Impact of Early Sign Language Exposure on Cochlear Implant Benefits

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Childhood Development after Cochlear Implantation (CDaCI)
The benefits of learning sign language clearly outweigh the risks. For parents and families who are willing and able, this approach seems clearly preferable to an approach that focuses solely on oral communication.
Childhood Development after Cochlear Implantation (CDaCI) Study

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Childhood Development after Cochlear Implantation
Participants

Childhood Development after Cochlear Implantation (CDaCI)

Enrolled \((n = 188)\)

- CI ≤ 38 months \((n = 137)\)
  - Reported early sign exposure \((n = 129)\)
    - Tested early and late elementary \((n = 97)\)
    - Not tested early and late elementary \((n = 32)\)
  - Did not report early sign exposure \((n = 8)\)
- CI > 38 months \((n = 51)\)
Sign Language Exposure Groups

• **No sign** \((N = 35)\)
  No sign used pre-implant or the first three years post-implant

• **Short-term sign** \((N = 26)\)
  Sign used pre-implant and/or 12 months post-implant

• **Long-term sign** \((N = 36)\)
  Sign used pre-implant and at least 36-months post-implant
## Baseline characteristics of CI recipients

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>No sign (n = 35)</th>
<th>Short-term sign (n = 26)</th>
<th>Long-term sign (n = 36)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent Female</td>
<td>49%</td>
<td>35%</td>
<td>58%</td>
</tr>
<tr>
<td>Household income &lt; $50k</td>
<td>32%</td>
<td>44%</td>
<td>42%</td>
</tr>
<tr>
<td>Mother graduated college</td>
<td>69%</td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td>Aided PTA better ear a</td>
<td>75 dB HL</td>
<td>73 dB HL</td>
<td>78 dB HL</td>
</tr>
<tr>
<td>Age at onset of deafness</td>
<td>0.3 mos</td>
<td>1.2 mos</td>
<td>1.3 mos</td>
</tr>
<tr>
<td>Amplification age</td>
<td>9 mos</td>
<td>11 mos</td>
<td>12 mos</td>
</tr>
<tr>
<td>CI Activation age</td>
<td>19 mos</td>
<td>22 mos</td>
<td>23 mos</td>
</tr>
</tbody>
</table>

*Average of available thresholds between 500-4000 Hz, where at least 1 frequency was tested (88/97 of participants had 4-frequency PTA)*
## Baseline characteristics of CI recipients

| Characteristic                  | No sign  
|                               | \( n = 35 \) | Short-term sign  
|                               | \( n = 26 \) | Long-term sign  
|                               | \( n = 36 \) |
| Maternal Sensitivity \(^a\)    | 5           | 5            | 5            |
| Baseline IQ \(^b\)            | 94          | 97           | 99           |
| Vocabulary \(^c\)             | 15          | 11           | 16           |
| Auditory perception \(^d\)    | 10          | 7            | 6            |

\(^a\) Sensitivity scale from the NICHD Early Childcare Study codes;

\(^b\) Bayley Scales of Infant Development (BSID II) (Bayley, 1993);

\(^c\) Words understood and said on the MacArthur-Bates Communicative Development Inventory (MBCDI: Words and Gestures Form; Fenson et. al. 1993);

\(^d\) Infant-Toddler Meaningful Auditory Integration Scale (IT-MAIS) (Robbins AM, 1991).
## Post-Implant Outcome Measures

### Speech perception
- **Speech Recognition Index in Quiet (SRI-Q)**
  - 1, 2, and 3 years post-CI

### Spoken language
- **Comprehensive Assessment of Spoken Language (CASL)**
  - 5-7 and 9-11 years of age

### Speech intelligibility
- **McGarr sentences**
  - 6, 7, or 8 years of age

### Reading comprehension
- **Woodcock-Johnson (WJ) Tests of Achievement**
  - 5-7 and 9-11 years of age
Does an early exclusive focus on spoken language promote faster development of auditory speech perception skills, leading to more intelligible speech in elementary grades?
## Speech perception

