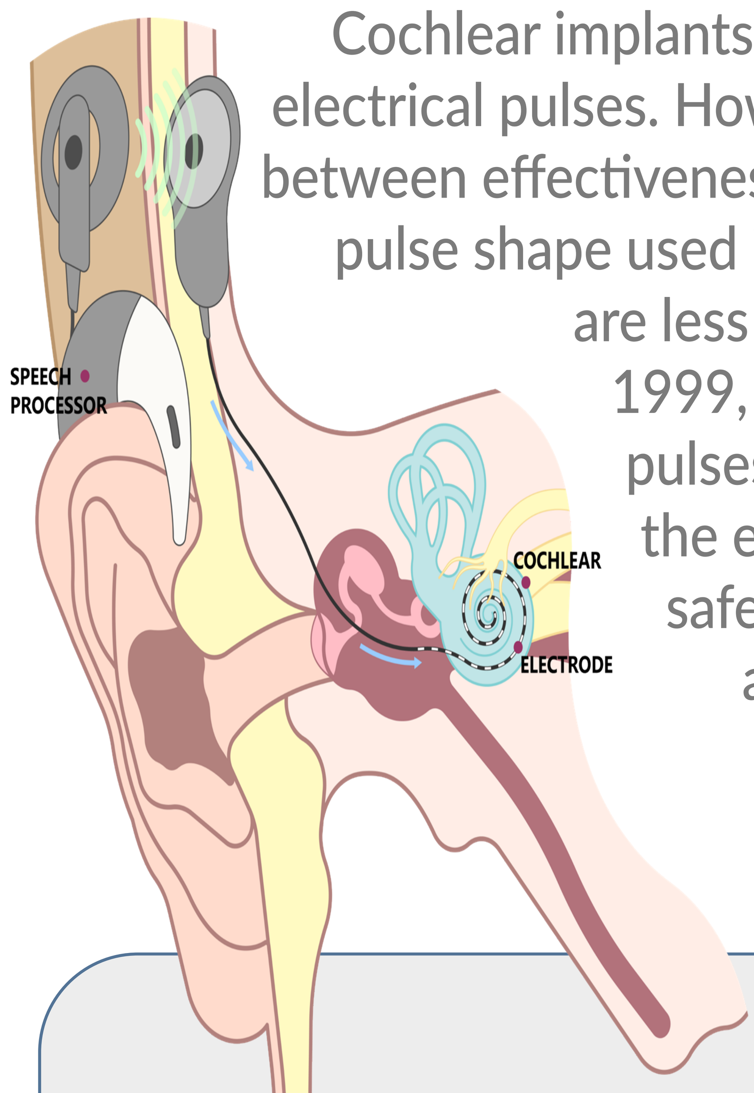
THE EFFECT OF PULSE SHAPE ON PITCH SENSITIVITY OF COCHLEAR IMPLANT USERS

BACKGROUND



Cochlear implants (CIs) stimulate the auditory nerve fibers with electrical pulses. However, the choice of pulse shape is a balance between effectiveness and safety. While biphasic pulses are the clinical pulse shape used in CI processing schemes due to their safety, they are less effective than monophasic pulses (Shepherd et al., 1999, Frijns 1996, Miller et al., 1995, 1999). Triphasic pulses have been proposed as an alternative to replicate the effectiveness of monophasic pulses while maintaining safety. In particular, previous research has shown that anodic-centered triphasic pulses outperform cathodic-centered triphasic pulses in activating the auditory nerve fibers in CI users (e.g., Carlyon et al., 2013).

OBJECTIVES

This research examined if anodic-centered triphasic (A-TP) pulses could enhance CI users' place and temporal pitch sensitivity as compared to cathodic-centered triphasic (C-TP) and biphasic (BP) pulses.

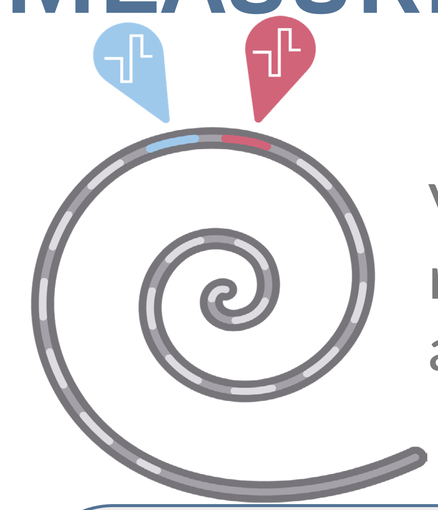
KEY FINDINGS

In both the AMFR and VCR tasks, the basal electrodes exhibited poorer pitch ranking thresholds compared to the apical and middle electrodes, likely due to poor neural survival and degraded sound quality in basal area.

