Minimal Hearing Loss in Children: Possibilities and Limitations of Diagnostics and Hearing Aid Fittings

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Current Definitions of Minimal Hearing Loss

- **Permanent mild bilateral HL** = PTA at 0.5, 1.0, 2.0 kHz between 20 & 40 dB HL
- **Permanent high frequency HL** = PT thresholds > 25 dB HL at two or more frequencies above 2.0 kHz
- **Permanent unilateral HL** = PTA at 0.5, 1.0, 2.0 kHz >20 dB or PT thresholds >25 dB HL at two or more frequencies above 2 kHz in the affected ear

(Bess et al., 1998)
Unilateral Sensorineural Hearing Loss

Prevalence of UHL

~ 1/1000 in the newborn period (Prieve et al., 2000) and
~3/100 in the school-age population (Bess et al., 1998)
Possible Explanations for Change in Prevalence (from birth to school age)

- Progressive or late onset hearing loss
- Low follow-up rates in NBHS programs may be underestimating true prevalence (less assertive follow up for UHL)

Follow up Concerns: Unilateral to Bilateral HL

- Some unilateral losses prove to be progressive
  - Cytomegalovirus (CMV)
  - Enlarged vestibular aqueduct (EVA)
  - Hereditary progressive loss
  - Unknown causes

(Neault, 2005)
Newborn Hearing Screening Follow-Up: Factors Affecting Hearing Aid Fitting by 6 Months of Age

Figure 1 The effect of each of the seven factors on the probability of loss to follow-up. Probability of loss to follow-up is significantly increased if infants have unilateral hearing loss, coverage by Medicaid, conductive hearing loss, or late diagnosis.

Follow up Concerns: Unilateral to Bilateral HL

- Of 159 unilateral refers who were found to have HL, 64% had UHL and 36% had bilateral HL

- Two groups who move from UHL to BHL:
  - Those who had BHL at time of screening
  - Those who had UHL at time of screening but develop BHL later

(Neault, 2005)
CT Scan Findings in UHL:

- Of 18 children with unilateral sensorineural hearing loss (mild to profound) who underwent CT scans of the temporal bone, 8 (45%) had abnormal findings, including:
  - Enlarged vestibular aqueduct
  - Mondini deformity
  - Cochlear hypoplasia
  - Dysplastic vestibule and semicircular canals

The CT scan findings were abnormal BILATERALLY in 5 of the 8 children

(Licameli, Robson & Kenna, Children’s Hospital Boston)

Academic, Social, & Behavioral Outcomes
Age of Identification: UHL

Bess & Tharpe, 1986

Percent Failing at Least One Grade: UHL
Studies of Unilateral Hearing Loss

<table>
<thead>
<tr>
<th>Investigation</th>
<th>Failed (1 or more grades)</th>
<th>Resource Help (1 or more years)</th>
<th>Combined (failed and/or resource help)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bess (1986)</td>
<td>35%</td>
<td>13.3</td>
<td>48.3%</td>
</tr>
<tr>
<td>Oyler (1987)</td>
<td>27.3%</td>
<td>40.7</td>
<td>68.0%</td>
</tr>
<tr>
<td>Jensen (1988)</td>
<td>18.0%</td>
<td>36.0%</td>
<td>54.0%</td>
</tr>
<tr>
<td>Bovo et al (1988)</td>
<td>22.0%</td>
<td>12%</td>
<td>34%</td>
</tr>
<tr>
<td>Martini (1988)</td>
<td>25.0%</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>Wautier-Launey et al (1988)</td>
<td>40.4%</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>English &amp; Church (1990)</td>
<td>?</td>
<td>54%</td>
<td>?</td>
</tr>
</tbody>
</table>

Yoshinaga-Itano et al., (2008)
Sems in Hearing, 29:196-211

- 15 children with early onset permanent UHL
- Between 15-62 months
- 27% had significant language delays
Use of Vision in Deaf Individuals

