Simulating Hearing Loss in Children

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Previous Studies in Adults

- **Purpose**
  - Examine the deficits associated with hearing loss in addition to elevated thresholds
    - Spectral and temporal resolution
  - Explore the possibility of using normal-hearing adults as models for hearing loss

- **Equivocal results**
  - HI < SIM, HI = SIM, HI > SIM
Rationale

#1 Interaction of hearing loss and developmental age

The whole is greater than the sum of the parts
Influence of Hearing loss on the Perceptual Weighting Strategies of Children and Adults

Rationale

#1 Interaction of hearing loss and developmental age

#2 Configuration of hearing loss
Configuration of Hearing loss

Pittman & Stelmachowicz (2003) *Ear & Hearing*

60-year-old
Adults (n=248)

6-year-old
Children (n=227)
Configuration of Hearing loss

Pittman & Stelmachowicz (2003) *Ear & Hearing*

**Adults (n=248)**

![Graph showing hearing loss configuration]

- **Sloping U-shaped**: 73%
- **Flat**: 8%
- **Other**: 19%

Frequency (Hz)

<table>
<thead>
<tr>
<th></th>
<th>250</th>
<th>500</th>
<th>1000</th>
<th>2000</th>
<th>4000</th>
<th>8000</th>
</tr>
</thead>
<tbody>
<tr>
<td>dB HL</td>
<td>-20</td>
<td>0</td>
<td>20</td>
<td>40</td>
<td>60</td>
<td>80</td>
</tr>
</tbody>
</table>

Hearing Level (dB HL)
Configuration of Hearing loss
Pittman & Stelmachowicz (2003) *Ear & Hearing*

Children (n=227)

- **Other**: 23%
- **Rising**: 6%
- **U-Shaped**: 20%
- **Sloping**: 33%
- **Flat**: 18%

Frequency (Hz)

250 500 1000 2000 4000 8000
Rationale

#1 Interaction of hearing loss and developmental age
#2 Configuration of hearing loss
#3 Heterogeneity of children with hearing loss
Rationale #3…

- Intrinsic heterogeneity
  - Factors inherent to the child
- Extrinsic heterogeneity
  - Factors imposed on the child
Heterogeneity of HI Children

Intrinsic Heterogeneity
- Chronological age
- IQ/Cognitive capacity
- Age at onset of hearing loss
- Degree of hearing loss
- Configuration of hearing loss
- Etiology of hearing loss
- Other handicapping conditions

Extrinsic Heterogeneity
- Age at identification
- Age at amplification
- Type of amplification
- Consistency of hearing aid use
- Use of supplemental devices (FM system)
- Age at intervention
- Duration of intervention
- Quality of intervention
- Parental involvement
- Socioeconomic status
- Mono vs. bilingual language learner
For example...

- Amplification adjusted regularly
- Hearing loss identified
- Amplification fitted
- Home-based Intervention
- Preschool Intervention
- Enter Elementary School
- Poor vocabulary
- Poor attention in class
- Poor social skills
- Etc.

Age (years): 0 1 2 3 4 5 6 7
For Example...
For Example...
For Example…
For Example…
For Example...
Cumulative Effects of Hearing Loss
Immediate Effects of Hearing Loss

Cumulative Effects of Hearing Loss

Word Recognition Score (% Correct)

Presentation Level (dB HL)
Methods for Simulating Hearing Loss (in adults)

- Chemical (not appropriate for children)
  - Acetaminophen
  - Quinine

- Filtering
  - Manipulating the sensation level of the speech signal relative to threshold

- Masking
  - Elevating threshold through the use of frequency-shaped broadband noise
Simulation - Filtering

![Graph showing sound pressure level in dB against frequency in kHz. The graph indicates different thresholds for speech and hearing.]
Simulation - Filtering

![Graph showing sound pressure level (dB) vs frequency (kHz)]
Simulation - Masking

![Graph showing target hearing thresholds, quiet hearing thresholds, and masking noise across different frequency bands (0.25 kHz to 8 kHz).](image-url)
Simulation - Masking

![Graph showing sound pressure level (dB) against frequency (kHz). The graph includes two curves: one for speech and another for target hearing thresholds. The x-axis represents frequency in kHz, ranging from 0.25 to 8 kHz, and the y-axis represents sound pressure level in dB, ranging from 0 to 120 dB. The speech curve starts higher and decreases more rapidly than the target hearing threshold curve.]
Simulating Hearing Loss in Children
Pittman, Vincent, Carter (in process)

- **Purpose**
  - Determine whether or not children with normal hearing can respond reliably in a broadband noise.
  - Examine the short- and long-term effects of hearing loss on speech perception.
Method

- **Subjects**
  - 4 HI children (8 to 12 yrs of age)
  - 10 NH children (8 to 12 yrs of age)
    - 2 to 3 NH children were matched to each HI child (vocabulary or chronological age)

- **Stimuli**
  - Four-word sentences of varying predictability
    - High – grammatically & semantically correct
    - Low – grammatically correct & semantically anomalous
Method

Listening Conditions

- HI Children
  - Stimuli were frequency shaped according to DSL for average conversational speech
  - Five presentation levels
  - 5 dB steps

- NH Children
  - Same listening conditions
  - Masked & Filtered
Method

**Masking**

- Frequency (kHz): 250, 500, 1000, 2000, 4000, 8000
- Sound Pressure Level (dB): 0, 20, 40, 60, 80, 100

**Filtering**

- Frequency (kHz): 250, 500, 1000, 2000, 4000, 8000
- Sound Pressure Level (dB): 0, 20, 40, 60, 80, 100
Results

Masked Thresholds

- Present study
  - RMS error 2.3-6.9 dB
  - 20 minutes
- Humes et al. (1987)
  - RMS error 2.2-6.1 dB
  - 2 hours (equivalent)
Results

- Flat Hearing Losses
Simulating Hearing Loss in Children

Pittman, Vincent, Carter (in process)

- Flat Hearing Losses

The best we can expect from a child given the reduced sensation level reflects the immediate effects of hearing loss on speech perception. Reflects the long-term effects of hearing loss on speech perception.
Simulating Hearing Loss in Children
Pittman, Vincent, Carter (in process)

- High-Frequency Hearing Losses

![Diagram showing word recognition vs. speech intelligibility index for high and low predictability conditions.](image)
Simulating Hearing Loss in Children

Pittman, Vincent, Carter (in process)

- **High-Frequency Hearing Losses**

  The best we can expect from a child given the reduced sensation level reflects the immediate effects of hearing loss on speech perception.

  Reflects the long-term effects of hearing loss on speech perception.
Conclusions

- Hearing loss can be simulated as reliably in children as it is in adults.
- Like adults, the speech perception of HI children can be better, the same, or worse than that of NH children.
  - The relative performance of the HI children compared to the NH children may indicate the degree to which they were able to adjust to their hearing loss.
  - The ability to adjust to the hearing loss may be related to the configuration of loss.
Some last thoughts…

- In the future, simulating hearing loss may
  - Provide insight into the short-term and long-term effects of hearing loss
    - Both good and bad
  - Provide a method with which to optimize intervention for children
    - Amplification
...and a commercial.

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