Sensitivity to Interaural Level Differences is More Prevalent Than Interaural Timing Differences in Children Who Use Bilateral Cochlear Implants

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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. However, for people who use bilateral cochlear implants (BiCIs) these cues are mostly inaccessible, even when they are fit bilaterally. Due to the nature of cochlear implant sound processing, children with BiCIs are not exposed to ITDs on a daily basis and ILDs are present but less salient than in a NH system.

Pre-lingually deafened children also lack easy access to acoustic binaural input during particularly important developmental years. Therefore their auditory system may be insensitive to binaural cues. Finally, to optimize binaural sensitivity, pitch-matched electrode pairs can be used in order to stimulate the same anatomical region on the cochlea (Kan et al., 2013), something that is not taken into account in clinical mappings.

As little is known about binaural abilities in this population, the aim of this study was to investigate pitch matching abilities and ITD/ILD sensitivity in children with BiCIs.

Methods

Participants

- 16 children with bilateral Cochlear Nucleus devices (CI24, CI512) participated in three experimental tasks.
- 6 were tested only on a single pair, 7 were tested on multiple pairs (base, middle, and apex) and 3 were tested twice, on both a single pair and multiple pairs.

Stimuli

- 300 ms, constant amplitude, 100 pulses per second (pps) pulse train with a 25 µs pulse width was presented at a self-reported comfortable loudness level.

Procedure

- Both pitch magnitude estimation and pitch comparison tasks were used. The pairs were then used, one at a time, for the discrimination task.

Experiment 1: Pitch Magnitude Estimation

Subjects were asked to rank pitch of interaural electrodes along an arbitrary scale of 1-100. This was completed in order to estimate the degree of perceived interaural pitch mismatch occurring.

Experiment 2: Pitch Comparison

Subjects were asked to compare pitch of interaural electrodes for Δ0, Δ2, and Δ4, where Δ0 is defined as stimulation of the same number of electrode on each ear, Negative numbers represent electrodes closer to the apex. For example, Δ-2 would be 12 (left)/14 (right). An electrode from each ear was stimulated sequentially. The subject had to report whether the second sound was the same, "higher", "much higher", "lower", or "much" lower in pitch than the first sound. The measure used was calculated giving the above responses values of 2, 1, 0, -1, and -2, respectively and summing together (Kan et al., 2010).

Experiment 3: ITD/ILD Discrimination

The two pairs with the highest number of electrode pairs with Δ0. For all locations along the array, subjects most frequently reported Δ0 as sounding the same. However, there was high variability on this task between subjects.

Conclusions

-Lack of interaural pitch mismatch in pre-lingually deafened children could be due to pitch perception learned through clinical maps (i.e. Reiss et al., 2008). Therefore, pitch-matching tasks may not be a reliable way to identify anatomical mismatch in this population.

-Lack of measurable ITD JNDS may be due to a persistent underlying anatomical mismatch, which was not identified via the pitch matching tasks. However, ILD JNDS were still measurable because ILDs are less susceptible to interaural mismatch (Kan et al., 2013).

A more systematic investigation of ITD sensitivity on different interaural electrode pairings needs to be conducted to determine if pre-lingually deafened children are indeed sensitive to ITDs, and whether pitch-matching is a useful task for aligning BiCIs in children.

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References