Simulating Hearing Loss in Children

Andrea Pittman, PhD CCC-A
Kendell Vincent
Leah Carter
Arizona State University

Previous Studies in Adults

Humes, Dirks, Bell, Kincaid (1987), Fabry & Van Tassell (1986), Needleman & Crandell (1995), Dubno & Schaefer (1992, 1995)

- 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

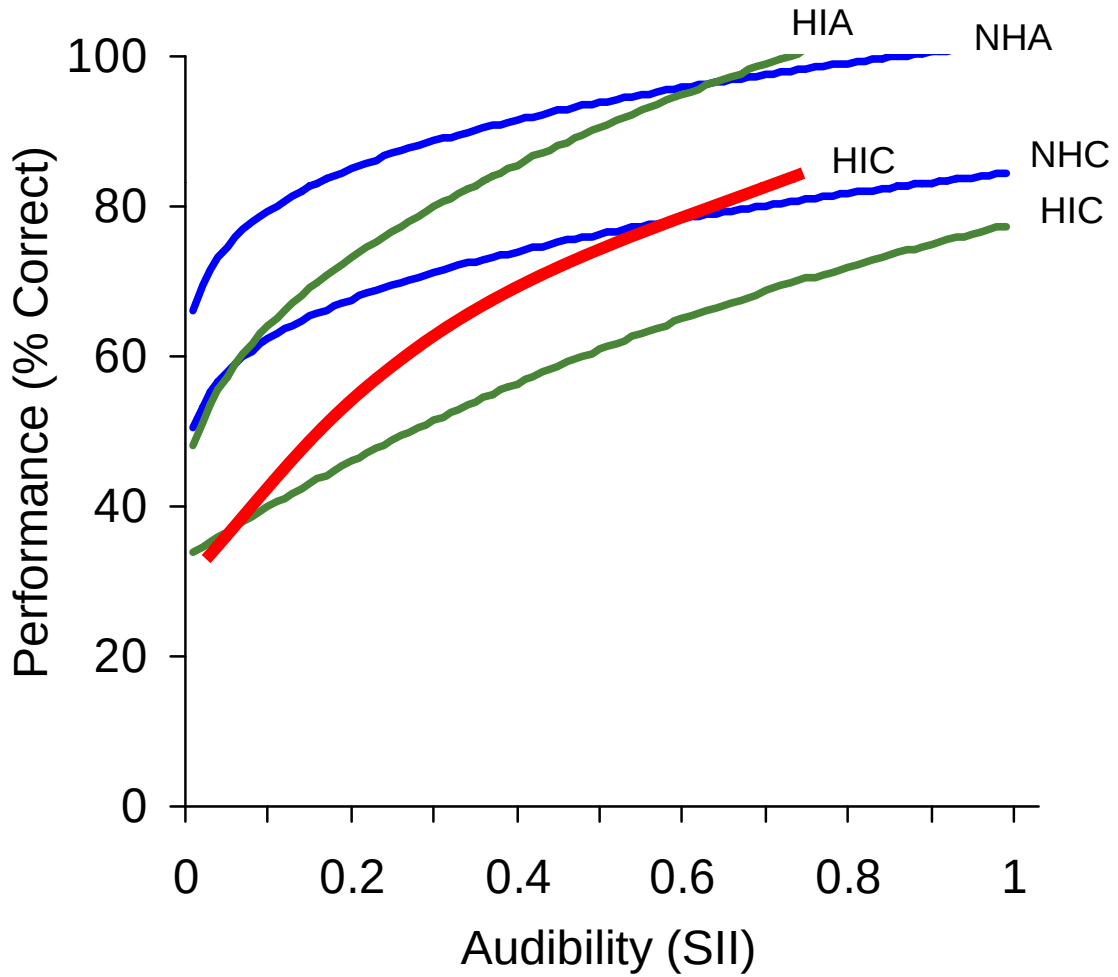
Rationale

#1 Interaction of hearing loss and development

The whole is greater than the sum of the parts.

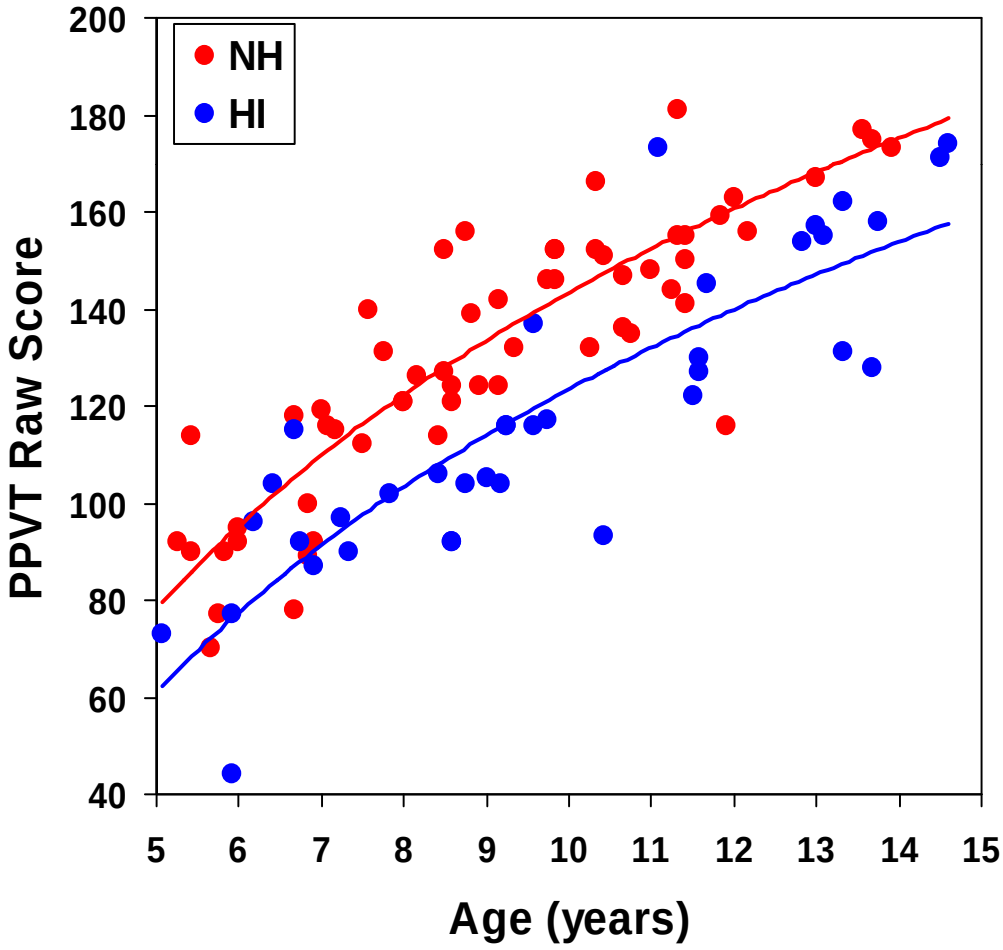
Influence of Hearing loss on the Perceptual Weighting Strategies of Children and Adults

