1. Introduction

• Bilateral cochlear implant (BCI) users have poorer localization ability than normal hearing (NH) listeners.  
• NH listeners have access to a full range of acoustic cues, such as interaural time and level differences (ITDs and ILDs)  
• However, BCI users have limited access to interaural cues (specifically ITDs), which is likely to degrade localization abilities  
• Traditionally, localization experiments have utilized mainly static sounds, which does not test the ability of BCI users to localize a moving sound.

The aims of the present study were:

1) To investigate the auditory motion perception abilities of BCI users.
2) To compare the auditory motion perception abilities of BCI users and NH listeners.

2. Stimulus

Binaural Recordings

• Auditory motion was simulated across an array of loudspeakers (Fig. 1) using Vector Base Amplitude Panning techniques  
• Stationary and moving sounds were white noise tokens similar to the input range of the Cochlear Ltd processors.  
• Recordings were made with binaural microphones placed in the ears of a KEMAR manikin at 19 target locations in azimuth spanning 90º to 10° in 10° intervals.  
• Dynamic ITDs were verified by performing short duration cross-correlation functions on binaural recordings (Fig. 2).

Stimulus conditions

Duration Motion

• Angular range response for two different durations.

3. Auditory Motion Perception Experiment

• NH Testing: Five NH listeners were presented the stimuli via Sennheiser HD 600 circumaural headphones.
• BCI Testing: Four BCI users were tested using their everyday processor settings.

Localization Performance

• The NH listener's localization ability was comparable for static and moving sounds at all locations and angular ranges (Figs. 3a & 3b).  
• In comparison to the NH listener, the BCI user had larger localization errors when indicating the start and end locations for a moving sound compared to their static conditions (Fig. 3c).

Directional Response Performance

• Static sounds were perceived as mostly static by the NH listener but not the BCI user.  
• At short angular ranges (10° and 20°), the NH listener was confused as to whether the sound was static or moving. In contrast, the BCI user was confused about both direction and motion.  
• At longer angular ranges (40°), the NH listener was able to report the correct direction, regardless of duration. In contrast, some confusion still occurs for the BCI user.

Angular Range Error Performance

• The NH listener had small angular range errors when indicating the location of a static sound across both durations.
• As the angular range increases for a moving sound, the BCI user had a large angular range error when indicating the location of the sound source.  
• The NH listener had small angular range error when locating the start of the sound across both conditions.
• At the longest angular range and motion, the NH listener had small angular range error when locating the start of the sound across both conditions.

4. Results

• Across durations, NH listeners had a higher number of static responses for both angular range conditions at a duration of 500 ms. This could be due to the shorter duration of exposure to the sound source (Fig. 6c).  
• At a duration of 500 ms, both groups responded with a decreasing average angular range error when presented a moving sound compared to a static sound. This is likely due to the high angular velocity of the sound (Fig. 6d).

5. NH vs BCI: Group Comparisons

• Compared to NH listeners, BCI users had larger RMS errors for the start and end locations across all angular range conditions and durations (Figs. 5a & 5b).  
• Across durations, NH listeners had a higher number of static responses for all angular range conditions compared to BCI users (Fig. 6c).  
• BCI users reported the highest percentage of static responses for all angular range conditions at a duration of 500 ms.  
• On average, BCI users had larger angular range response errors than NH listeners.  
• Experiments with moving sounds reveal more information about the ability of BCI listeners' source localization compared to static sounds.

6. Conclusions

• For both NH listeners and BCI users, localization of moving sounds was comparable to their respective localization performance with static sounds.  
• BCI users have more difficulty judging whether a sound was static or moving, and confuse the direction of sound movement more often than NH listeners.  
• On average, BCI users had larger angular range response errors than NH listeners.  
• Experiments with moving sounds reveal more information about the ability of BCI listeners' source localization compared to static sounds.

7. References