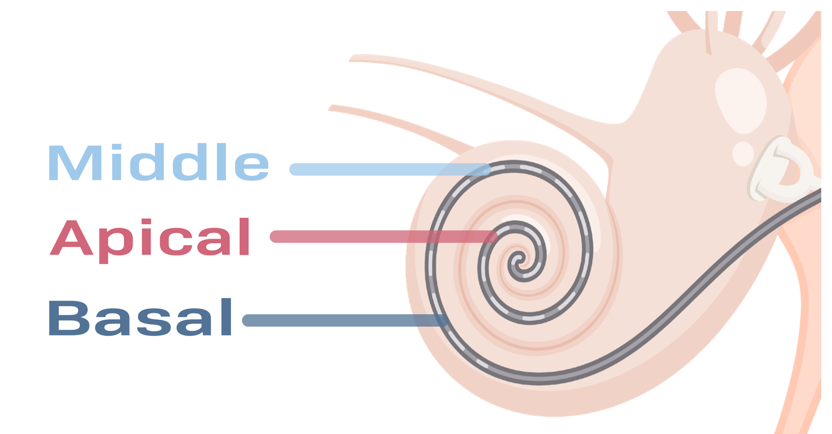
In experiment 1, the effect of pulse shape on VCR thresholds was not significant, possibly due to the interference of a fixed 99-Hz temporal pitch.

In experiment 2, the results revealed a polarity effect on supra-threshold place-pitch perception with CIs and suggest that A-TP pulses may more selectively stimulate auditory nerve fibers and potentially enable CI users to more accurately discriminate place pitches than C-TP pulses at a 1000-pps pulse rate.

MEASURES & RESULTS

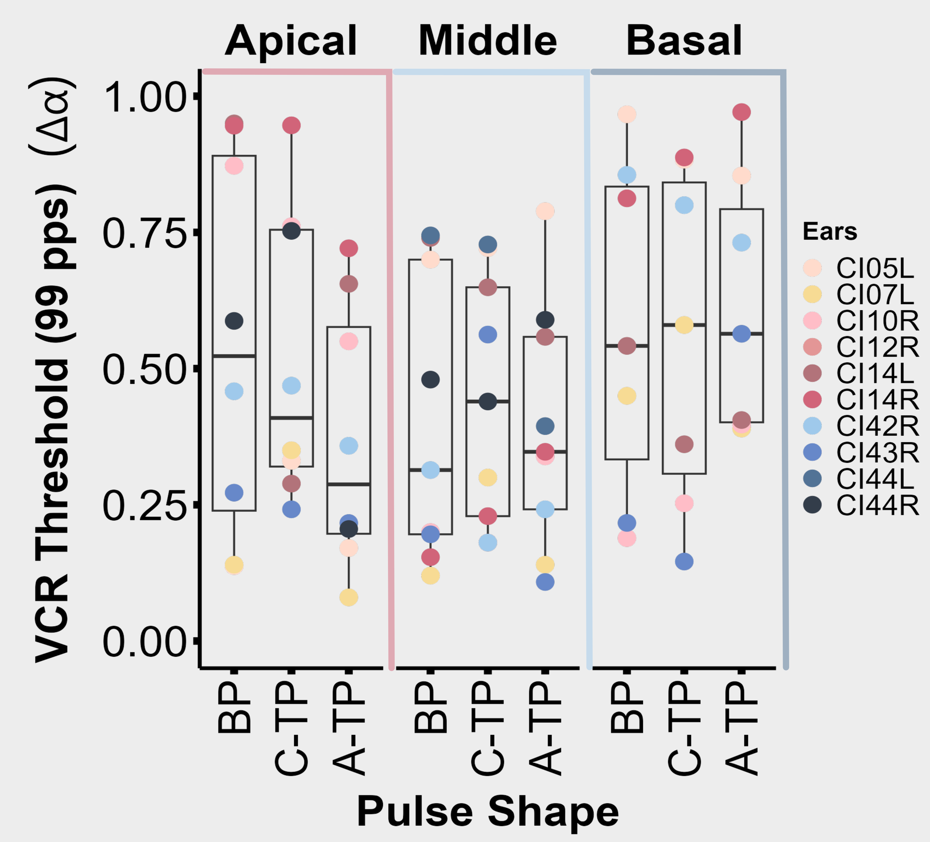


Virtual channel ranking (VCR) measures the ability of CI users to rank pitch percepts elicited by simultaneous stimulation of two adjacent electrodes with various proportions of current.



