Language and Academic Outcomes for Early-Implanted Children with Bilateral versus Unilateral Cochlear Implants

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The University of Melbourne, Department of Audiology and Speech Pathology receives research funding from Cochlear Limited.
5-year longitudinal study (2009-2014):

- To investigate whether bilateral CIs at a young age give children a greater ability to learn.
- To provide some of the first data worldwide comparing the effects of two CIs on language, social & academic outcomes.
- Do children with two CIs have:
  - better language outcomes?
  - better psychosocial outcomes?
  - better academic outcomes?
  - less disability, in terms of functional listening skills in daily life?
Selection Criteria

- First CI by 3.5 years
- Second CI under 6 years
- Aged 5-8 years at some time during the study
- Speak English as their primary language at home (some used supplementary sign)
- Normal cognitive ability (IQ)
- No other disabilities that would prevent completion of assessment tasks
• Are outcomes age-appropriate?
• Is there a significant difference in language outcomes between children with 1 & 2 CIs?
• What are the predictive factors for language outcomes?
  – N = 91 (44 boys, 47 girls) aged 5-8 years
  – 67 bilateral CIs
  – 24 unilateral CIs (19/24 used a HA also)
<table>
<thead>
<tr>
<th>Hearing</th>
<th>Parenting Style</th>
<th>Child Characteristics</th>
<th>Family Background</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age @ CI1 (yrs)</td>
<td>Parent involvement</td>
<td>Birth order</td>
<td>Parent education</td>
</tr>
<tr>
<td>Age @ CI2 (yrs)</td>
<td>Screen time</td>
<td>IQ</td>
<td>FH hearing loss</td>
</tr>
<tr>
<td>CI experience</td>
<td>Adult reading time</td>
<td>Birth weight (kg)</td>
<td>FH reading difficulties</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gender</td>
<td>FH speech difficulties</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Age @ diagnosis</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fine motor skills</td>
<td></td>
</tr>
</tbody>
</table>
N = 56 (41 bilateral, 15 unilateral)
Language at 8 years: CELF-4

N = 35, p = 0.002 (EL), 0.004 (CL)

Bilateral Unilateral
Vocabulary (PPVT): All children

N = 91, p = 0.0004

Bilateral

Unilateral
## Language: Predictive Factors

<table>
<thead>
<tr>
<th>Predictive Factors</th>
<th>5 years</th>
<th>8 years</th>
<th>Vocabulary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bilateral CIs</td>
<td></td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>Younger @ CI2</td>
<td>√</td>
<td></td>
<td>√</td>
</tr>
<tr>
<td>Younger @ CI1</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Higher parent involvement</td>
<td></td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>Less screen time</td>
<td>√</td>
<td></td>
<td>√</td>
</tr>
<tr>
<td>More adult reading time</td>
<td>√</td>
<td></td>
<td>√</td>
</tr>
<tr>
<td>Earlier birth order</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>Higher IQ</td>
<td></td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>Higher birth weight (kg)</td>
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</tr>
<tr>
<td>Female gender</td>
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<tr>
<td>Higher parent education</td>
<td></td>
<td></td>
<td>√</td>
</tr>
<tr>
<td>FH of hearing loss</td>
<td></td>
<td></td>
<td>√</td>
</tr>
</tbody>
</table>

√ = p<0.05
Age appropriate?

- Group mean scores always within 1SD of mean for bilateral children, but not for younger (5yo) unilateral children

Bilateral vs Unilateral:

- Significantly better language outcomes for older (8yo) children, but not for younger children
- Bilateral use predicted **better language outcomes** (moderated by age at CI2)

Predictive factors:

- Outcomes were significantly predicted by factors related to parenting, child characteristics & family background
  
  59-69% of variance predicted by the regression models
Are outcomes age-appropriate?

Is there a significant difference in academic outcomes for children with 1 & 2 CIs?

What are the predictive factors?
  - N = 44 (23 boys, 21 girls) aged 8 years
  - 34 bilateral CIs
  - 10 unilateral CIs (7/10 used Has also)
• Wechsler Individual Academic Achievement Test
• Broad range of academic skills in 4 composite areas:
  – Oral Language
  – Written Language
  – Maths
  – Reading
• Age-based standard scores
• 1.5 - 2 hours administration time
Academic Outcomes

N = 44

- Bilateral
- Unilateral
## WIAT-II: Predictive Factors

<table>
<thead>
<tr>
<th>Predictive Factors</th>
<th>Oral Lang</th>
<th>Maths</th>
<th>Written Lang</th>
<th>Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bilateral CIs</td>
<td>√</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Younger @ CI2</td>
<td>√</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Younger @ CI1</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Hearing aid use</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Higher parent involvement</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Earlier birth order</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Higher IQ</td>
<td></td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Higher birth weight (kg)</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Higher parent education</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Time spent reading</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>FH of speech/reading difficulties</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ \sqrt {p < 0.05} \]
Children with CIs can achieve language & academic outcomes within the normal range

Bilateral CIs predict significant benefits to language & academic development

Bilateral benefit across all outcomes is maximized with earlier age at implantation.

Practical findings of clinical relevance include the importance of parental involvement & of children developing a regular reading habit

Hearing aid use before & after implantation very important

Although we have come a long way over the past decade, there is still room for improvement
• Participating families

• Collaborative centres:
  Melbourne Cochlear Implant Clinic (RVEEH), The Shepherd Centre, The Hear & Say Centre, The Cora Barclay Centre, Sydney Cochlear Implant Clinic, The Women’s & Children’s Hospital, Hearing House, New Zealand

• LOCHI Study

• Australian Research Council & Cochlear Ltd
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