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
  - e.g., poor 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 development

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

![Graph showing performance vs. audibility](image_url)
Rapid Word-Learning in Normal-Hearing and Hearing-Impaired Children

Pittman, Lewis, Hoover, & Stelmachowicz (2005) *Ear and Hearing*
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)

Frequency (Hz)

-20 0 20 40 60 80 100 120 140

Hearing Level (dB HL)

250 500 1000 2000 4000 8000

6-year-old
Children (n=227)

Frequency (Hz)

-20 0 20 40 60 80 100 120 140

Hearing Level (dB HL)

250 500 1000 2000 4000 8000
Configuration of Hearing loss
Pittman & Stelmachowicz (2003) *Ear & Hearing*

Adults (n=248)

Frequency (Hz)
250 500 1000 2000 4000 8000

Other 19%
Flat 8%
Sloping U-shaped 73%
Configuration of Hearing loss

Pittman & Stelmachowicz (2003) Ear & Hearing

Children (n=227)

Frequency (Hz)

250 500 1000 2000 4000 8000

-20 0 20 40 60 80 100 120 140

- Other (23%)
- Sloping (33%)
- Rising (6%)
- U-Shaped (20%)
- Flat (18%)
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
- Gender
- Chronological age
- Intelligence
- 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

- Amplification fitted
- Home-based Intervention
- Preschool Intervention

- 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…

![Bar graph showing word recognition score (% correct) vs. presentation level (dB HL).](image-url)
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)

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

- Masking
  - Elevate threshold using frequency-shaped broadband noise
Simulation - Filtering

![Graph showing hearing thresholds over frequency.](image)

Hearing Thresholds
Simulation - Masking

The graph illustrates the relationship between sound pressure level (dB) and frequency (kHz) for different hearing thresholds. The graph shows:

- **Target Hearing Thresholds**:
  - Frequencies range from 0.25 kHz to 8 kHz.
  - Threshold levels range from 0 dB to 120 dB.

- **Masking Noise**:
  - Frequency range from 0.25 kHz to 8 kHz.
  - Threshold levels are generally higher than the target hearing thresholds.

- **Quiet Hearing Thresholds**:
  - Frequency range from 0.25 kHz to 8 kHz.
  - Threshold levels are significantly lower than the masking noise levels.

The graph highlights the importance of masking noise in understanding hearing thresholds across different frequencies.
Simulation - Masking

- Target Hearing Thresholds

- Speech

Sound Pressure Level (dB)

Frequency (kHz)
Simulating Hearing Loss in Children
Pittman, Vincent, Carter

Purpose

- Determine whether or not children with normal hearing can respond reliably in a broadband noise.
- Estimate the contribution of the immediate and cumulative effects of hearing loss on speech perception.
Method

- Subjects
  - 4 HI children
    - 8 to 10 yrs of age
  - 10 NH children
    - 8 to 10 yrs of age
    - 2 to 3 NH children were matched to each HI child (vocabulary or chronological age)
Method – Pure Tone Thresholds

- **Listening Conditions**
  - Single interval response paradigm
  - Decision rule = 71% on psychometric function
  - HI children
    - Quiet
  - NH Children
    - Continuous masking noise
Method – Speech Perception

- Listening Conditions
  - Stimuli were frequency shaped according to DSL m[i/o] DLL 5.0 for average conversational speech
  - 5 presentation levels
  - 5 dB steps
  - HI Children
    - Quiet
  - NH Children
    - Masked & Filtered
Method – Speech Perception

Masking

Filtering

Sound Pressure Level (dB)

Frequency (kHz)

Frequency (kHz)
Method – Speech Perception

Stimuli

- Four-word sentences of varying predictability
  - High – grammatically & semantically correct
    - “Pick up this room”
    - “Blue planes fly far.”
  - Low – grammatically correct & semantically anomalous
    - “Quick books look bright.”
    - “Cats get good boats.”
Results – Pure Tone 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
Results

- Flat Hearing Losses

Best performance for these stimuli (re: reduced sensation levels)

Reflects the immediate effects of hearing loss on speech perception

Reflects the cumulative effects of hearing loss on speech perception
Results

- High-Frequency Hearing Losses
Results

- **High-Frequency Hearing Losses**

  Best performance for these stimuli (re: reduced sensation levels)

  Reflects the immediate effects of hearing loss on speech perception

  Reflects the cumulative effects of hearing loss on speech perception
Intrinsic Heterogeneity
Chronological age
Configuration of hearing loss
Vocabulary Age
Application

Extrinsic Heterogeneity

Hearing History

Twins

DETERIORATION

SIMULATED LOSS

RECOVERY/ADJUSTMENT

Word Recognition Score (% Correct)

Speech Intelligibility Index

0.3
Application

HIGH PREDICTABILITY

LOW PREDICTABILITY

WORD RECOGNITION (% CORRECT)

0.00 0.10 0.20 0.30 0.40 0.50
SPEECH INTELLIGIBILITY INDEX

HIC
O MASKING
△ FILTERING
Application

![Graph showing word recognition and speech intelligibility index. Two graphs: High Predictability and Low Predictability. The x-axis represents Speech Intelligibility Index, and the y-axis represents Word Recognition (% Correct). Two sets of data points are shown: NH SIB and HI SIB.]
Conclusions

- Hearing loss can be simulated as reliably in children as it is in adults.
- Like adults, the speech perception of HI children is better, the same, or worse than that of NH children with simulated losses.
  - Pattern of performance may reflect long-term adjustment to hearing loss.
  - Preliminary data suggest both intrinsic and extrinsic factors contribute to performance.
In the Future

- Simulating hearing loss in children may...
  - be useful for determining the relative contributions of the factors associated with hearing loss
  - provide a method with which to optimize amplification for children
Thank you