Pittman, Stelmachowicz, Lewis & Hoover (2002) J*r of Sp Lang & Hear Res*



Rapid Word-Learning in Normal-Hearing and Hearing-Impaired Children

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



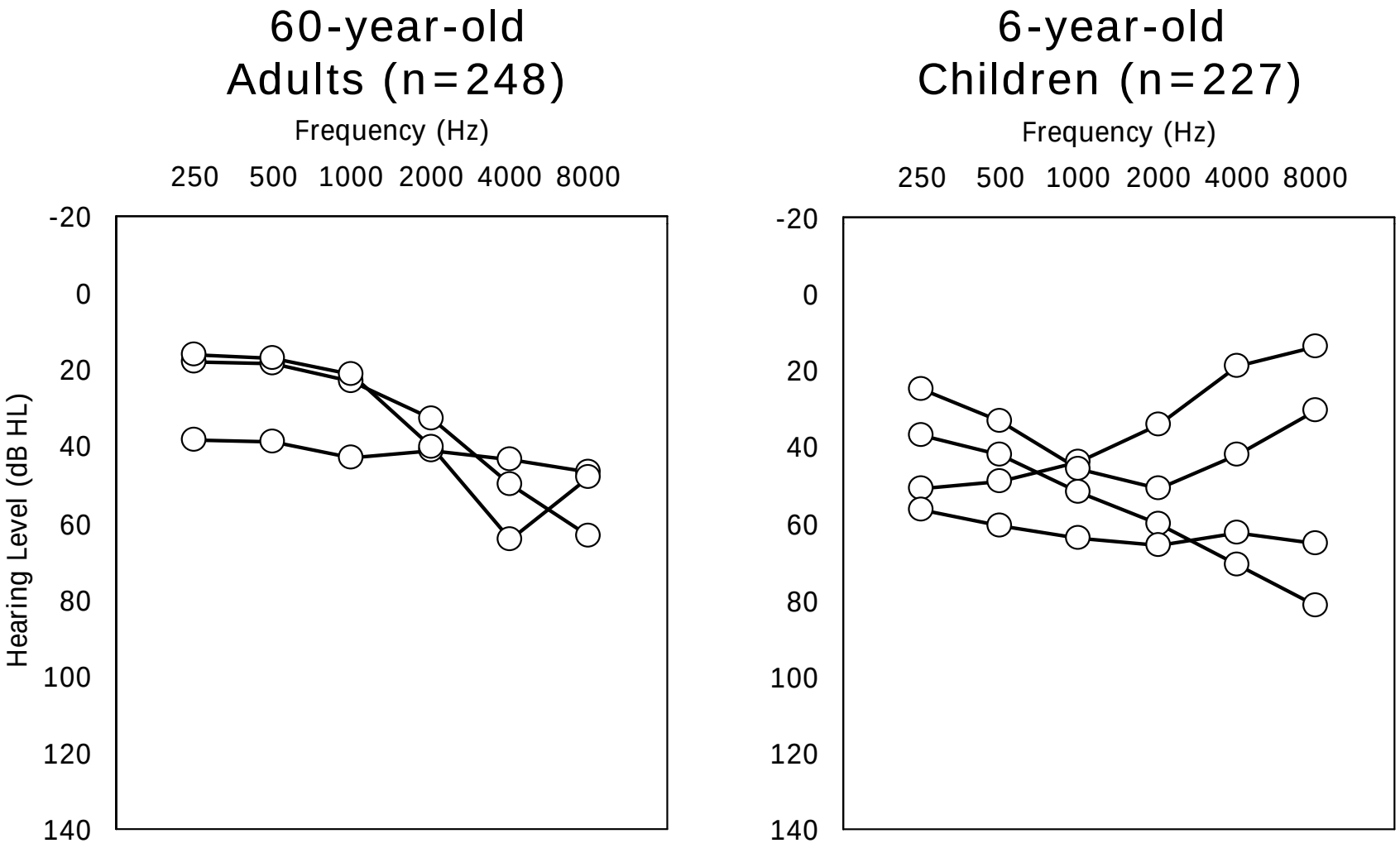
Rationale

#1 Interaction of hearing loss and developmental age

#2 Configuration of hearing loss

Configuration of Hearing loss

Pittman & Stelmachowicz (2003) *Ear & Hearing*



Configuration of Hearing loss

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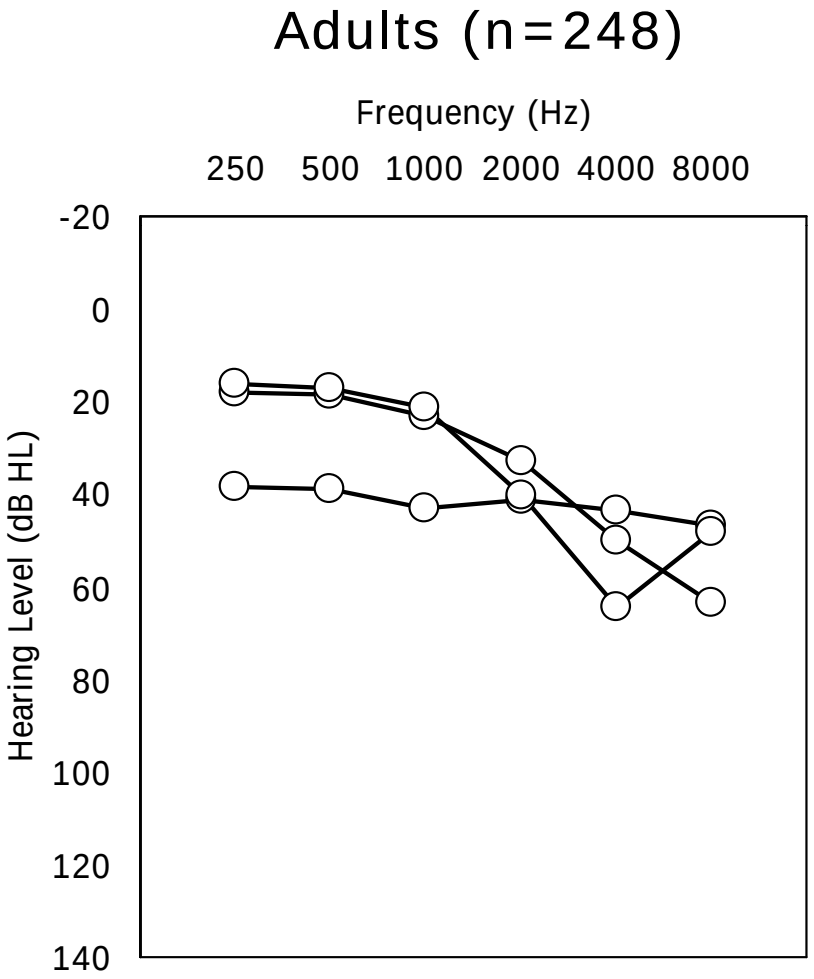

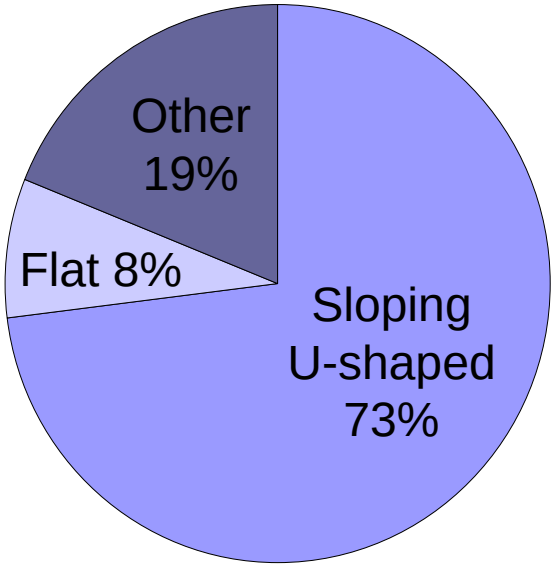

Configuration of Hearing loss

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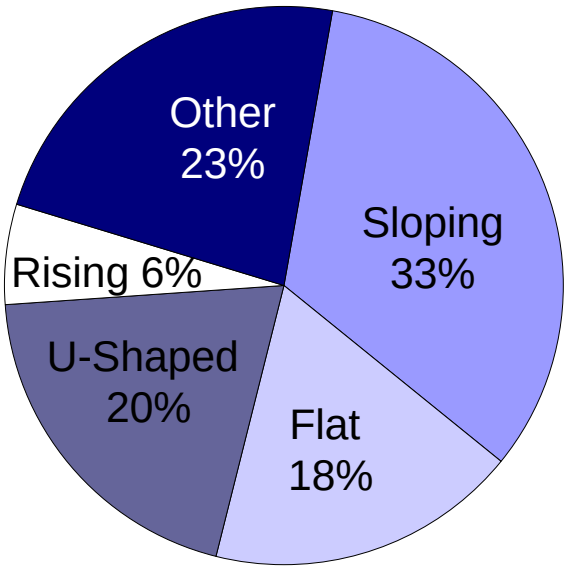
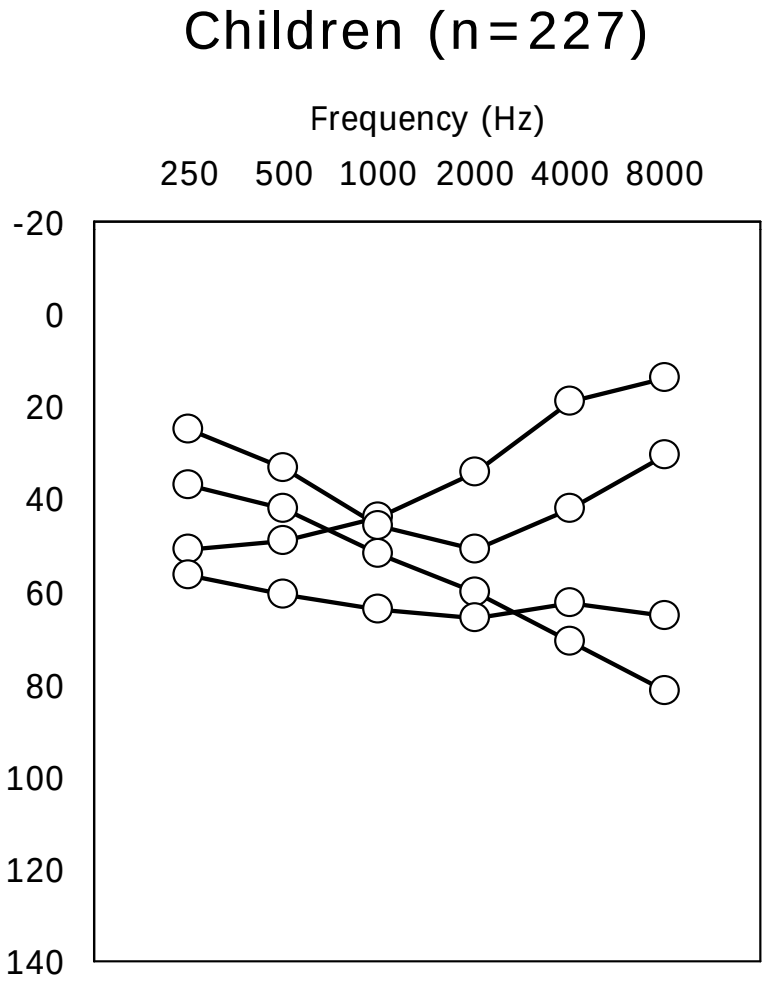




