Introduction

- Bilateral implantation in children is partly motivated by the attempt to activate binaural circuits in the auditory system, in order to achieve better spatial hearing abilities. The important auditory cues ideally provided would be interaural time and level differences (ITDs and ILDs).
- Previous research, in which children were tested using synchronized processing strategies with low rate, 100 pulses per second (pps), pulsatile stimulation on pitch matched electrode pairs, suggested that children generally have sensitivity to ILD cues, but sensitivity to ITD cues is weak or absent (Ehlers et al., 2015).
- This lack of ITD sensitivity may arise from two possible factors:
  1. Pitch matching may not be a reliable way for identifying anatomical mismatch in place of stimulation for congenitally deaf children, if they have learned pitch through their clinical maps (c.f. Reiss et al., 2008).
  2. Providing children with low rate stimulation may not be close enough to what is found in their everyday listening environment. If children are provided with higher rate amplitude modulated stimuli, they may demonstrate the ability to use ITD cues.
- To examine these two factors in greater detail, ITD sensitivity will be compared to direct pitch comparison data and high rate amplitude modulated stimuli will be compared to low rate stimuli.

Aims

Experiment I: Relationship of pitch matching and ITD sensitivity

- The aim of the first experiment was to determine whether pitch matching tasks can identify the best electrode pair for ITD sensitivity in children with BICIs.
- It was hypothesized that for children who did not previously show ITD sensitivity at a pitch matched pair, they might show ITD sensitivity at a different interaural electrode pair, which is better matched for anatomical stimulation. This result would suggest that pitch matching is not beneficial for some subjects in the pediatric population as its results may merely be a representation of their perception based on the frequency allocation tables in their clinical MAPs.

Experiment II: Relationship of stimulation rate and ITD sensitivity

- The aim of the second experiment was to determine whether the rate of stimuli affects ITD sensitivity in children with BICIs.
- A 300 ms, constant amplitude pulse train with a 25 µs pulse width was presented. Stimulation varied between experiments:
  - Experiment I: 100 pps
  - Experiment II: 100 pps, 1000 pps, 1000 pps with 100 Hz AM
- Stimuli were presented at a self-reported comfortable level.
- Stimuli were presented via a bilaterally synchronized pair of LSI speech processors (Cochlear Ltd.).
- Procedure:
  - Subjects: threshold, comfortable, and most comfortable levels were measured through the research processors for each stimulus separately (100 pps, 1000 pps, and 1000 pps with 100 Hz AM). Comfortable levels were binaural balanced between ears and for the different maps.

General Methods

Participating Subjects:

- Sixteen children with bilateral Cochlear Nucleus devices participated in previous research (Ehlers et al., 2015) where ITD sensitivity was measured on pitch matched electrode pairs using low-rate stimulation. Of that 16, data is also shown for five subjects on the two experiments conducted in the current study and are shown in yellow in the top of the table.

Stimuli:

- A 300 ms, constant amplitude pulse train with a 25 µs pulse width was presented. Stimulation varied between experiments:
  - Experiment I: 100 pps
  - Experiment II: 100 pps, 1000 pps, 1000 pps with 100 Hz AM
- Stimuli were presented at a self-reported comfortable level.
- Stimuli were presented via a bilaterally synchronized pair of LSI speech processors (Cochlear Ltd.).

Procedure:

- Subjects: threshold, comfortable, and most comfortable levels were measured through the research processors for each stimulus separately (100 pps, 1000 pps, and 1000 pps with 100 Hz AM). Comfortable levels were binaural balanced between ears and for the different maps.

Tasks:

Direct Pitch Comparison (DPC): Subjects were asked to compare pitch of interaural electrodes for δ0, δ2, and δ4, where δ0 is defined as stimulation of the same numbered electrode in each ear. Negative numbers imply electrodes in the right ear were closer to the apex. For example, δ2 would be 12 (right/4/4/4).
- An electrode from each ear was stimulated sequentially. The subject reported whether the second sound was the “higher”, “lower”, or “much lower” in pitch than the first sound.
- The metric, µ, was calculated by giving the above responses values of 2, 1, 0, -1, and -2, respectively and summing together (Litovsky et al., 2012).

Results: Direct Pitch Comparison

- The majority of subjects perceived no difference in pitch for the same numbered electrodes across the ears, which was reflected in the electrode pairs chosen for ITD testing (see Table 2).

References:


Conclusions

- Previous research showed that 50% of subjects did not demonstrate sensitivity to ITDs even when tested at multiple places along the electrode array (Ehlers et al., 2015).
- Pitch matching appears to be an effective method for identifying an electrode pair that can yield ITD sensitivity in children who use cochlear implants.
- ITD sensitivity appears to be more prevalent for 100 pps and high rate amplitude modulated stimuli.
- The data suggest that factors other than anatomical mismatch and stimulus rate may be responsible for a lack of ITD sensitivity in this population. Early acoustic experience and/or binaural maturation may be required for ITD sensitivity.

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