INTRODUCTION

Background: Bilateral cochlear implants (BCIs) have become a widespread tool for many clinical indications in an effort to improve hearing skills in profoundly deaf individuals. However, BCIs users demonstrate poorer sound localization accuracy when compared to normal hearing (NH) listeners. One of the factors that might contribute to poorer performance is the behind-the-ear microphone placement of these devices. Such placement does not maximize the ability to capture the natural filtering properties of the head and torso to important cues for sound localization. Here, we evaluated sound localization performance of NH listeners at various locations. The factor of interest in this current study is the effect the CI speech processor microphone placement has on sound localization performance.

METHODS

Subjects: 10 NH listeners (ages 24-30) and 4 BiCI users (ages 46-70). Listeners were divided into 3 groups: ITE listeners, BTE listeners, and SHD listeners.

Equipment: Acoustic transfer function (ATF) recordings and sound localization measures were made in the same sound attenuated IAC booth. Stimuli were presented from 19 loudspeakers (Cambridge Soundworks) positioned 1.2 m from the center of the room and spaced every 10° from -90° to 90° along a semicircular arc (ATF measurements) or using virtual acoustic space (VAS stimuli).

Stimuli: Acoustic transfer function (ATF) recordings and sound localization measures were made in the same sound attenuated IAC booth. Stimuli were presented from 19 loudspeakers (Cambridge Soundworks) positioned 1.2 m from the center of the room and spaced every 10° from -90° to 90° along a semicircular arc (ATF measurements) or using virtual acoustic space (VAS stimuli).

Procedure:Listener weighting of cues for lateral angle: the duplex theory of sound localization.

Procedures:
1. Measure ATFs for each loudspeaker location for 3 microphone positions using standard techniques.  
   - In-the-Ear (ITE)  
   - Behind-the-Ear (BTE)  
   - Shoulders (SHD)

Stimuli:
- NH listeners  
  - single pink noise bursts (170 ms)  
  - ±10 dB
- BiCI users  
  - four pink noise bursts (each 170 ms)  
  - ±6 dB
- NH listeners with BiCI  
  - Male synthetic CNC words

Localization Performance:
- Stimuli were presented from each virtual location (15 reps) at 60dB SPL and moved at 10°/s.
- Subjects indicated the perceived sound source location on touch screen.

- The root-mean-square difference (RMS) error between the target and response angle was calculated for each presentation.

Effect of Microphone Placement on NH Localization Performance:
- Localization errors increased as the microphones moved from ITE to SHD positions.

Effect of Microphone Placement on BiCI Localization Performance:
- The ITE microphone position tended to produce larger ILDs as a function of location and frequency.

CONCLUSIONS

- In NH listeners, significant differences in localization performance were observed for the microphone positions and systematically increased as the microphone moved from the ITE to SHD position.
- In the BiCI listeners, distribution of localization performance was often similar between the ITE and BTE conditions, though a small improvement can be observed in the ITE condition as indicated by lower RMS errors.
- In five out of six BiCI subjects, the ITE microphone condition led to a decrease in the RMS error compared to the BTE or SHD position. However, statistical analysis only found a significant difference between the ITE and SHD condition.
- This indicates that BiCI users are not sensitive to the acoustic features responsible for the degradation observed in NH performance when moving from an ITE to BTE microphone configuration.
- Similar localization performance to BiCI users were observed for NH listeners using the VAS-VC stimulus, suggesting that CI signal processing may be less effective than the NH condition.

REFERENCES

- Litovsky, R., Exploring the benefits of bilateral cochlear implants, Audiology and Neurotology, 2009, 9, pp234-246.
- Litovsky, R., Exploring the benefits of bilateral cochlear implants, Audiology and Neurotology, 2009, 9, pp234-246.
- Litovsky, R., Exploring the benefits of bilateral cochlear implants, Audiology and Neurotology, 2009, 9, pp234-246.
- Litovsky, R., Exploring the benefits of bilateral cochlear implants, Audiology and Neurotology, 2009, 9, pp234-246.
- Litovsky, R., Exploring the benefits of bilateral cochlear implants, Audiology and Neurotology, 2009, 9, pp234-246.
- Litovsky, R., Exploring the benefits of bilateral cochlear implants, Audiology and Neurotology, 2009, 9, pp234-246.
- Litovsky, R., Exploring the benefits of bilateral cochlear implants, Audiology and Neurotology, 2009, 9, pp234-246.
- Litovsky, R., Exploring the benefits of bilateral cochlear implants, Audiology and Neurotology, 2009, 9, pp234-246.
- Litovsky, R., Exploring the benefits of bilateral cochlear implants, Audiology and Neurotology, 2009, 9, pp234-246.
- Litovsky, R., Exploring the benefits of bilateral cochlear implants, Audiology and Neurotology, 2009, 9, pp234-246.
- Litovsky, R., Exploring the benefits of bilateral cochlear implants, Audiology and Neurotology, 2009, 9, pp234-246.

ACKNOWLEDGEMENTS

We would like to thank all our listeners. This work is funded by NICHD R0100398 (Litovsky) and in part by a core grant to the Waxman Center from the NICHD (P30 HD015235).