- Speech reading
- Sign language
- Monitoring environment


- Used the Erikson Flanker Task to assess visual skills in deaf and normal hearing adults
- Requires participant to make judgment about a target stimulus in a fixed location when flanked by similar or dissimilar elements
Flanker task: Identify the target letter, N or H

**Compatible**

HHHHH

N H H H H

**Incompatible**

NNHNN

N N H N N

30 trials per condition

Flanker task: Identify the target letter, N or H

**Near**

**Compatible**

HHHHH

**Incompatible**

HHHHH

Flanker task: Identify the target letter, N or H

**Far**

**Compatible**

H H H H H

**Incompatible**

H H H H H
Flanker Task Study

- Deaf Group (N=10)
  - Mean age = 29.7 (18-45 years)
  - PTA > 80 dB HL bilaterally
  - Sign language was primary communication modality
- Hearing Group (N=10)
  - Mean age = 29.9 (18-45 years)
  - Hearing thresholds < 20 dB HL (500-4KHz) bilaterally
  - Not experienced sign language communicators
Possible implications…

- Allocation of visual resources over a greater area? (consistent with Proksch & Bavalier, 2002)

- Can this contribute to distractibility or other attentional factors?
Bilateral Minimal Hearing Loss

Hearing Loss in School-Age Children (3rd, 6th, & 9th grades; N=1218)  

(Bess et al., 1998)

<table>
<thead>
<tr>
<th>HL Category</th>
<th>N</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>BSNHL</td>
<td>12</td>
<td>1.0</td>
</tr>
<tr>
<td>HFSNHHL</td>
<td>17</td>
<td>1.4</td>
</tr>
<tr>
<td>CONDHL</td>
<td>41</td>
<td>3.4</td>
</tr>
<tr>
<td>OTHER</td>
<td>30</td>
<td>2.5</td>
</tr>
<tr>
<td>TOTAL</td>
<td>139</td>
<td>11.3</td>
</tr>
</tbody>
</table>

Minimal losses = 8.8 % !!!
Failure Rates of Children with MSHL & with NH (Bess et al., 1998)

- Screenining tool for functional health
- Developed at Dartmouth
- Ten different charts
**DOMAINS USED IN COOP CHARTS**

- Emotional feelings
- School work
- Social support
- Stress
- Family
- Self esteem
- Behavior
- Energy
- Getting along with others
- Overall Health

**STRESS**

During the past month, how much stress or pressure did you feel from other people? (family, friends, teachers, other grown-ups or other kids)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>None</td>
</tr>
<tr>
<td>2</td>
<td>A little</td>
</tr>
<tr>
<td>3</td>
<td>Some</td>
</tr>
<tr>
<td>4</td>
<td>Quite a bit</td>
</tr>
<tr>
<td>5</td>
<td>A lot</td>
</tr>
</tbody>
</table>
COOP Results:

- For 6th graders -
  - scores were higher (more dysfunction) for MSHL group in 9 of 10 domains
  - Significant difference found on energy domain
- For 9th graders –
  - Scores were higher for MSHL group in 9 of 10 domains
  - Significant differences found on stress and behavior domains
Listening Effort

Effort = the exertion of physical or mental power

Dual-Task Paradigm (Effort)

- Subjects
  - 14 children with mild or HF HL matched with NH children for grade level
  - Ages between 6 – 11 years

(Bourland-Hicks & Tharpe, 2002)
Dual-Task Paradigm

- Primary task: speech recognition in noise (PBK)
- Secondary task: button push to random presentations of probe light
- Reaction times were calculated for button push

No difference in baseline RTs between groups
Johnson et al., *Pediatrics* 2005

- Multi-Center study (7 centers screened 86,634 babies)
- **Purpose:** To determine estimate of children who pass UNHS when hearing loss is present
- **Design:** Follow-up children at 9 mos. of age who failed OAE, but passed A-ABR in 2-stage UNHS programs

