Children who are Hard of Hearing: Still Forgotten?

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A Sound Foundation Through Early Amplification
December, 2013
Chicago, IL
Children who are “Hard of Hearing”

- Characteristics of children who are HH:
  - Hearing levels in the mild through moderately severe range
  - Use hearing aids rather than CIs
  - Reliant on spoken language for functional communication (Jamieson, 2010)

- Described by Julia Davis as “Our Forgotten Children”
Why Called “Forgotten Children?”

- Underestimation of needs
- Limited training of classroom teachers, school personnel
- Little is known about:
  - outcomes and academic achievement
  - problems faced in classrooms
  - extent of support services & impact
- Poorly monitored amplification

Davis, J. (1977)
Background

- 30,000 children < age 6 have mild-to-severe, persistent bilateral hearing loss

- Paucity of research on outcomes of HH children
  - Reflect a belief that HL does not place these children at risk?

- NIDCD Working Group in 2006 identified research gaps & needs
  - Ear & Hearing, 2007
OCHL Study: Aims

- To describe the characteristics of:
  - children and families
  - intervention services
  - factors associated with service variations
- To measure a range of:
  - child and familial outcomes compared to NH age-mates with similar backgrounds
- To explore:
  - how variations in child & family factors & intervention characteristics relate to functional outcomes

Supported by NIDCD R01 DC009560
Each child followed for 3+ years (around birthday)
- Comprehensive battery of child, family, & intervention measures
## Sample Description

<table>
<thead>
<tr>
<th></th>
<th>HH</th>
<th>NH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of subjects</td>
<td>316</td>
<td>115</td>
</tr>
<tr>
<td>Hearing (PTA)</td>
<td>25-75 dB HL</td>
<td>&lt; 20 dB HL</td>
</tr>
<tr>
<td>Age ranges</td>
<td>0;6 to 6;11 at entry</td>
<td></td>
</tr>
<tr>
<td>Nonverbal IQ</td>
<td>Within the average range</td>
<td></td>
</tr>
<tr>
<td>Maternal education</td>
<td>Matched but &gt; US sample</td>
<td></td>
</tr>
<tr>
<td>Language use</td>
<td>Spoken English in the home</td>
<td></td>
</tr>
<tr>
<td>Additional disabilities</td>
<td>No autism; no major vision, cognitive, or motor disabilities</td>
<td></td>
</tr>
</tbody>
</table>

From 17 states
76.1% HH children identified through NHS
Many HH children demonstrate resilience
- Some children (25-30%) & some aspects of development are particularly susceptible to effects of HL.
- Strong and systematic effects of degree of loss on speech and language development.
- HL interferes with consistency/quality of access to input.
- Aspects of language *most dependent on the fidelity of the speech signal* may be most vulnerable to delays.
Children with HL experience inconsistent access to linguistic input, due to:

- **Periods without amplification**
  - Delays in hearing aid fitting
  - Inconsistent hearing aid use

- **Limitations of hearing aids**
  - Bandwidth
  - Audibility

- **Effects of negative environmental acoustics**
  - Distance, noise, and reverberation
Profile of Relative Strengths and Vulnerabilities at 3 yrs

- ★ ★ Mild hearing loss (25-45 dB HL)
- ★ ★ ★ Moderate & Mod-Severe (> 45 dB HL)

<table>
<thead>
<tr>
<th></th>
<th>70</th>
<th>85</th>
<th>100</th>
<th>115</th>
<th>130</th>
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</thead>
<tbody>
<tr>
<td>BASIC CONCEPTS</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SYNTAX</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PRAGMATICS</td>
<td>★</td>
<td>★</td>
<td>★</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SPEECH PRODUCTION</td>
<td>★</td>
<td>★</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Tomblin, Oleson, Ambrose, Walker, & Moeller, in review
Evidence of Vulnerable Domains

Articulation

Use of verb endings (sits, goes, walked)

\[ p < .001 \]

Koehlinger, Owen Van Horne & Moeller, *JSLHR*, 2013

63% > 1 SD
Emerging Model: Inconsistent Access

Hearing Loss (degree, type, configuration, & stability) → Cumulative Auditory Experience → HA Use History (duration, consistency) ↔ Audibility ↔ Linguistic Input → Outcomes
- Linguistic
- Social
- Auditory
- Family
Degree to which HA improves audibility is constrained by severity of HL

Created residual SII (rSII)
  - To test unique contribution of HAs (Aided SII)
  - After controlling for the unaided SII

Tomblin, Oleson, Ambrose, Walker, & Moeller, in review
1. Audibility provided by HA is significantly associated with speech & language.
2. Audibility has similar relationship with outcomes for children with mild and moderate-to-severe HL.
Spontaneous language samples - 51 HH 3 yr olds

Do hearing-related factors predict use of word endings?
- BEPTA, SII, 4kHz SL

Does perceptibility influence accuracy in HH?
- In NH children, /s/ and /z/ emerge before /l/z/
- Hits, cars > houses, fixes

More audible?