Rationale

#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

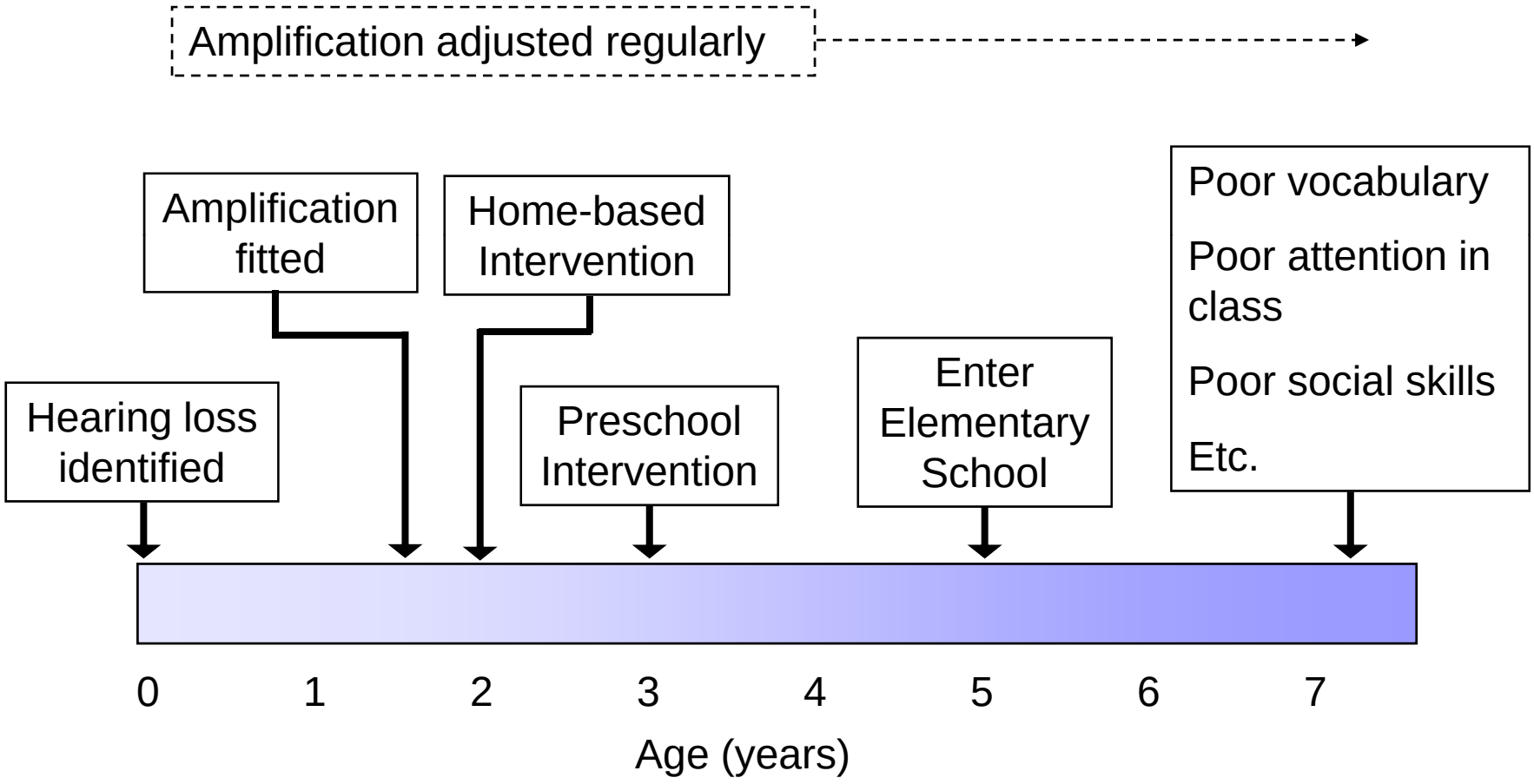
Intrinsic Heterogeneity

- 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

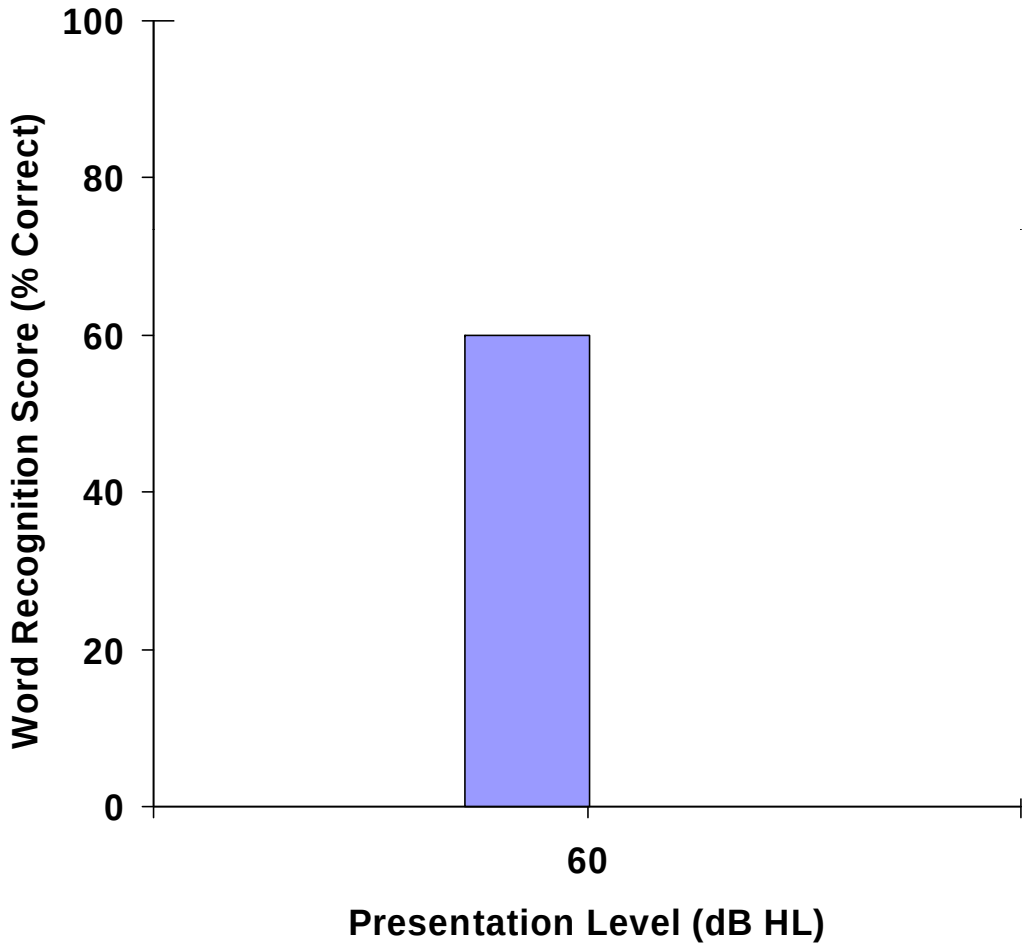
Extrinsic Heterogeneity

- 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

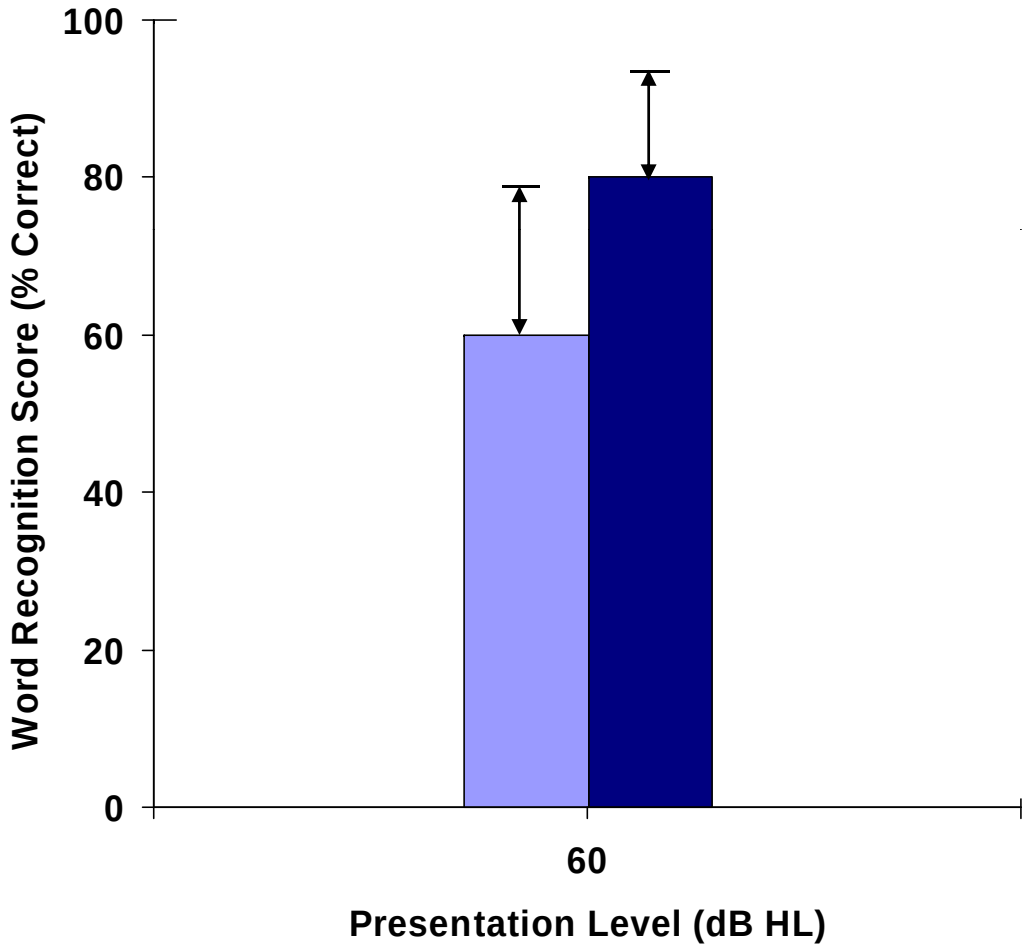
For example…


Amplification adjusted regularly
Amplification fitted
Home-based Intervention
Poor vocabulary
Poor attention in class
Poor social skills
Etc.
Hearing loss identified
Preschool Intervention
Enter Elementary School
0
1
2
3
4
5
6
7
Age (years)

For Example…


100
80
60
40
20
0
Word Recognition Score (% Correct)
60
Presentation Level (dB HL)