EXPERIMENT 1

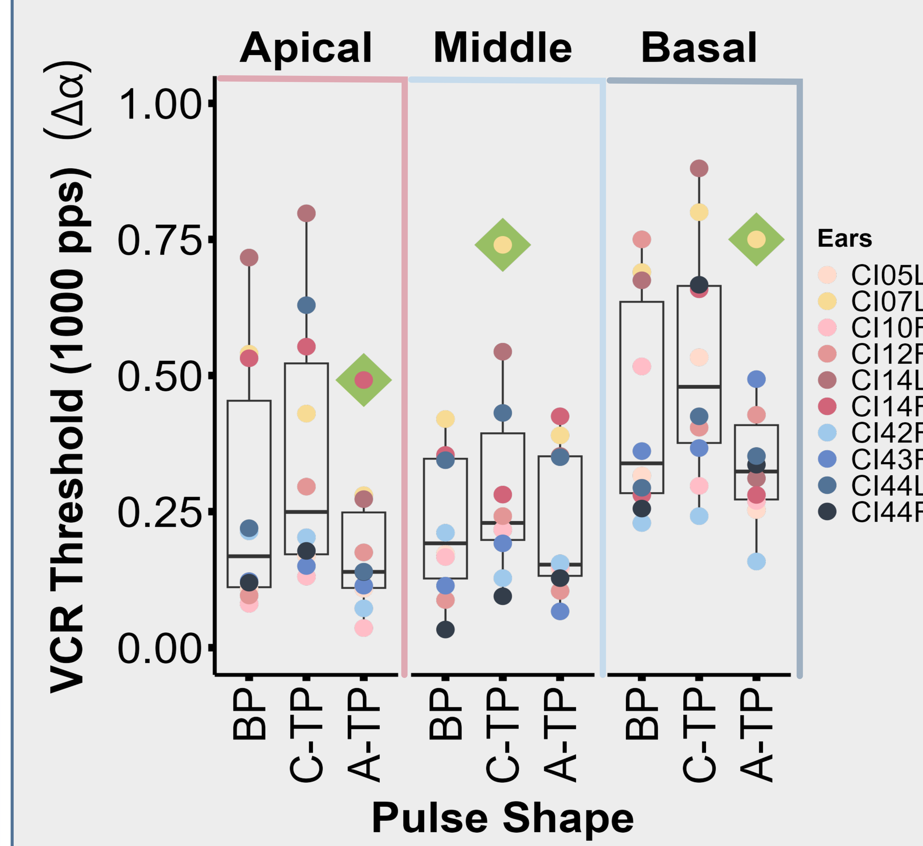
Experiment 1 measured VCR thresholds using BP, A-TP, and C-TP pulses on apical, middle, and basal electrodes at a low pulse rate (99 pulses per second; pps).



- Eight participants (ten ears).
- No significant [electrode] x [pulse shape] interaction ($F_{(4,63)} = 0.62$, $p = 0.65$).
- Significant main effect of [electrode] ($F_{(2,65)} = 4.10$, $p = 0.02$):
  - basal poorer than middle ($p = 0.02$),
  - no significant difference between apical and middle or basal pairs.
- No significant main effect of [pulse shape] ($F_{(2,63)} = 0.39$, $p = 0.68$).

