Effects of Stimulus Polarity on Physiological Spread of Excitation in Cochlear Implants

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INTRODUCTION

Commercially-available cochlear implants use cathodic-leading current pulses, despite recent evidence that suggests anodic-leading pulses are more effective.1-3 However, much of the work in humans has been done with pseudonormalophonic current pulses meant to stimulate the monophasic stimuli used in animal research. Because these pulses are not used clinically, the effect of stimulus polarity remains unclear for standard biphonic stimuli. The goal of this study was to examine how stimulus polarity affects physiological spread-of-excitation (SOE) measures obtained with the electrically evoked compound action potential (ECAP). Specific metrics included: (1) overall amplitude, (2) location of the peak amplitude, (3) area under the curve, and (4) spatial separation between SOE functions. Due to more effective stimulation and/or masking, we expect larger amplitudes, wider separation between SOE functions. The results of this study will be used to assess how polarity affects the relation between physiological (ECAP SOE patterns) and perceptual measures (pitch ranking) in cochlear implant recipients.

METHODS

Subjects: n=16 (7 CI24RE, 5 CI422, 2 CI512, 2 CI522), ages 13-77
Stimuli:
• Symmetric biphonic pulses for masker and probe.
• Cathodic (e.g. 5-MP1) and anodic (e.g. MP1-5) leading
• Standard forward masking paradigm for artifact reduction
• Pulse duration: usually 25 µsec/phase; Number of sweeps: 100
Procedure:
• SOE functions were obtained for probe electrodes 5-18.
• Stimulation level based on 8 (of 10) loudness rating
Outcome measures:
• Mean amplitude across all masker electrodes (see Figure 2, inset)
• Electrode location of the peak of the SOE function (see Figure 3, inset)
• Curve area, cumulative amplitude of individually normalized SOE function (see Figure 4, inset).
• Spatial separation: sum of difference for amplitudes between each comparison pair, normalized to peak of the pair (see Table 1: Figure 5, inset)

RESULTS

<table>
<thead>
<tr>
<th>Basal</th>
<th>Middle</th>
<th>Apical</th>
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<tbody>
<tr>
<td>5, 6, 7, 8, 9</td>
<td>9, 10, 11, 12, 13</td>
<td>14, 15, 16, 17, 18</td>
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Table 1. Comparison pairs for spatial separation and pitch ranking measures. Underlined electrode was compared to the other 4 electrodes (e.g. 7 vs. 5, 6, 8 and 9).

Figures:
- Example Waveforms
- Electrode location of the peak of the SOE function (Figure 3, inset)
- Curve area, cumulative amplitude of individually normalized SOE function (Figure 4, inset)
- Spatial separation: sum of difference for amplitudes between each comparison pair, normalized to peak of the pair (Figure 5, inset)

CONCLUSIONS

Polarity had significant effects on ECAP spread of excitation. The anodic-leading current pulses produced larger ECAPS, broader SOE patterns, and consequently less spatial separation between patterns. There was no effect of polarity on peak electrode location. These results suggest the anodic phase of the current pulse may produce more effective masking and thus more accurately reflect physiological spread of excitation. Objective physiological measures are useful for mapping cochlear implant recipients who cannot respond behaviorally. Anodic-leading stimuli may improve the predictability of perceptual responses from physiological responses and lead to better outcomes.

FUTURE DIRECTIONS

Next steps include investigating the effects of polarity on behavioral performance (Figure 6) and exploring the relation between SOE functions and pitch ranking.

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REFERENCES