For Example…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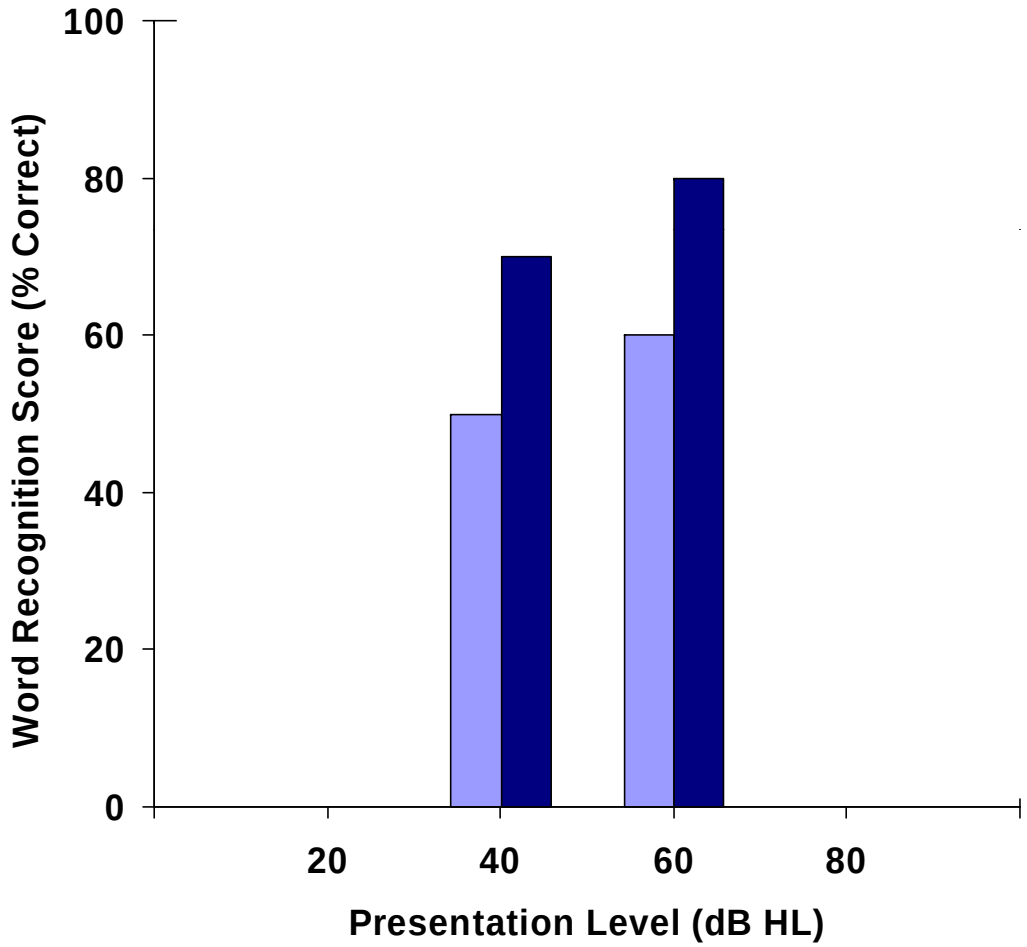
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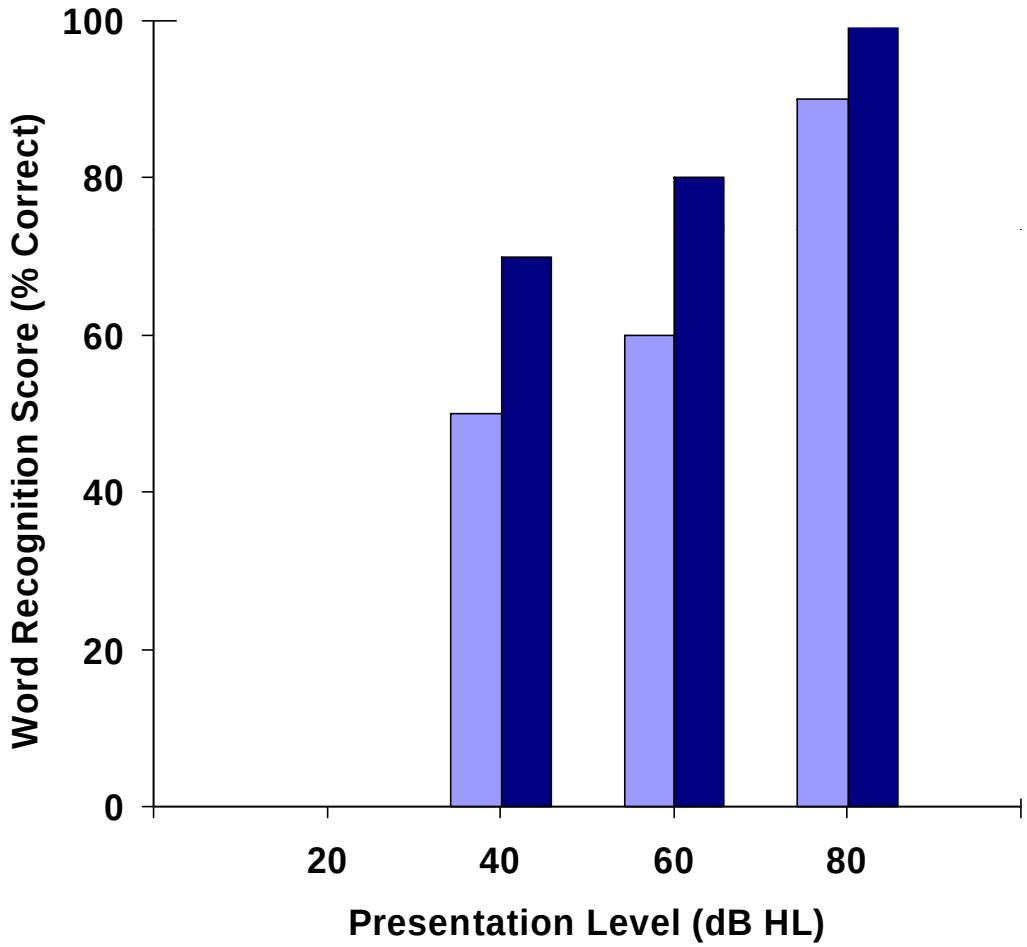
