INTRODUCTION

• Poor sound localization abilities in bilateral cochlear implant users have been attributed to the lack of sensitivity to interaural time differences (ITDs) when listening with clinical processors. While fine structure ITDs are discarded by the signal processing, envelope ITDs should still be encoded by the sound processor. However, the independent operations of the sound processors in each ear may still affect the fidelity of the ITD cues available.

• In this work, we measure the abilities of Advanced Bionics HiRes-S and Cochlear Advanced Combination Encoder (ACE) strategies to encode a simple acoustic signal to estimate how well envelope ITD cues can be encoded.

METHOD

Stimuli

<table>
<thead>
<tr>
<th>Synchronization tone</th>
<th>Silence</th>
<th>Transposed tone (or complex) (30 Hz envelope, carrier frequency at center of electrode frequency range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 ms</td>
<td>200 ms</td>
<td>300 ms</td>
</tr>
</tbody>
</table>

Figure 1 shows an example of a single channel stimulus. For multi-channel measurements, multiple transposed tones were added together. All channels had 30 Hz amplitude modulation.

Table 1. Measurement configurations

<table>
<thead>
<tr>
<th>Electrode Numbers and Center Frequencies are shown.</th>
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<tbody>
<tr>
<td>Configuration</td>
</tr>
<tr>
<td>Single-Apical</td>
</tr>
<tr>
<td>Single-Mid</td>
</tr>
<tr>
<td>Single-Basal</td>
</tr>
<tr>
<td>Multi-Apical</td>
</tr>
<tr>
<td>Multi-Basal</td>
</tr>
<tr>
<td>Multi-Interleaved</td>
</tr>
</tbody>
</table>

Measurement Setup

• Electrical stimulation patterns were measured using a National Instruments USB-6343 data acquisition card (NIDAQ). The NIDAQ has 32 channels of input and a maximum sampling rate of 655.36 kHz.

• Stimuli presented to processor via auxiliary input port

Table 2. Processor settings

<table>
<thead>
<tr>
<th>Parameters</th>
<th>AB Naida Q70</th>
<th>Cochlear Nucleus 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategy</td>
<td>HiRes-S</td>
<td>ACE (8 maxima)</td>
</tr>
<tr>
<td>Pulse Width</td>
<td>25.1 µs</td>
<td>25</td>
</tr>
<tr>
<td>Channel Rate</td>
<td>1243</td>
<td>900</td>
</tr>
</tbody>
</table>

RESULTS

• The acoustic signal’s envelope is highly reproducible across different recordings (Fig. 3).

• The acoustic envelope is encoded well by HiRes-S at the electrode allocated for high frequency (Electrode 15), but is temporally smeared at the low frequency electrode (Electrode 2). In contrast, ACE maintains the fidelity of the signal envelope at the three target electrodes (Fig. 3).

• Estimated variance in the onset of the electrical signal envelopes from 50 recordings show a small amount of jitter (Table 3).

• Recording on the entire electrode array shows other electrodes being activated even though only one electrode was targeted. The spread of activation on neighboring electrodes was more prevalent with HiRes-S than ACE (Fig. 4).

• With multi-electrode stimulation, ACE appears to be able to reproduce the spectrum of the acoustic signal better than HiRes-S. However, the N of M channel selection of ACE appears to miss some of the targeted electrodes in favor of others (Fig. 5).

DISCUSSION

• The relatively good envelope encoding and small onset jitter suggests that independent processors on the two ears are capable of presenting envelope ITDs with good temporal precision for simple stimuli.

• However, these processors activate channels beyond that of the spectral content of the acoustic signal. This poor spectral encoding may degrade location cues of real-world sounds by introducing random interaural time and level differences within channels that should not be active.

• The different outcomes between the HiRes-S and ACE strategies may reflect the difference between using band pass filters and Fast Fourier Transform based signal analysis.

REFERENCES


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