**Speech Recognition Index in Quiet (SRI-Q)**

<table>
<thead>
<tr>
<th>600</th>
<th>Open-set</th>
<th>Hearing in Noise Test for Children (quiet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>500</td>
<td></td>
<td>Phonetically Balanced Kindergarten words</td>
</tr>
<tr>
<td>400</td>
<td></td>
<td>Lexical Neighborhood Test</td>
</tr>
<tr>
<td>300</td>
<td>Closed-set</td>
<td>Pediatric Speech Intelligibility Test</td>
</tr>
<tr>
<td>200</td>
<td></td>
<td>Early Speech Perception Test</td>
</tr>
<tr>
<td>100</td>
<td>Parent report</td>
<td>Meaningful Auditory Integration Scale</td>
</tr>
</tbody>
</table>
Speech perception in quiet

- Baseline (Pre-CI)
- 1 Year Post-CI
- 2 Years Post-CI
- 3 Years Post-CI

Legend:
- No Sign
- Short-term Sign
- Long-term Sign
Speech perception in quiet

- Baseline (Pre-CI)
- 1 Year Post-CI
- 2 Years Post-CI
- 3 Years Post-CI

SRI-Q

No Sign | Short-term Sign | Long-term Sign
Speech intelligibility
McGarr sentences

Speech intelligibility
McGarr sentence examples

High Context
3 Syllable:  Read the book.
5-Syllable:  The cat chased the mouse.
7 Syllable:  The flag is red, white and blue.

Low Context
3 Syllable:  Get the cake.
5-Syllable:  Who wants this ice cream?
7-Syllable:  Is the fat baby crying?
Many listeners rated each child’s speech.
Speech Intelligibility at age 8 years

![Box plot showing percent intelligible speech for No sign, Short-term Sign, and Long-term Sign conditions. The plot indicates significant differences with p < .001 for No sign vs. Short-term Sign and p < .01 for Short-term Sign vs. Long-term Sign.]
Does early speech perception predict later speech intelligibility?

<table>
<thead>
<tr>
<th>Speech recognition index in quiet (SRI-Q)</th>
<th>$p$</th>
<th>$p &lt;$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>.10</td>
<td>NS</td>
</tr>
<tr>
<td>1 year post-CI</td>
<td>.24</td>
<td>.02</td>
</tr>
<tr>
<td>2 years post-CI</td>
<td>.32</td>
<td>.002</td>
</tr>
<tr>
<td>3 years post-CI</td>
<td>.42</td>
<td>.001</td>
</tr>
</tbody>
</table>
Question 1 response

Children whose families used spoken language exclusively developed better auditory speech perception skills and had more intelligible speech than children whose families used sign language 3+ years.

Short-term sign use did not affect speech intelligibility.
Question 2

Does early exposure to sign language promote the development of spoken language and reading in elementary grades?
Comprehensive Assessment of Spoken Language

- Antonyms
- Syntax construction
- Paragraph comprehension
- Nonliteral language
- Pragmatic judgment
- Grammatical morphemes
- Sentence comprehension
Woodcock-Johnson Tests of Achievement

• Passage Comprehension
  – Understanding of printed words, phrases, and paragraphs
Early exposure to sign language did not enhance either spoken language or reading.

Children whose parents signed were significantly more likely than children of non-signing parents to exhibit delays.
Is the quantity of sign exposure over the first three years post-implant important for age-appropriate spoken language and reading development?
Percent of Subjects below Average Range

The diagram shows the percentage of subjects with scores below 85 in Language and Reading, classified into Early and Late groups. The categories are:

- Language
  - Early: 60%
  - Late: 60%
  - Short-term
  - No Sign
  - Long-term

- Reading
  - Early: 10%
  - Late: 60%
  - Short-term
  - No Sign
  - Long-term
Odds of Language Delay Re: No-Sign Group

![Bar chart showing odds ratios for Early Grades and Late Grades. The chart indicates a significant difference between Short-term and Long-term groups in the Late Grades.](chart.png)
Odds of Reading Delay Re: No-Sign Group

- Early Grades:
  - Short-term: 1.8
  - Long-term: 1.2

- Late Grades:
  - Short-term: 4.0
  - Long-term: 3.6

Significance:
- * indicates significance at p < 0.05
- ** indicates significance at p < 0.01
Question 3 response

Children with sign language exposure, whether short-term or long-term, were at a significant disadvantage compared to those from non-signing families. By late elementary school, participants exposed to sign language, were 3 to 4 times more likely to exhibit spoken language and reading comprehension delays relative to hearing age-mates.
If long-term development of oral communication and literacy is the primary objective for a child with a cochlear implant, focus on early spoken input increases the probability of achieving those goals.