Cochlear implants (CI) successfully promote monaural hearing abilities such as speech perception. However, spatial hearing abilities such as sound localization are challenging with one CI, and often are better with bilateral CIs (BICI). BICIs in young children provide a unique opportunity to study spatial hearing in deaf children who undergo auditory deprivation prior to the onset of hearing. Previous findings from our lab suggest that minimum audible angle (MAA) thresholds in children with BICIs are lower (better) than in children who use a single CI and a hearing aid in the contralateral ear. However, sound localization accuracy with multiple source locations is a more functionally relevant task. Earlier studies in our lab with bilateral children (5-14 years) who had extended periods of deafness in the second-implanted ear indicated that 1/19 had improved sound localization accuracy with BICI compared with one CI. In the present study, we investigated the effect of bilateral experience on performance, and how earlier bilateral activation might lead to the development of sound localization accuracy at a younger age and in a larger proportion of subjects. Children 4-9 years old were tested in BICI mode, at one of three time periods: 6-12 mos, 12-24 mos, 24-36 mos, or 42+ mos. Several children returned for a follow-up visit at the next consecutive interval. Stimuli were spoked words (60.4 dB(a)), presented randomly from one of 15 loudspeakers positioned in the horizontal plane at 10-degree increments. Results indicated that RMS errors ranged from 19.2 to 49.5 degrees. Overall, localization accuracy improved as children experienced increased bilateral experience. Preliminary findings from those with second visit follow-up testing indicate that all children showed decreased improvement in RMS error as the amount of experience with the second implant increased.

**METHOD**

**Localization Testing Apparatus (Fig. 1):**
- Array of 15 loudspeakers in azimuth, 1.2m radius
- Head position: center of array, facing 0°
- Double wall, IAC Sound booth RT= 250 ms

**Stimuli:**
- Targets: Spondees spoken by adult male talker
  - Examples: “airplane,” “balloons”
  - 60 dB SPL, ±4 dB rove
  - Software is written in Matlab

**Procedure:**
- Tested while wearing both CIs as fit by clinician
- Child instructed to indicate location of target word
- Sound Localization: 1-AFC task; Source location varied randomly; 150 trials; At each of 15 possible locations
- MAA: 2-AFC task; Source locations varied for fixed pairs of R-L speakers; MAA = smallest angle at which performance >75% correct (or interpolated angles from psychometric function)
- Feedback: Flashing icon on monitor indicating correct location (Loc test) or direction (MAA)

**RESULTS: INDIVIDUAL**

![Fig. 2: Representative data from 4 normal-hearing (NH), typically-developing, children tested as part of a larger study](image)

**RESULTS: GROUP**

![Fig. 5: Sound localization and MAA threshold are shown for each child, along with average sound-source hearing (RMS) data for seven-year-old children. Note MAA thresholds do not seem to predict smaller RMS values.](image)

**CONCLUSIONS**

- Variability in sound localization was high across this group of children. RMS for some fell within the range of typically-developing children; others showed errors that are not predicted by chronological age or hearing loss.
- Localization errors are likely influenced by the fidelity with which binaural cues are available to individual listeners
- Performance on the localization task is not clearly related to the MAA threshold. In general, right-left discrimination is an easier task, producing smaller azimuthal deviations (discriminable angles) compared with RMS errors.
- Note that this is generally a “high-achieving” sample of children with high scores on standardized intelligence measures.
- 5 children were tested on repeated visits, 4 showed improved localization.
- Children will continue to return to the lab at annual intervals so that the growth of curves regarding these measures will be established over time.

**REFERENCES**


**ACKNOWLEDGEMENTS**

Research supported by NIH Grant No. 5R01DC008365 to (R. Litovsky, PI)