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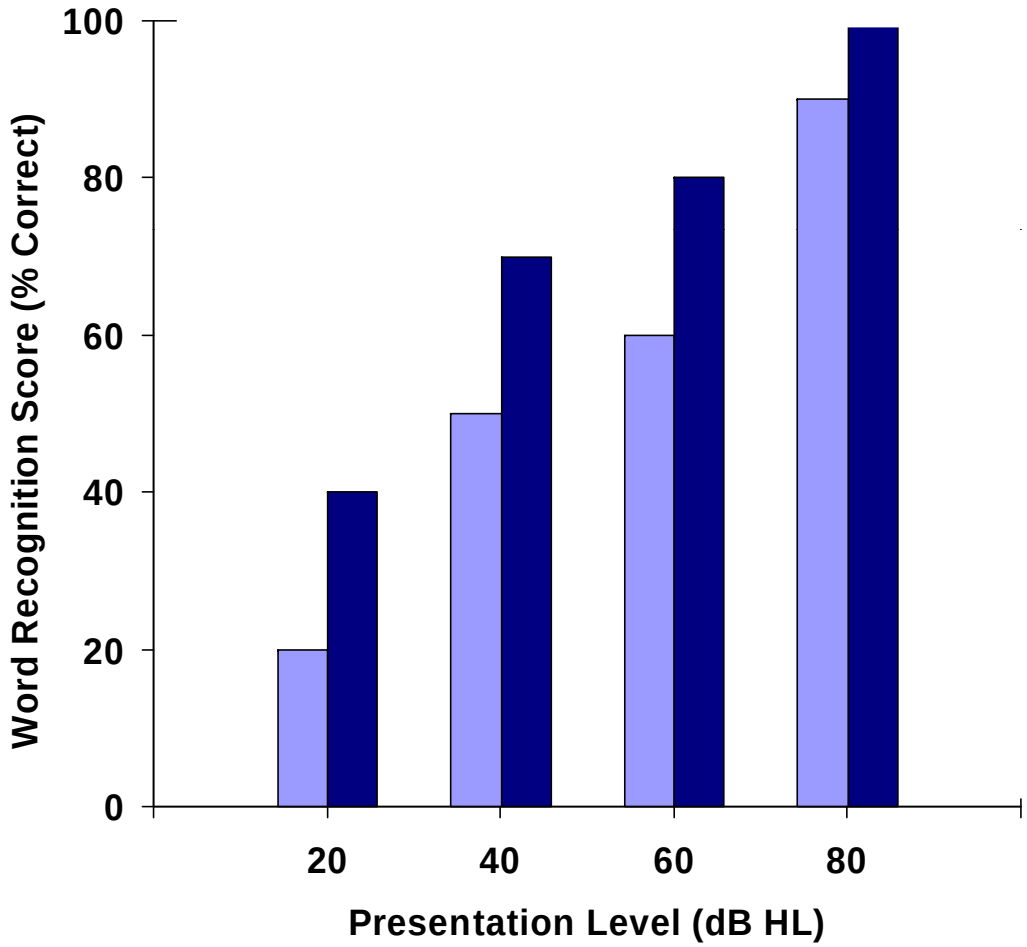
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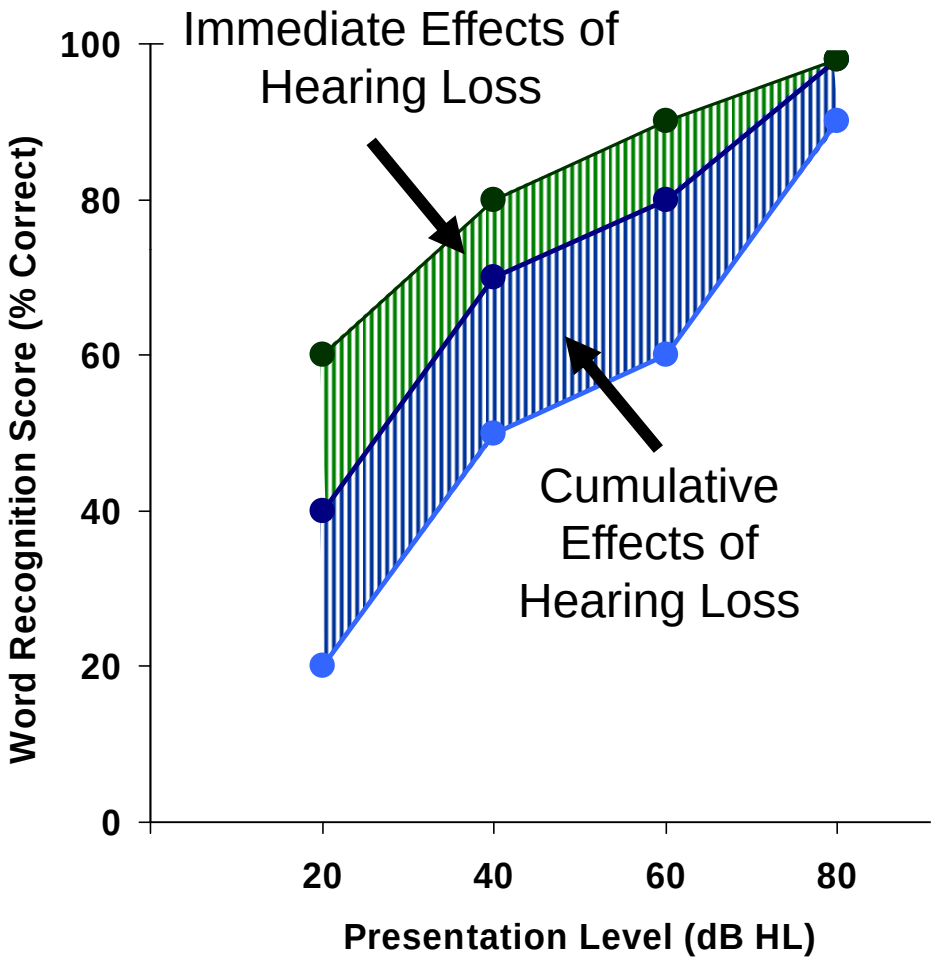
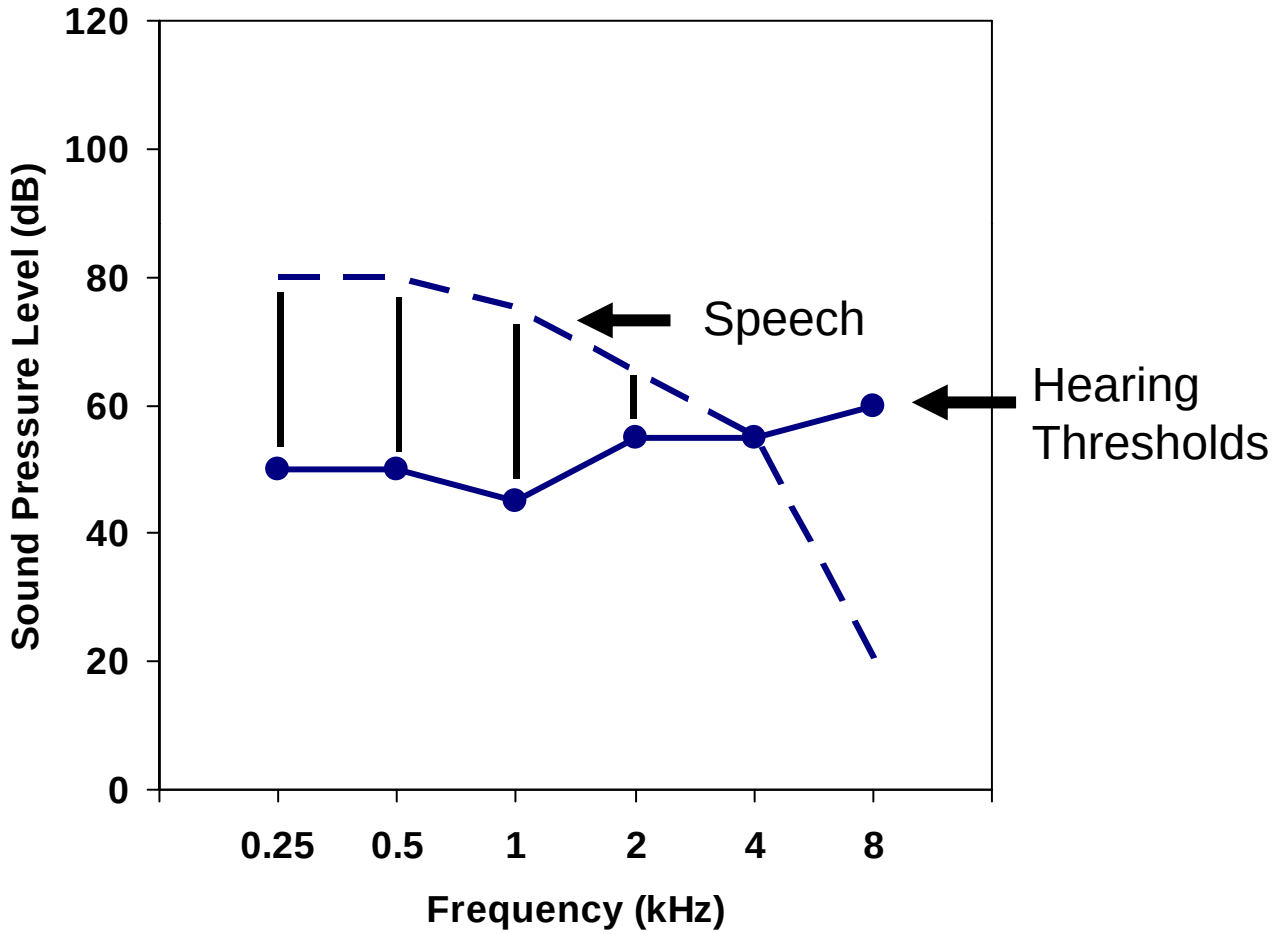

