1. Introduction

- Recently, individuals with single-sided deafness have been implanted with a cochlear implant (SSD(CI)) as a treatment for tinnitus[1-3]. Little is known about how these individuals combine their two different hearing modalities (acoustic + CI) for spatial hearing tasks. In particular, this study concerns the ability to perceive movement of sound sources.
- For SSD(CI) individuals, we hypothesize that:
  - Adults with SSD(CI) and BiCI subjects had more difficulty locating lateral azimuthal positions compared to TCC.
  - SSD(CI) and BiCI subjects had more difficulty locating lateral azimuthal positions compared to TCC.
  - SSD(CI) patients who were implanted with a CI in their deaf ear could localize stationary sound sources similarly to adults with NH.

2. Stimulus

- White noise tokens (100-6000 Hz bandwidth, 500 ms duration) were recorded using binaural microphones placed in the ears of a KEMAR manikin.
- Angular ranges of motion: 0° (stationary), 10°, 20°, and 40°.
- 19 target locations, spanning -90° to +90° in 10° intervals.
- Moving sound sources were simulated using Vector Base Amplitude Panning[9] and an array of loudspeakers (Fig. 1).

3. Participants

<table>
<thead>
<tr>
<th>Listener Group</th>
<th>Sex</th>
<th>Age</th>
<th>Yrs. of CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSD(CI) BiCI</td>
<td>M</td>
<td>35</td>
<td>2</td>
</tr>
<tr>
<td>NH</td>
<td>M</td>
<td>28</td>
<td>3</td>
</tr>
<tr>
<td>SSD(CI)</td>
<td>F</td>
<td>25</td>
<td>4</td>
</tr>
<tr>
<td>NH</td>
<td>F</td>
<td>35</td>
<td>5</td>
</tr>
<tr>
<td>SSD(CI) BiCI</td>
<td>M</td>
<td>40</td>
<td>6</td>
</tr>
<tr>
<td>NH</td>
<td>M</td>
<td>30</td>
<td>7</td>
</tr>
</tbody>
</table>

Table 1. NH adults (n = 10) Table 2. Adults with SSD(CI) (n = 8)

4. Auditory Motion Experiment

Testing
- NH adults were presented stimuli via Senheiser HD 600 circumaural headphones.
- SSD(CI) adults were tested in the free field to assess spatial hearing abilities when listening with two different modalities (acoustic + CI).
- BiCI adults listened to stimuli presented to their clinical sound processors via auxiliary input ports.
- Prior to testing, processor volumes and sensitivity were set to ensure a frontal auditory image.

Testing
- Stationary and moving sounds were presented randomly within a single block.
- Participants were asked to report the perceived trajectory of the stimuli on a graphical user interface (Fig. 2).
- Stationary responses were reported by a single dot and moving responses were reported by a line indicating the perceived trajectory.

5. Stationary Sound Localization Ability

- Adult's with SSD(CI) and BiCIs had a larger spread in their responses compared to NH subject (TCC).
- SSD(CI) and BCI subjects had more difficulty locating lateral azimuthal positions compared to TCC.
- SSD(CI) subject (MAH) had less variability than all of the SSD(CI) and BiCI listeners but still not comparable to the NH adults.
- Most SSD(CI) listeners exhibit similar variability in their sound localization ability compared to the BiCI users.
- On average, adults with SSD(CI) had a similar RMS error compared to the BiCI users but both groups were poorer than the NH adults.

- MAF and MAG responded more similarly to the side of their acoustic ear compared to their CI ear.
- Overall, adults with SSD(CI) performed more similarly to adults with BiCIs when compared to TCC.

6. Moving Sounds

- Adults with SSD(CI) detected stationary sound sources similarly to adults with NH.
- NH and SSD(CI) adults improved their motion detection as a sound source traversed a wider angular range. This trend did not occur for BiCI users.
- Adults with SSD(CI) detected stationary sound sources similarly to adults with NH.
- NH and SSD(CI) adults improved their motion detection as a sound source traversed a wider angular range. This trend did not occur for BiCI users.
- Across all angular range conditions, SSD(CI) and BCI listeners had similar performance for discriminating the direction of a moving sound.
- The NH adults had the best performance for discriminating the direction of movement, regardless of the angular range condition.
- At a 10° angular range, all groups of listeners overestimated the target angular range.
- When the sound source moved a wider angular range (20° & 40°), SSD(CI) and BCI listeners were able to track the trajectory of movement but with larger variability than the NH adults.

7. Summary

- SSD patients who were implanted with a CI in their deaf ear could localize stationary sound sources comparable to that of BCI users.
- The ability to detect sound source movement was better for adults with SSD(CI) than with BiCIs but overall, both of these groups performed poorer than NH adults.
- Use of this novel auditory motion paradigm examined the efficacy of spatial hearing in SSD(CI) individuals, not previously reported in the literature[10].

8. References