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**Does a 2-stage (OAE/AABR) newborn hearing screening protocol miss babies with mild hearing loss?**

- **OAE Screening Prior to Hospital Discharge**
  - Pass
  - Discharge

- **AABR Screening**
  - Fail

- **Comprehensive Hearing Evaluation Before 6 Months of Age**
  - Fail

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**Study Sample**
- Comprehensive Audiological Assessment at 8-12 months of age
Johnson et al., 2005

Conclusions:
- ~23% of all infants with PHL ≥ 25 dB will not be identified by a 2-stage screen
- The majority of those not identified will have mild hearing loss (>70% in this study)
- Not known what proportion of PHL was congenital vs. late-onset
- A-ABR equipment was designed to identify moderate or greater bilateral HL
Hearing Technology Options for UHL & MBHL

- Traditional hearing aids
- Contralateral Routing of Signal (CROS) hearing aids
- Frequency modulated (FM) systems

Traditional Hearing Aids for UHL

- Unaidable hearing
  - Profound SNHL
  - Very poor word recognition
  - Marked intolerance for amplified sounds

(Valente et al., 2002)
Traditional Hearing Aids for UHL

- Binaural interference - decrease in bilateral performance when an individual is receiving asymmetric auditory input (Jerger et al, 1993)
- Evidence of BI for adults, but not children, when listening to asymmetrically degraded speech (Rothpletz et al, 2004)
- No binaural advantage when listening to asymmetrically-degraded speech (Rothpletz et al, 2004)
CROS HAs for UHL

- CROS HAs are considered for those ineligible for other technology
- CROS HAs are not recommended for consideration until child is able to control his/her communication environment (AAA, 2003; Kenworthy et al., 1990)
- Useful for children who do not have access to FM or need assistance outside of school

Transcranial CROS Aids

- Quasi-transcranial – high level AC signal creates vibration of skull to stimulate opposite ear
- True transcranial – BC signal is transmitted from poor ear to opposite normal cochlea (eg, BAHA)
- BAHA can be considered at age 5 years and above; however, data from the pediatric population are lacking (AAA, 2003)
Traditional HAs for Infants & Young Children with MBHL

- Will have large RECDs leaving only a few dB recommended gain across frequencies
- Consider acoustic modifications, shorter speaker-listener distance, and increased voice volume
- Counsel regarding need for amplification as RECD decreases
- Consider noise floor of HAs – typically not heard by those with greater degrees of HL

When to fit minimal losses?

Babies are usually at a close distance to the caregiver allowing for an optimal signal-to-noise ratio
After 12 months, they venture off…

FM Fitting with MBHL or UHL: The Problem

- Need for enhanced signal from teacher
- Need for communication with fellow students
  - Classroom discussions
  - Question/answer sessions
  - Other group or social interactions
Study Design

- **Equipment**
  - Phonak MicroEar
  - Sound delivery options
    - Skeleton mold
    - Open mold
- **Configuration**
  - monaural fitting
  - bilateral fitting

(Tharpe, Ricketts, Sladen, 2004)

Study Design

- **Schedule**
  - baseline testing
  - 2 week acclimatization with each device followed by testing
  - Total of 6 weeks

(Tharpe, Ricketts, Sladen, 2004)
Loudspeaker Placement

0°
180°
90°
270°
135°
225°

FM
Summary of HINT Results:

- Significant improvement in FM vs. No-FM condition
- No effect of “teacher” location
- On average, 2 dB advantage with skeleton vs. open EM in monaural condition
- On average, 2.2 dB binaural advantage

(Tharpe, Ricketts, Sladen, 2004)
Centers for Disease Control & Prevention Workshop Proceedings (2005)

Summarizes
- presentations &
- breakout group discussions
- future research needs

Online Literature Review
- Includes summary tables (by topic)
- Over 100 articles
- All available on the CDC EHDI website:
  www.cdc.gov/ncbddd/ehdi/

Thank You!
- Dan Ashmead
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