Introduction

- The number of children receiving bilateral cochlear implants (BiCIs) has grown in recent years. Early research in this population showed that during the first year after bilateral activation performance on spatial hearing tasks is better with two CIs than one CI.
- However, little is known about the resolution of their spatial hearing maps, or the extent to which spatial hearing is mapped onto acoustic space, and the emergence of this ability with added bilateral listening experience.

Methods

Listeners
- 12 children who use bilateral cochlear implants (BiCIs)
  - 4 to 12 years
  - BiCI experience ranged from 13 to 50 months
- Testing at intervals separated by approximately 12 months.
  - 4 children participated in 3 annual tests
  - 8 children participated in 2 annual tests
- 6 children with normal hearing (NH), age 5 years

Stimuli
- Spondee spoken by adult male talker (e.g. “airplane”, “cupcake”)
- 60 dB SPL, ± 4 dB rove

Set-up and Procedure
- 15 loudspeakers, 10° intervals (-70° to 70°)
  - shape icons at speakers matched monitor
- Task: To identify sound source location by pointing to or verbally reporting perceived location.
- Feedback: Flashing icon on monitor indicated correct location
- Reps = 10 at each location

Data analysis – Localization sensitivity

Responses obtained for each target location comprised a response group (e.g. responses in the red frame indicates a response group to target at - 70°). We used a non-parametric Kruskal-Wallis test (non-parametric one-way ANOVA) to examine the pair-wise spatial independence between all possible pairs of response groups.

The analysis produces a matrix of independence indices, plotted in coordinates of response group vs. response group. The matrix was interpolated to find a contour (black) of independence index with a z-score of 1.65 (95% probability significantly different), which we defined as independence response threshold. The overall localization sensitivity (LS) is defined as:

\[ LS = \frac{N_{\text{z-score}>1.65}}{N_{\text{total}}} \text{in a matrix} \]

Examples of Localization Results

Longitudinal Localization Results

- Children with early auditory deprivation and less hearing experience in the BiCI group tended to make categorical judgments regarding sound source locations, and typically clustered responses as left and right.
- With an increase in bilateral hearing experience, the children in the BiCI group developed perceptual mapping representations of acoustic space first at midline and subsequently extended for lateral positions.
- Children with BiCIs develop their localization strategy by transitioning from sound source categorization strategies to more fine-grained sound source locations, and typically clustered responses as left and right.

Conclusions

- The overall localization sensitivity (LS) improved with additional bilateral experience over a 2-3 year period. The improvement is notable in the pattern of the localization sensitivity. High sensitivity emerged first at locations near the front, and subsequently at the lateral positions. This is evident from reduction in size of response “clusters”. Right panel shows the change in LS and RMS with bilateral experience for all individual participants. LS and RMS values were computed for each individual at each testing interval (visit).

References


Acknowledgements

This research is supported by NIH-NIDCD grant No. R01DC009385 to Ruth Litovsky. We would like to thank all the families for their participation in this study, as well as the members of the Binaural Hearing and Speech Lab, and T. Grieco-Calub for preliminary work.