Attention to Speech in Deaf Infants with Cochlear Implants

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Disclosure

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Language Development in Infants with CIs

- Delayed development
- Immense variability
The ear is connected to the brain

Hearing loss affects:
- Working memory (Pisoni & Geers, 2000)
- Executive function (Castellanos et al., 2015)
- Sequence learning (Conway, Pisoni, Anaya, Karpicke, & Henning, 2011)
- Attention (Houston et al., 2003; Smith, Quittner, Osberger, & Miyamoto, 1998)
Theoretical models: attention to speech

Word Recognition and Phonetic Structure Acquisition (WRAPSA) (Jusczyk, 1993)

The developmental framework for Processing Rich Information from Multidimensional Interactive Representations (PRIMIR) (Curtin, Byers-Heinlein, & Werker, 2011; Werker & Curtin, 2005)
NH infants show enhanced attention to speech over:

- filtered speech (Spence & DeCasper, 1987)
- noise (Butterfield & Siperstein, 1970)
- silence (Houston et al., 2003)
- other naturally occurring sounds (Shultz & Vouloumanos, 2010)
Attention to speech is related to:

Speech processing in adults (Toro, Sinnett, & Soto-Faraco, 2005)

Language outcomes in infants
• Expressive vocabulary at 18m (Vouloumanos & Curtin 2014)

Attention to speech may be more important for children with CIs
• Processing of degraded speech depends critically on attention (Wild et al., 2012)
Attention to speech - CI

CI vs. hearing age-matched NH infants

Fig. 2 Houston et al. (2003)
Goals

Q1: Do infants with CIs show reduced attention to speech as compared to their *chronological age-matched* NH peers?

Q2: Is attention to speech related to spoken language development in infants with CIs?
Participants

22 infants with CIs (93 sessions):
• CI activated: 7.6-27.7 months;
• Tested 1 to 7 times: 1 day -18 months post CI

80 infants with NH (93 sessions):
• Each CI session was matched to a NH session based on the chronological age

<table>
<thead>
<tr>
<th>Post-CI months</th>
<th>Pairs</th>
<th>CI group</th>
<th>NH group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>CI age</td>
<td>Age</td>
</tr>
<tr>
<td>(&lt; 1 month)</td>
<td>41</td>
<td>.55 (.41)</td>
<td>17.77 (5.29)</td>
</tr>
<tr>
<td>(3-6 months)</td>
<td>30</td>
<td>4.50 (1.69)</td>
<td>20.62 (5.52)</td>
</tr>
<tr>
<td>(12 months)</td>
<td>11</td>
<td>11.74 (.55)</td>
<td>28.87 (5.23)</td>
</tr>
<tr>
<td>(18 months)</td>
<td>11</td>
<td>17.85 (.48)</td>
<td>31.42 (3.78)</td>
</tr>
</tbody>
</table>
Visual Habituation (VH) procedure

Infants were randomly assigned to 4 conditions:
- [hap] vs. silence
- [a] vs. silence
- [i] vs. silence
- [i] vs. silence

20 blocks in total: 2 sound trials and 2 silent trials within each block

Dependent measure:
- Average looking times across trials to each type of auditory stimuli across the blocks
Speech and language measures

<table>
<thead>
<tr>
<th>Construct</th>
<th>Test</th>
<th>Abbreviation</th>
<th>Post-CI years</th>
<th>Data point no.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speech perception</td>
<td>Grammatical Analysis of Elicited Language (Moog et al., 1983)</td>
<td>GAEL-P</td>
<td>1.5-3</td>
<td>39</td>
</tr>
<tr>
<td>Speech articulation</td>
<td>Goldman-Fristoe Test of Articulation (Goldman &amp; Fristoe, 1986)</td>
<td>GFTA</td>
<td>1.5-8</td>
<td>68</td>
</tr>
<tr>
<td>Speech perception</td>
<td>The Lexical Neighborhood Test (Hay-McCutcheon, 1999)</td>
<td>LNT</td>
<td>2-11</td>
<td>68</td>
</tr>
<tr>
<td>Receptive vocabulary</td>
<td>Peabody Picture Vocabulary Test (Dunn, 1997; Dunn &amp; Dunn, 2007)</td>
<td>PPVT</td>
<td>1.5-11</td>
<td>104</td>
</tr>
<tr>
<td>Speech perception</td>
<td>Pediatric Speech Intelligibility (Jerger &amp; Jerger, 1984)</td>
<td>PSI</td>
<td>1.5-3.5</td>
<td>33</td>
</tr>
</tbody>
</table>
Results: Q1

Attention to speech

Model: `lmer(Lookingtime ~ Hearing status*Type + (1|CI participant) + (1|Session) + (1|Hearing status:Session) + (1|Type:Session), data=attention)`

*: $p < .05$  
+: $.05 < p < .01$
## Results: Q2

### Outcome measures

<table>
<thead>
<tr>
<th>Post-CI months</th>
<th>GAEL</th>
<th>GFTA</th>
<th>LNT</th>
<th>PPVT</th>
<th>PSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1 month</td>
<td>.19(.10)</td>
<td>-2.19(1.18)*</td>
<td>--</td>
<td>--</td>
<td>.67(.53)</td>
</tr>
<tr>
<td>3-6 months</td>
<td>-.84(.47)</td>
<td>.71(.77)</td>
<td>2.29(.73)**</td>
<td>.29(.48)</td>
<td>--</td>
</tr>
<tr>
<td>12 months</td>
<td>-1.52(.97)</td>
<td>--</td>
<td>-.65(.98)</td>
<td>1.15(.66)*</td>
<td>-.22(.54)</td>
</tr>
<tr>
<td>18 months</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>AdjR²</td>
<td>.143</td>
<td>.03</td>
<td>.18</td>
<td>.029</td>
<td>.008</td>
</tr>
<tr>
<td>Model p</td>
<td>.195</td>
<td>.141</td>
<td>.013*</td>
<td>.171</td>
<td>.382</td>
</tr>
</tbody>
</table>

Model: `lm(Outcome ~ ATS_{Bin1} + ATS_{Bin2} + ATS_{Bin3} + ATS_{Bin4} + (1|CI participant) + (1|Interval), data=outcome)`
Summary and Conclusions

Infants with CIs showed a similar degree of attention to speech as compared to their chronologically age-matched peers with NH during 3-6, 12, and 18 months post CI.

- Attention to speech may be influenced by experience-independent processes.
- Lack of auditory experience before implantation, including in utero, and the degraded nature of input via CIs, may have led to reduced attention to speech in CI infants as compared to hearing age-matched NH peers.
Summary and Conclusions

Attention to speech is associated with later speech perception
• Supports WRAPSA and PRIMIR theoretical models.
• Has implications for early intervention: developing strong listening skill.
Thank you!