The Effects of the Interphase Gap on Neural Response of the Electrically-Stimulated Auditory Nerve in Children with Cochlear Nerve Deficiency and Children with Normal-Sized Cochlear Nerves

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Background

• The sensitivity of the eCAP to changes in the inter-phase gap (IPG) has been shown to be associated with neural survival of the cochlear nerve (CN) in guinea pigs (Prado-Guitierrez et al., 2006; Ramekers et al., 2014).

• Studies investigating the effects of the IPG on eCAP results in human cochlear implant (CI) users have shown conflicting findings (Hughes et al., 2018; Schwartz-Leyzac and Pfingst, 2016, 2018), presumably due to the unpredictable CN neural survival pattern in individual CI patients.
Background

• Cochlear nerve deficiency refers to a small (hypoplastic) or absent (aplastic) CN as revealed by high-resolution magnetic resonance imaging (MRI).

• Children with CND can be considered as a human model for poor CN function, which provides an extremely valuable opportunity to verify many important findings reported in animal studies in human listeners.
Study Aim and Working Hypotheses

• To compare effects of increasing the IPG on the eCAP between children CND and children with normal-sized CNs.

• We hypothesized that poor CN functional status would affect the effectiveness of increasing the IPG on enhancing neural responsiveness of the electrically-stimulated CN.
Subjects and Electrodes

• 60 implanted children with Cochlear® Nucleus™ devices
  • 30 children with CND
  • 30 children with normal-sized CNs

• Testing Electrodes: three electrode locations across the electrode array with relatively equal separation between testing electrodes
eCAP Measures and Data Analysis

- Stimulus: biphasic, charge balanced, cathodic-leading electrical pulse
  - The pulse phase duration was 50 µs/phase.
  - IPGs tested ranged from 7 to 42 µs with a step size of 7 µs.
- Dependent variables include eCAP threshold, maximum eCAP amplitude and slope of the eCAP Input/Output (I/O) function.
Results: Maximum eCAP Amplitudes

- Increasing the IPG duration resulted in larger maximum eCAP amplitudes.
- Children with CND showed smaller maximum eCAP amplitudes than children with normal-sized CNs.
Results: Maximum eCAP Amplitudes

- The size of the IPG effect increased as the IPG duration increased at all three electrode locations.

- Compared to children with normal-sized CNs, children with CND showed larger IPG effects on the maximum eCAP amplitude.
Results: eCAP Thresholds

- Increasing the IPG duration resulted in lower eCAP thresholds.
- Children with CND showed higher eCAP thresholds than children with normal-sized CNs.
Results: eCAP Thresholds

- The size of the IPG effect increased as the IPG duration increased at all three electrode locations.
- Compared to children with normal-sized CNs, children with CND showed smaller IPG effects on the eCAP threshold.
Results: Linear Slopes

- The effect of the IPG on slope was not statistically significant.
- Children with CND showed smaller slopes of the eCAP I/O function than children with normal-sized CNs.
Results: Linear Slopes

- Increasing the IPG had a larger effect on increasing the slope of the eCAP I/O function in children with CND than in children with normal-sized CNs.
Conclusions

• Increasing the IPG improves neural responsiveness of the electrically-stimulated CN in both children with CND and children with normal-sized CNs.

• The maximum eCAP amplitude and the slope of the eCAP I/O function measured in human listeners with poorer CN survival are more sensitive to changes in the IPG.

• In contrast, the eCAP threshold in listeners with poorer CN survival is less sensitive to increases in the IPG.
Thank you!