How much can my baby hear?
Quantifying speech audibility for children who are deaf or hard of hearing
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Conflict of Interest Disclosure

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Boys Town National Research Hospital

AG Bell
Impact of cumulative auditory experience: Case studies

Child A: “Hayden”
- Passed NHS
- Parents suspected hearing loss at 27 months
- Severe hearing loss by age 3

Child B: “Hugh”
- Failed twice on NHS
- Family did not initially pursue follow-up
- Severe hearing loss by age 3
## Comparison at Age 7

<table>
<thead>
<tr>
<th>Speech Production and Communication Measures</th>
<th>Below average</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goldman-Fristoe Test of Articulation</td>
<td>&lt;1 %ile</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Language Measures</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Peabody Picture Vocabulary Test - 4 (From B)</td>
<td>48 SS</td>
<td>&lt;0.1 %ile</td>
</tr>
<tr>
<td>WASI Vocabulary</td>
<td>20 T</td>
<td></td>
</tr>
<tr>
<td>CELF-4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Word Structure</td>
<td>1 Sc</td>
<td>0.1 %ile</td>
</tr>
</tbody>
</table>

**Notes:**
- Below average and average scores are indicated.
- Specific measures and their results are detailed.
- The table provides a comprehensive view of the comparison at age 7.
Duration variables

- Age of identification (by 3 months)
- Age of amplification (within 1 month of ID)
- Age of intervention (by 6 months)
Age of identification

• Earlier is better
  – Before 6 months vs. after 6 months
    (Moeller, 2000; Yoshinaga-Itano et al. 1998)

• Led to widespread adoption of universal newborn hearing screening and early intervention programs
Yoshinaga-Itano et al. 1998

Adjusted Mean Total Language Quotient

Age of Identification (Months)

0 - 6 7 - 12 13 - 18 19 - 24 25 - 34

Pure Tone Average: 63 62 80 72 64
Cognitive Quotient: 88 74 82 76 71
Moeller, 2000

Fig 2. Mean vocabulary scores plotted as a function of the two key variables, age of enrollment and family involvement ratings. The area above the horizontal dashed line represents the lower end of the average range for normal hearing students (average range is 100 ± 15). The rating 4 to 5 (filled circle) represents the highest levels of family involvement; 3 (filled triangle) represents average family involvement; 1 to 2 (open square) represents below average family involvement.
Children with cochlear implants

No audibility

Full audibility

EARS ON

EARS OFF

Time
Invariance assumption

Duration of HA use

Age of HA fitting

Duration of HA use

Age of HA fitting

Time
Prior to newborn hearing screening

- Age of amplification

Later-amplified THEN

Less hearing loss
Average age of ID
Overall – 2 years
Late group – 3.5 + years
Age at HA FIT: After UNHS

Later-amplified NOW
Early compared to pre-UNHS
Delayed onset hearing loss
Mild hearing loss
Language scores as a function of age at HA fitting

Tomblin et al., 2015
What now?

• Duration variables do not explain
• Demographic factors
  – Degree of hearing loss
  – Socioeconomic status
  – Additional disabilities?
  – Cochlear implants
  – Non-English speaking homes
Demographic Factors

- Cochlear implant
- Girls
- Milder degree of HL

- Additional disabilities
- Boys
- Greater degree of HL

Age of amplification - NS

Ching et al. 2013
Demographic Factors

Advantages
- Puts findings in context
- Target intervention?

Disadvantages
- Not malleable
- Assumes demographic groups are homogeneous
  - i.e. Girls, Mild HL, Late ID
- Send a frustrating message to parents/caregivers
What’s next?

- Auditory experience
  - Adds auditory experience: QUANTITY QUALITY
- Demographic factors
- Duration variables

OCHL builds on previous research
Findings are mixed re: relationship between audiogram and outcomes

Fitzpatrick et al., 2007
Wake et al., 2005
Delage & Tuller, 2007

Davis et al., 1986
Moeller, 2000
Ramkalawan & Davis, 1992
Gilbertson & Kamhi, 1995
Audiogram does not tell us....

How different configurations may impact speech understanding

How child will perceive speech with hearing aids (aided audibility)
Problems with degree of hearing loss
Audibility in previous studies

• Audibility is related to degree of hearing loss

• Hearing aid use is assumed to be full time

Sinninger et al. 2010
What is audibility?

• How much sound (speech) we hear
• Depends on:
  – Hearing loss
  – Distance
  – Noise
• Quantified with the Speech Intelligibility Index (SII)
SPL-o-gram SII Snapshot

For each band –

Audibility x FIW = weighted audibility

SII = Sum of weighted audibility of all frequency bands
Audibility

Aided

Unaided
Cumulative Auditory Experience
Hearing aid candidacy

• Audiogram method
Hearing aid candidacy

• Audibility method – 3 month-old
Hearing aid candidacy

- Audibility method – 10 year-old
Using audibility for hearing aid candidacy

- Children with an unaided Speech Intelligibility Index of < 80 should be considered candidates for amplification.
How do we do that?

Enter audiogram into Verifit

Observe unaided SII value for average speech
Language scores as a function of audibility

Tomblin et al., 2016

10 point difference (2/3 of a SD)
Pediatric AZBio in Quiet

1 = Normal
2 = Mild
3 = Moderate
4 = Severe

McCreery et al. in preparation
Pediatric AZBio + 6 dB SNR

1 = Normal
2 = Mild
3 = Moderate
4 = Severe

McCreery et al.
in preparation
LittlEARS
PEACH
When to move to cochlear implantation?

- Reduced or stable outcomes despite:
  - Good audibility
  - Consistent hearing aid use

- Shift in candidacy
  - Current: Audiogram
  - Future: Audibility, hearing aid use, and outcomes
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