EXPERIMENT 2

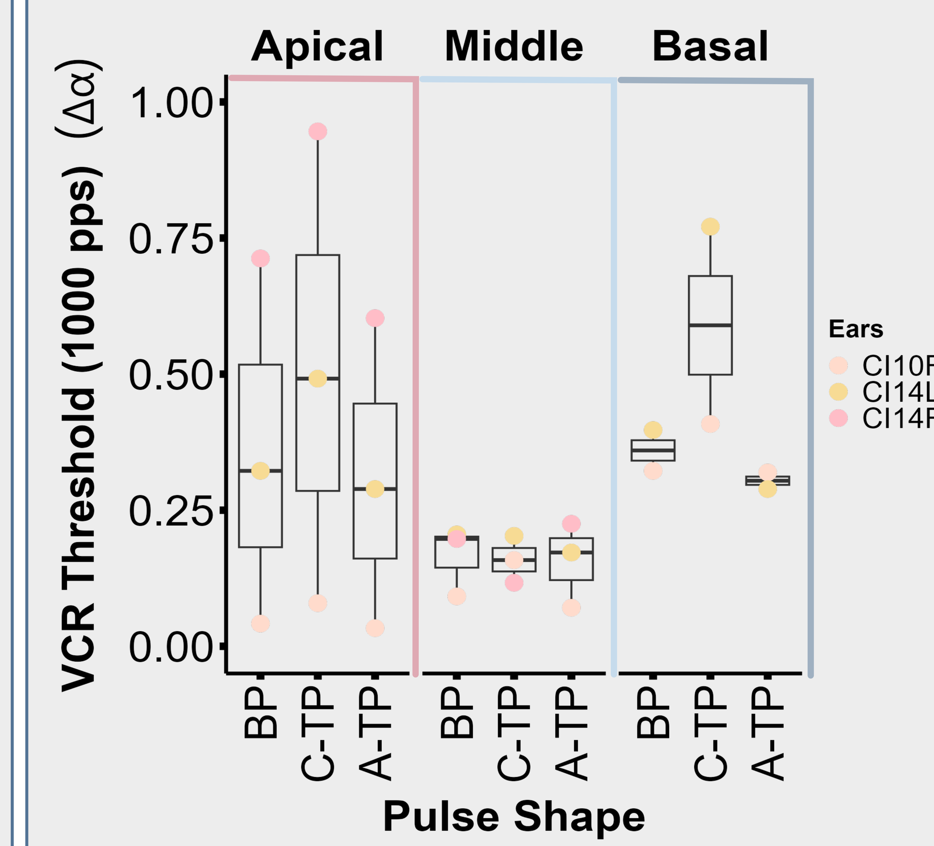
Experiment 2 used a 1000-pps pulse rate to measure VCR thresholds as well as amplitude modulation frequency ranking (AMFR) thresholds with a 100-Hz base AM frequency.

