Pitch ranking, pitch matching, and binaural fusion in children with bilateral cochlear implants: bringing research into clinical practice

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Background

• **Bilateral** hearing $\neq$ **binaural** hearing

• Why does binaural hearing matter?
  • Sound localization
  • Hearing in complex listening environments
Children with bilateral CIs show…

greater variability and poorer performance on localization and speech in noise tasks

NH1: 8.9°
Investigating this variability and poorer performance on binaural tasks
Cochlear implant studies via direct stimulation

Nucleus Implant Communicator (NICs)
- Bilaterally synchronized implants in the two ears
- Direct and precise control over each pulse
- Loudness balanced
- Pitch matched
- Vary stimulation levels, interaural cues
Current research
16 children with bilateral CIs ages 10-15 years

1. Pitch ranking
   • Rank order pitch of various electrodes along array in one ear

2. Pitch comparison
   • Compare pitch of electrodes between the two ears

3. Binaural fusion
   • Listen to simultaneous stimulation on the arrays in both ears and decide whether it produces one sound or two
Findings

16 children with bilateral CIs ages 10-15 years

1. **Pitch ranking**: All children rank ordered pitch consistent with the high → low, base → apex.

2. **Pitch comparison**: Some children with bilateral CIs perform similarly to adults with CIs in direct pitch comparison tasks.

3. **Binaural fusion**: Most children did not form a single auditory image from simultaneous bilateral stimulation.
What can we (clinicians) do?

1. Raise clinical awareness: **bilateral CIs** do not necessarily equal use of **binaural cues**
   
   - Electrodes may not be pitch-matched or loudness balanced between ears
   - Binaural timing, level, and fine structure cues are not necessarily preserved by the devices
   - Binaural pathways may have a critical period of development
What else can we (clinicians) do?

2. Use the bilateral mapping screens
   • Loudness balancing
   • Adjust for a centered auditory image

3. Aural (re) habilitation
   • Potential for improved localization and fusion over time
   • Practice localization

4. Counseling

5. Environmental modifications
   • Continue use of remote microphone technology

Quiet is ideal…

But unrealistic!
Future directions: our thoughts

• Processing strategies that aim to better preserve important binaural cues
• Fully synchronized processors
• Pitch matching in commercially available software
• Continue research on children throughout their lifespan
  • If processors and strategies can provide binaural cues, are children able to use them successfully?
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