TESTING SPEECH PERCEPTION WITH COCHLEAR IMPLANTS THROUGH DIGITAL AUDIO STREAMING IN A VIRTUAL SOUND BOOTH: A FEASIBILITY STUDY

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Disclosures

- DMZ: Advanced Bionics - Research funding, Advisory Board; Cochlear - Consultant; MED-EL - Advisory Board
- CC, AS, MLH, HM, LL: None
- This study was funded by Advanced Bionics Corp.
Background

- Speech perception testing typically conducted in clinic sound-treated booth
  - Specialized equipment
  - Remote locations, accessibility issues
  - Barriers to hearing healthcare

- Reaching critical mass in many CI clinics

- Options for testing outside of traditional sound booths
  - Mobile or remote testing?

Background

- Simplest option: teleconference speaker in quiet room
  - *Hughes, 2012* – speech scores worse than sound booth
  - Ambient noise and/or reverberation?

- Direct audio input (DAI) has been studied (wire)
  - **Advantages**: no cable required, audio signal not susceptible to noise, frequency shaping, or attenuation
  - Single calibration

- No studies to date comparing DAS vs sound booth
Aims

Experiment 1: Compare speech perception scores obtained in traditional sound booth to those using DAS in experienced CI listeners

Experiment 2: If DAS scores differ from sound booth, can pre-processing the DAS speech materials to emulate sound booth minimize differences?
Methods

- IRB approved study
- 19 Adult CI recipients (AB Corp, LLC, Valencia, CA)
  - Experiment 1: 12 ears, 11 subjects
  - Experiment 2: 12 ears, 11 subjects
  - 3 subjects participated in both
- Mean age 53.9 yr (35-70 yr)
- Mean duration of CI use 6.9 yr (11 mo-19 yr)
Methods: test environment

■ Sound Booth (SB)
  - *Traditional booth with 1.2 m speaker distance*
  - *Naída CI processor with everyday setting, 100% T-mic*
  - *ListPlayer software at 60 dBA*

■ Digital Audio Streaming (DAS)
  - *Enclosed meeting room*
  - *Sound tokens digitally streamed via Bluetooth from laptop to ComPilot to CI processor via Phonak HiBAN wireless*
  - *ListPlayer software using Bluetooth output*
  - *SoundWave Professional Suite – input only from ComPilot*
**Test Conditions Experiment 1:**

1. CNC words and phonemes
2. AzBio quiet + noise (fixed SNR +8, 20 talker babble)
Results: Experiment 1

NS, $p = 0.41$ (SB 78, DAS-U 79.8)

NS, $p = 0.18$ (SB 89.5, DAS-U 91.1)
Results: Experiment 1

**ns, p = 0.41**
SB 93.4, DAS-U 84.1

**p = 0.004**
(SB 69.5, DAS-U 78.4)
Amplitude of input vs. output signals

- Periodic logarithmic sinusoid-sweep excitation signals (220-8000 Hz) at 60 dB SPL(A)
- Input and output after SB and ComPilot recorded
- SB has attenuation or amplification for different input frequencies
Acoustic transfer function of the SB

Sources of variability: person, room, microphone, speaker
Methods: noise floor

- Similar to IR measurement, noise floor recorded through CI sound processor at T-mic in sound booth
- NF broadband level = 29 dbA
- Sound file played continuously during pre-processing
<table>
<thead>
<tr>
<th>Method</th>
<th>Diagram</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SB</td>
<td><img src="image" alt="Sound booth" /></td>
<td>Processing speech tokens in a sound booth</td>
</tr>
<tr>
<td>DAS</td>
<td><img src="image" alt="DAS" /></td>
<td>Connecting the processed speech (IR + NF) to ComPilot</td>
</tr>
<tr>
<td>DAS-P</td>
<td><img src="image" alt="DAS-P" /></td>
<td>Processing speech tokens and connecting to ComPilot</td>
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</tbody>
</table>

**ComPilot** follows the processed speech flow.
Results: Experiment 2

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>SB</td>
<td>51.3</td>
</tr>
<tr>
<td>DAS-U</td>
<td>64.1</td>
</tr>
<tr>
<td>DAS-P</td>
<td>49.6</td>
</tr>
</tbody>
</table>

** = 0.003

NS
Individualized pre-processing?

- Individualized IR N = 5
- Performed AzBio-N pre-processed speech (generic IR) vs. unique pre-processed speech (Individual IR)
- No difference between groups
- Unique pre-processing seems unnecessary (higher N needed)
Discussion

- **Primary benefit** of DAS – bypasses microphone eliminating noise floor, reverberation
  - Added benefit of reducing time, space, and equipment demands

- **Primary concern** of DAS – scores that differ from sound booth
  - Better: eliminates reverberation and noise
  - Worse: ? poorer frequency response vs. external microphone (de Graaff et al., 2016; Sevier et al., 2019)
Discussion

■ Previous studies comparing speech perception in sound booth vs. DAI (de Graaff et al., 2018, Sevier et al., 2019)
  - No differences for CNC testing
  - Sentences in noise significantly better for DAI

■ Feasibility of DAS for speech perception testing in CI listeners
  - Sound quality “too good”, scores “too high”
  - Requires pre-processing to emulate sound booth
Conclusions

- Current standard for CI speech perception testing (sound booth) introduces barriers to care and increases demands on CI clinics
- Alternative testing paradigms will become popular as wireless technology becomes readily available
- DAS is alternative for CI speech testing, but likely requires sound filtering due to its “clean” signal
- OR maybe not...