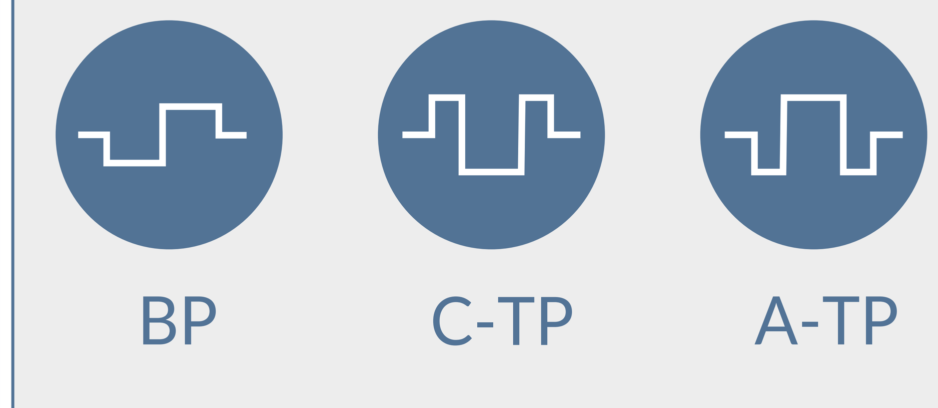


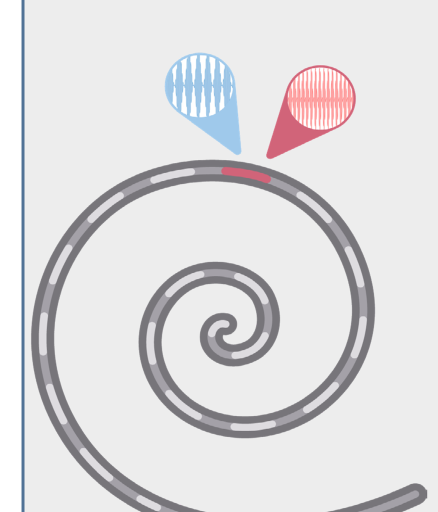
- Eight participants (ten ears).
- No significant [electrode] x [pulse shape] interaction: ($F_{(4,77)} = 1.23$, $p = 0.30$).
- Significant main effect of [electrode] ($F_{(2,77)} = 22.79$, $p < 0.001$):
  - basal poorer than middle and apical ($p < 0.001$),
  - no significant difference between apical and middle pairs.
- Significant main effect of [pulse shape] ($F_{(2,77)} = 22.79$, $p < 0.001$):
  - C-TP poorer than A-TP ($p < 0.001$), C-TP poorer than BP ($p = 0.048$), and BP poorer than A-TP ($p = 0.064$).

EXPERIMENT 3

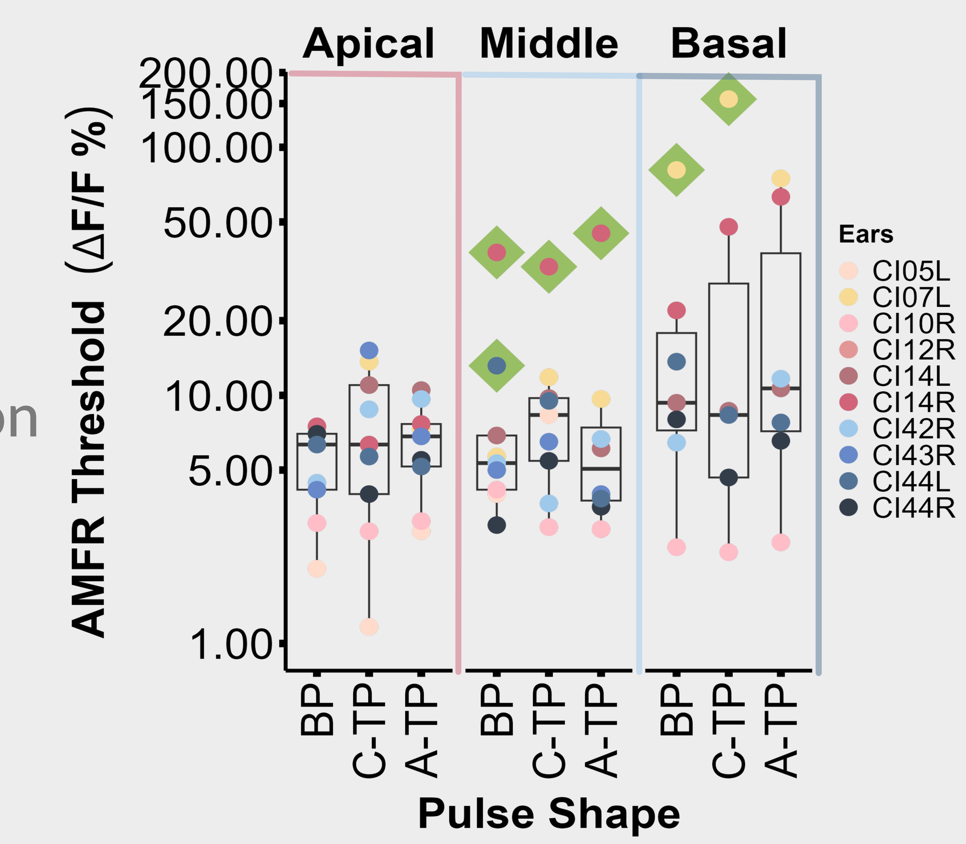
Experiment 3 employed a different methodology for implementing triphasic pulses to assess VCR thresholds at a rate of 1000 pps.







AMFR measures the ability of CI users to rank pitch percepts elicited by different amplitude modulation frequencies of pulse trains on the same electrode.



- Eight participants (ten ears).
- No significant [electrode] x [pulse shape] interaction ($F_{(4,59)} = 1.59$, $p = 0.19$).
- Significant main effect of [electrode] ($F_{(2,61)} = 7.40$, $p = 0.001$):
  - basal poorer than middle ($p = 0.002$) and apical ($p = 0.006$),
  - no significant difference between apical and middle electrodes.
- No significant main effect of [pulse shape] ($F_{(2,59)} = 1.72$, $p = 0.19$).