Owen Van Horne, Koehlinger, Oleson, & Moeller, in preparation
Summary of Results

- Audibility matters
  - 4kHz SL predicts word endings
    - Audibility in the high frequencies + articulation skills are essential for development of English morphology

- Perceptibility influences in HH
  - HH different from NH /lz/ > /s/ and /z/

Owen Van Horne, Koehlinger, Oleson, & Moeller, in preparation
Challenges to Consistent HA Use

More challenges:
• At young ages (toddlers)
• With mild degrees of hearing loss
• Less educated families

Strategic counseling?

### Greatest Benefit of Aided Hearing Seen With Longer Use

<table>
<thead>
<tr>
<th>Duration Category</th>
<th>Outcome</th>
<th>Linear Slope (Beta)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Language</td>
<td>3.89</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>Speech</td>
<td>58.49</td>
<td>0.04</td>
</tr>
<tr>
<td>2</td>
<td>Language</td>
<td>3.66</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>Speech</td>
<td>80.26</td>
<td>0.005</td>
</tr>
<tr>
<td>3</td>
<td>Language</td>
<td>2.43</td>
<td>0.14</td>
</tr>
<tr>
<td></td>
<td>Speech</td>
<td>52.93</td>
<td>0.06</td>
</tr>
<tr>
<td>4</td>
<td>Language</td>
<td>-0.70</td>
<td>0.71</td>
</tr>
<tr>
<td></td>
<td>Speech</td>
<td>30.42</td>
<td>0.17</td>
</tr>
</tbody>
</table>

n = 161 (Speech); n = 148 (Language)
HH children at 3 and 5 years of age

Tomblin, et al., in review

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rSII significantly associated with speech & language

Greatest benefit of aided hearing for s/l seen with longer HA use
How Much Input?

M age = 30 months

HH n = 38
NH n = 17

No significant differences between groups

For HH group, more input = better language

- Mullen Receptive correlated with AWC ($r = 0.44^{**}$) and CTC ($r = 0.46^{**}$)

Ambrose, Van Dam & Moeller, JDSDE, 2012
Parent-child interaction samples analyzed in 3-year olds

HH group exposed to significantly:
- fewer high-level utterances
- more directive utterances

HH CASL scores significantly correlated with:
- proportion of high-level utterances ($r = 0.57$)
- proportion of directives ($r = -0.38$)

HH group also exposed to:
- less complex utterances
- fewer different words

Ambrose, et al., in preparation
Emerging Model: Inconsistent Access

Hearing Loss
(degree, type, configuration, & stability)

Cumulative Auditory Experience

Audibility

HA Use History
(duration, consistency)

Linguistic Input

Home/Environmental Factors:
- SES
- Parenting skills
- Auditory environment

Educational Interventions

Outcomes
- Linguistic
- Social
- Auditory
- Family

Child Factors
- Cognition
- Temperament
- Age
- Executive Function
Protective Factors

What protective factors result in resilience?
Protective Factors: Big Picture

- Milder degree of hearing loss
- Better audibility
- Well-fit amplification
- Longer duration of hearing aid fitting (early fit)
- Amplification worn consistently
- High quantity and quality of linguistic input
- Provision of timely & consistent early interventions
- More resourced homes
- Stronger cognitive abilities
Early Intervention Services

Contribution of number of early intervention visits per month to CASL Scores at 3 years (regression results)

- Covariates (sex, race, maternal ed**, PTA)
- Number visits per month**
- Unexplained

145/155 infants received early intervention
Implications: No Longer Forgotten

- Optimize audibility
  - Audibility matters
  - Benefits observed with longer durations of use
- Promote use consistency
  - Toddlers; mild HL
  - Novel approaches?
- Support families to provide language-rich environments
  - Promotes cumulative auditory-linguistic experience
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