Immediate Effects of Hearing Loss
Cumulative Effects of Hearing Loss
Word Recognition Score (% Correct)
100
80
60
40
20
0
20
40
60
80
Presentation Level (dB HL)

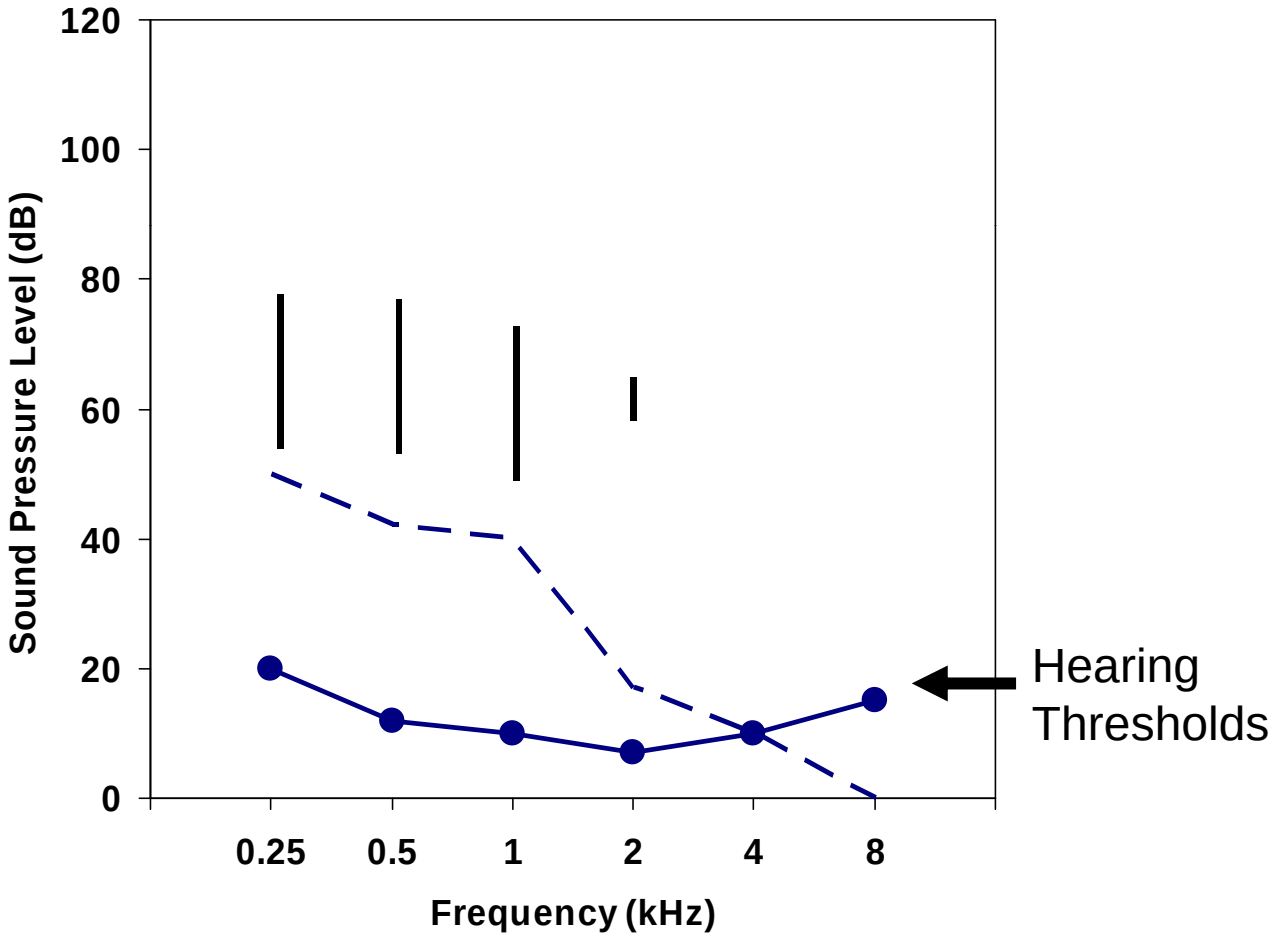
Methods for Simulating Hearing Loss (in adults)

- Filtering
  - Adjust the sensation level of the speech signal relative to threshold
- Masking
  - Elevate threshold using frequency-shaped broadband noise

