Binaural sensitivity in children with bilateral cochlear implants and in normal hearing children

Ruth Y Litovsky, Erica Ehlers, Alan Kan & Matthew J Goupell
University of Wisconsin-Madison, USA
e-mail: litovsky@waisman.wisc.edu

Introduction

- Spatial hearing tasks depend on access to binaural cues, such as interaural time and level differences (ITDs and ILDs).
- Binaural hearing provides reliable access to these cues in normal-hearing (NH) listeners.
- Patients who are fitted with bilateral cochlear implants (BiCIs) have little or no access to ITDs through their clinical processors. This led us to question whether children who use BiCIs are sensitive to ITDs.
- In addition, we compared ITD sensitivity in children with BiCIs with children with NH. The latter were tested with stimuli that mimic aspects of CI processing, namely transposed tones with high-rate carriers and low-rate envelope modulation (Ehlers et al., 2016).

Testing of BiCI users was conducted using bilaterally synchronized research stimuli and processed tones with 2 different pulsatile stimulating rates. ITD sensitivity in children with bilateral cochlear implants (BiCIs) is better for some subjects when DPC is used. The benefit of pitch matching for children with BiCIs for ITD sensitivity is not well understood, and may not be an efficient or helpful approach.

Figure 1: A: Schematic representation of possible interaural frequency mismatch in frequency allocation that can occur when using clinical processors. B: Electrodes at the same insertion depth, matched for pitch when using research processors.

Figure 2: 330 µs, constant amplitude pulse train 
- 64 pps with a 25 µs pulse width
- 1000 pps with 100 Hz AM

Mapping Procedure

- Thresholds (T), transposed (C) and maximum comfortable (MC) levels were measured through the L34 Speech processors for each stimulus separately.
- C levels were loudness-balanced between ears and also for the different maps.

Figure 3: Just noticeable differences (JNDs) thresholds are shown for individual (left) and group average (right) for two sets of data: ILD and ITD. Color coding refers to three places of stimulation along the cochlear array (base, middle and apex) where pitch-matched electrode pairs were stimulated.

Subjects compared pitch in the two ears; and lateralization is weak or absent in children with BiCIs.

Right-Left vs. Left-Right Discrimination

- A set of experiments on binaural sensitivity in children with bilateral cochlear implants (BiCIs) suggests that ILD sensitivity and intracranial lateralization are observed in all children.
- ITD sensitivity is restricted to a small number of children who previously had hearing experience, and lateralization is weak or absent in children with BiCIs.
- When ITD sensitivity occurs, it is at both 100 pps and 1000 pps with 100 Hz AM.
- Pairing of electrodes across the two ears using the “direct pitch comparison” method sharpens the pitch matched pairing. ITD sensitivity may be slightly better for some subjects when DPC is used. The benefit of pitch matching for children with BiCIs for ITD sensitivity is not well understood, and may not be an efficient or helpful approach.

References


Acknowledgement

This work was supported in part by a grant from the University of Wisconsin-Madison (5R01DC008365) to Ruth Y Litovsky, and in part by NICHD (P30 HD03352) to Matt Winn and Shelly Godar.

The Waisman Center from the NIH-NICHD (P30 HD03352). Thank you to Matt Winn and Shelly Godar.

We would like to thank the families who have participated in this study. Ruth Y Litovsky, Erica Ehlers, Shelly Godar, Tania Grieco-Calub, Susan Aggarwal, Sarah Kindle, Todd A. Hess and Matthew J Goupell (2012). Studies on Auditory Fusion in Children at the University of Wisconsin-Madison and Speech Lab. Journal of the American Academy of Audiology. 23(4):124-137.