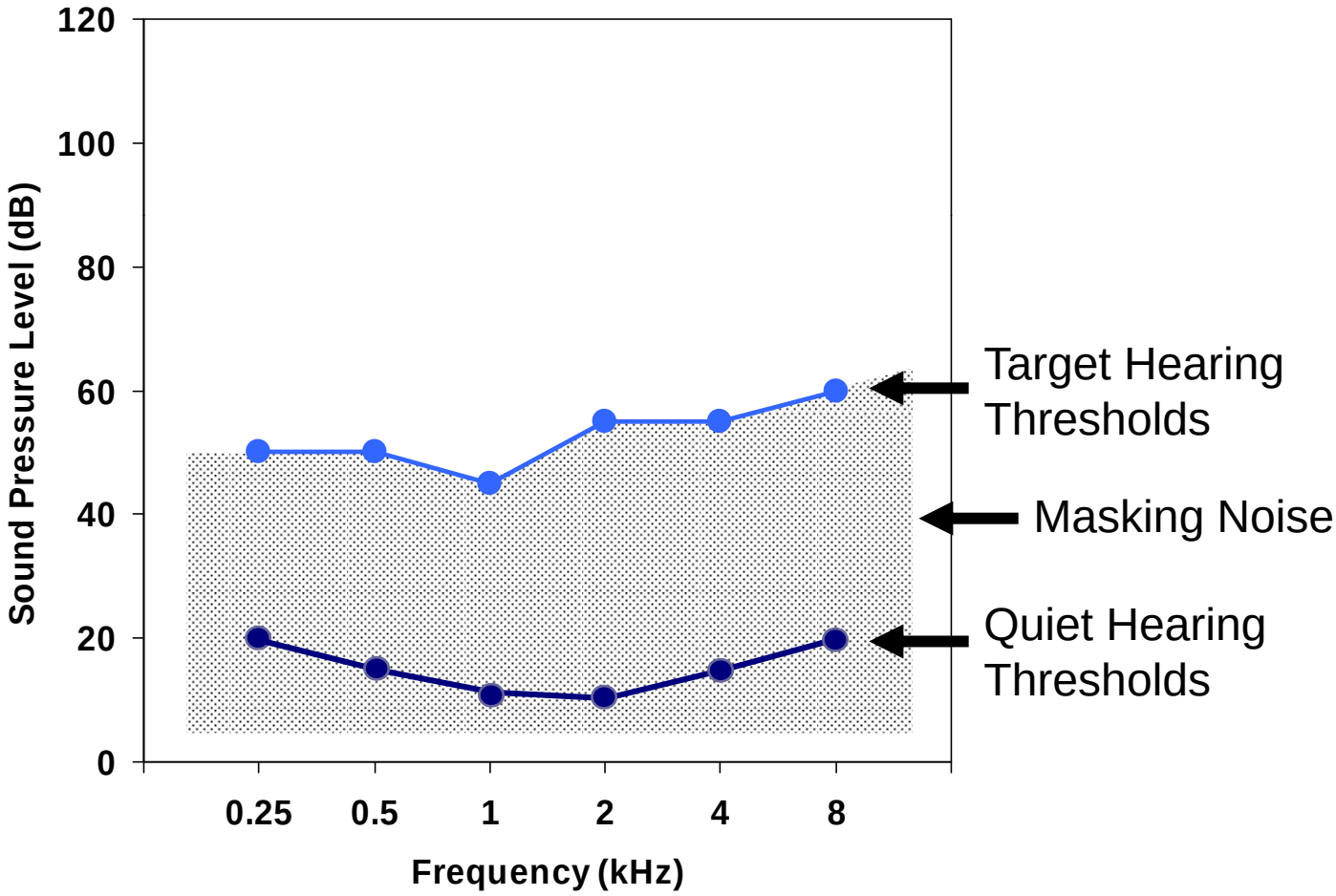
Simulation - Filtering



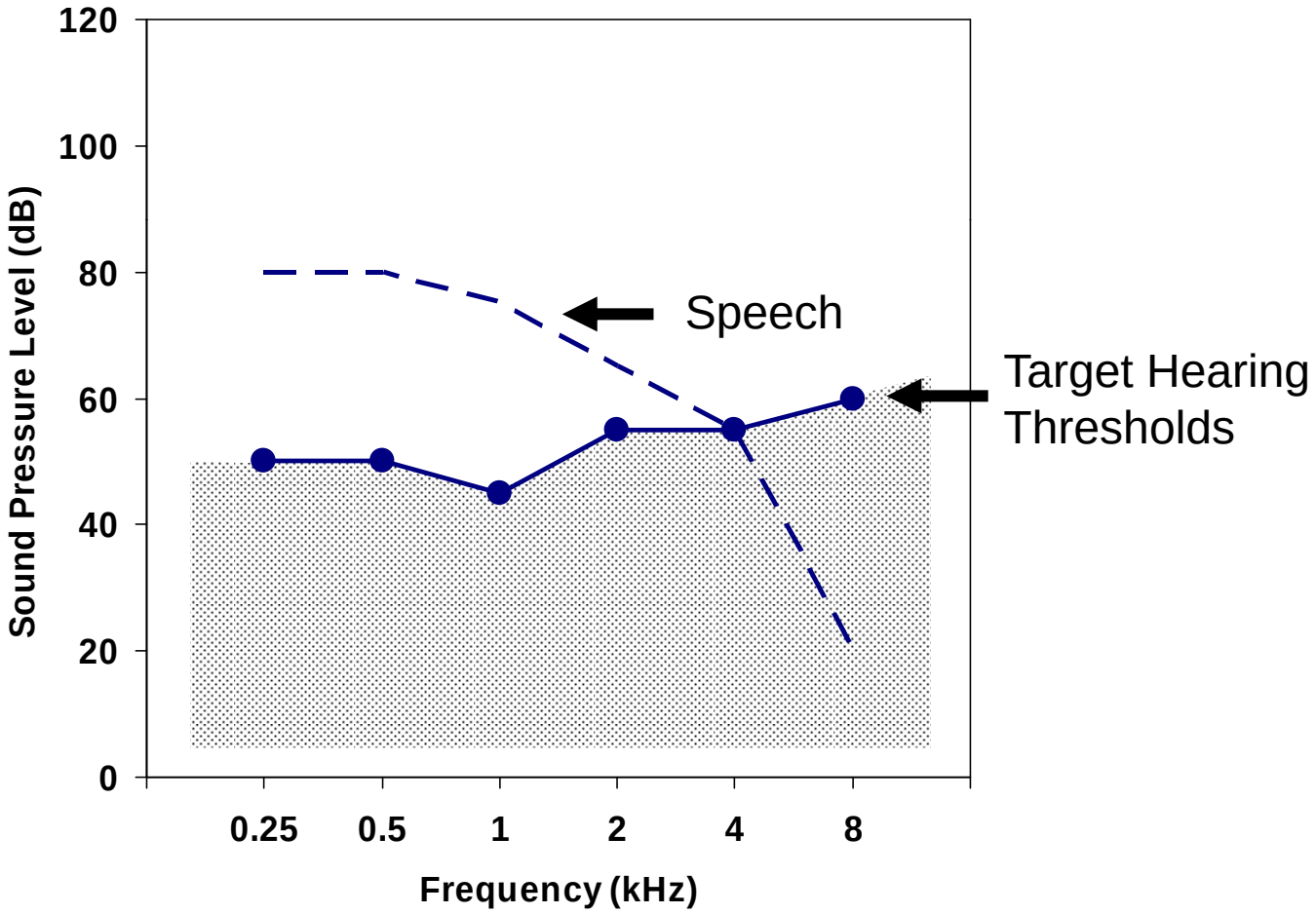
Simulation - Filtering



Simulation - Masking



Simulation - Masking



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)

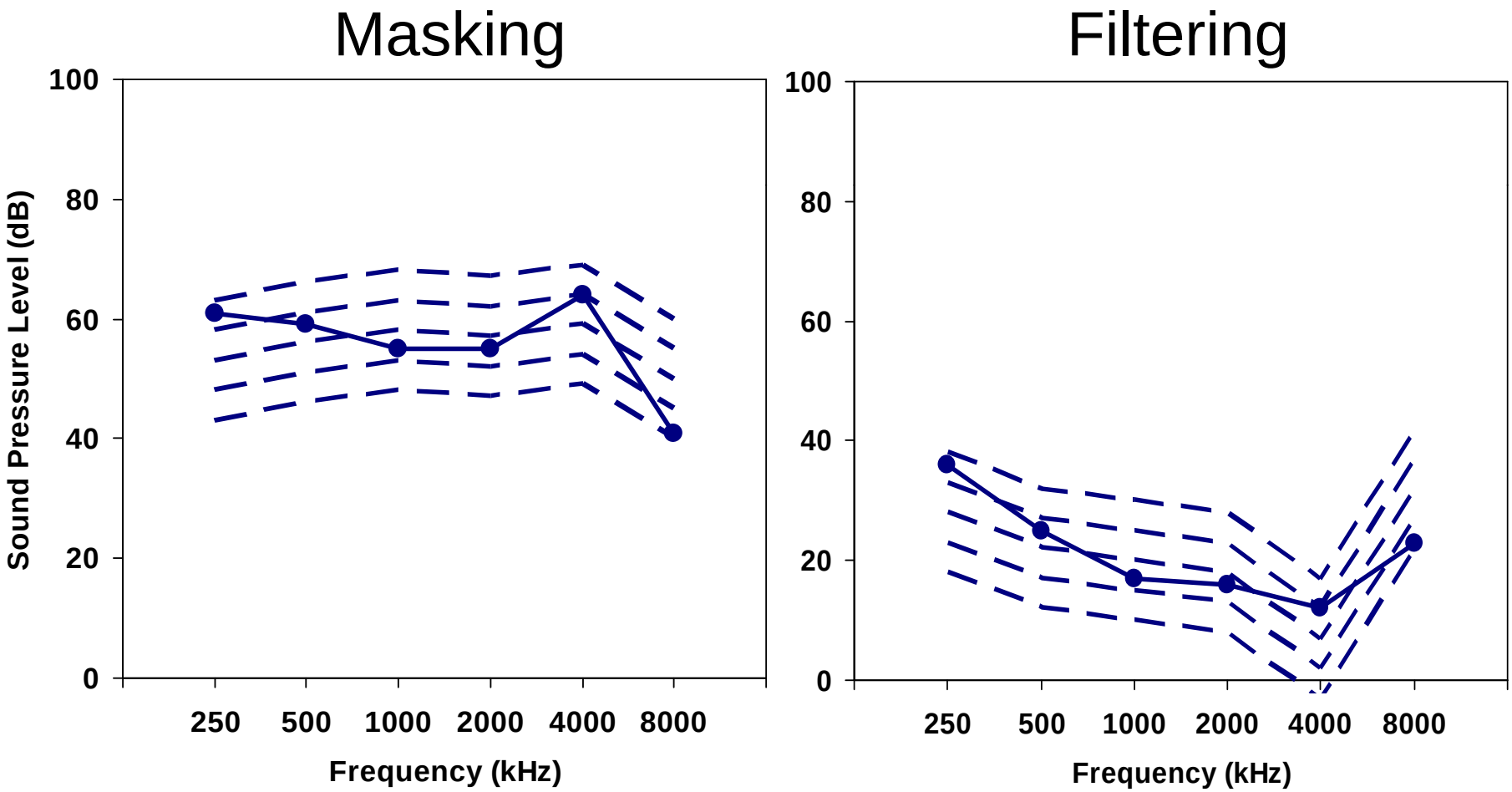
Method – Pure Tone Thresholds

- 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

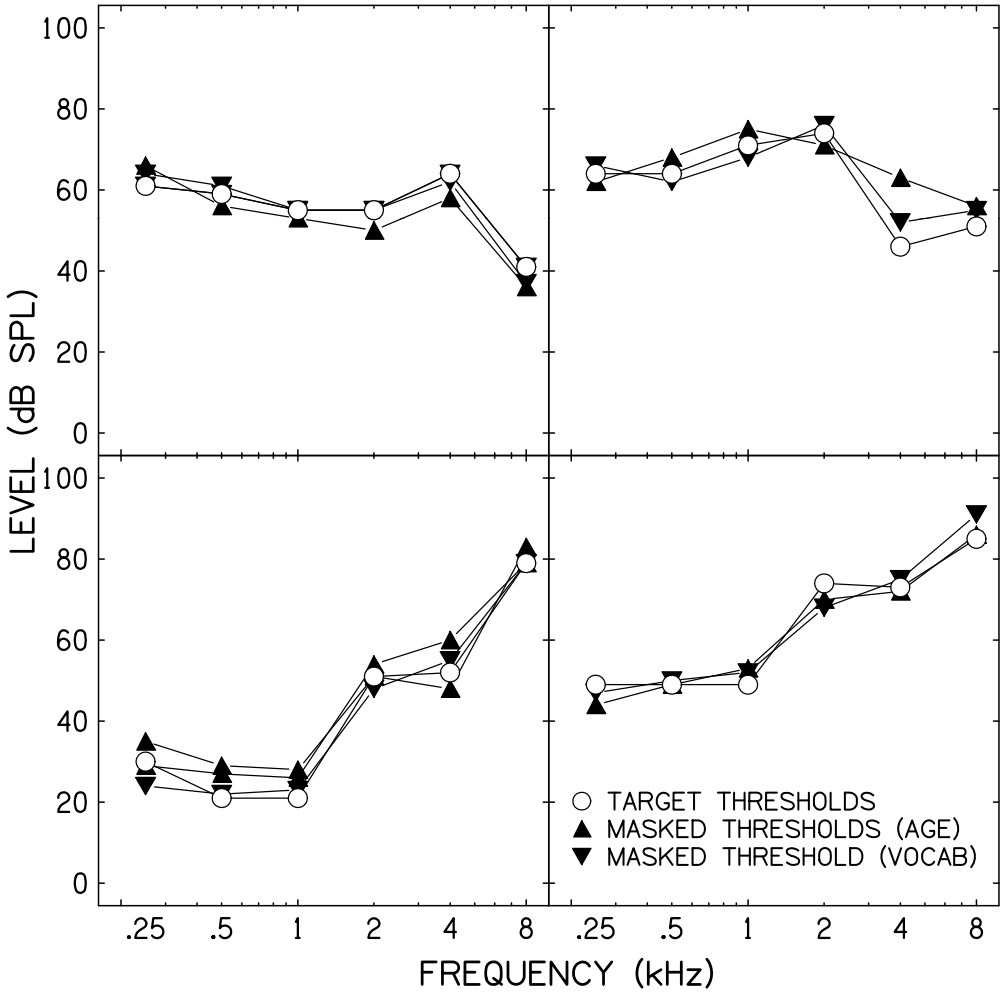


Method – Speech Perception

- 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.”

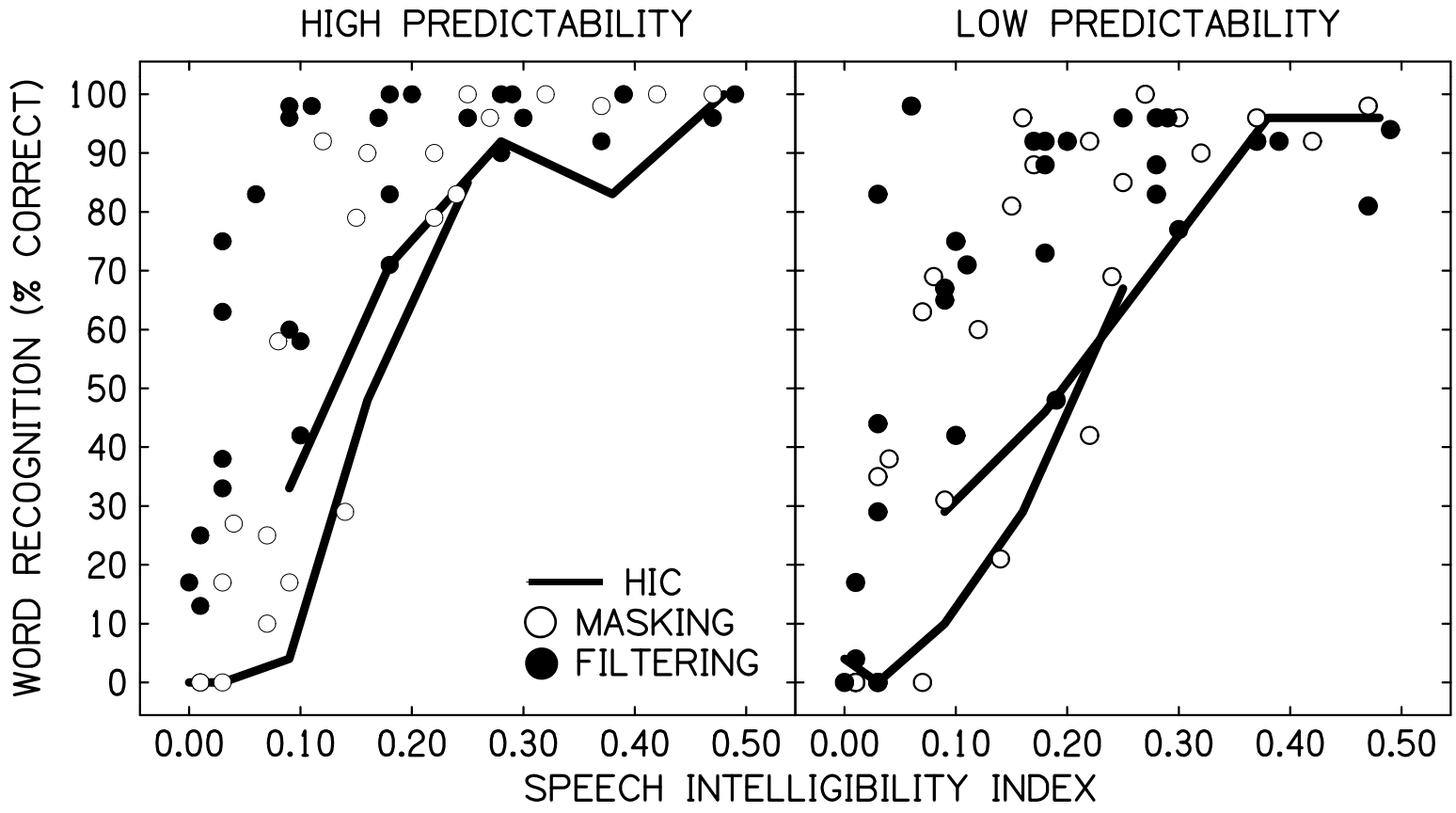
Results – Pure Tone Thresholds

- 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



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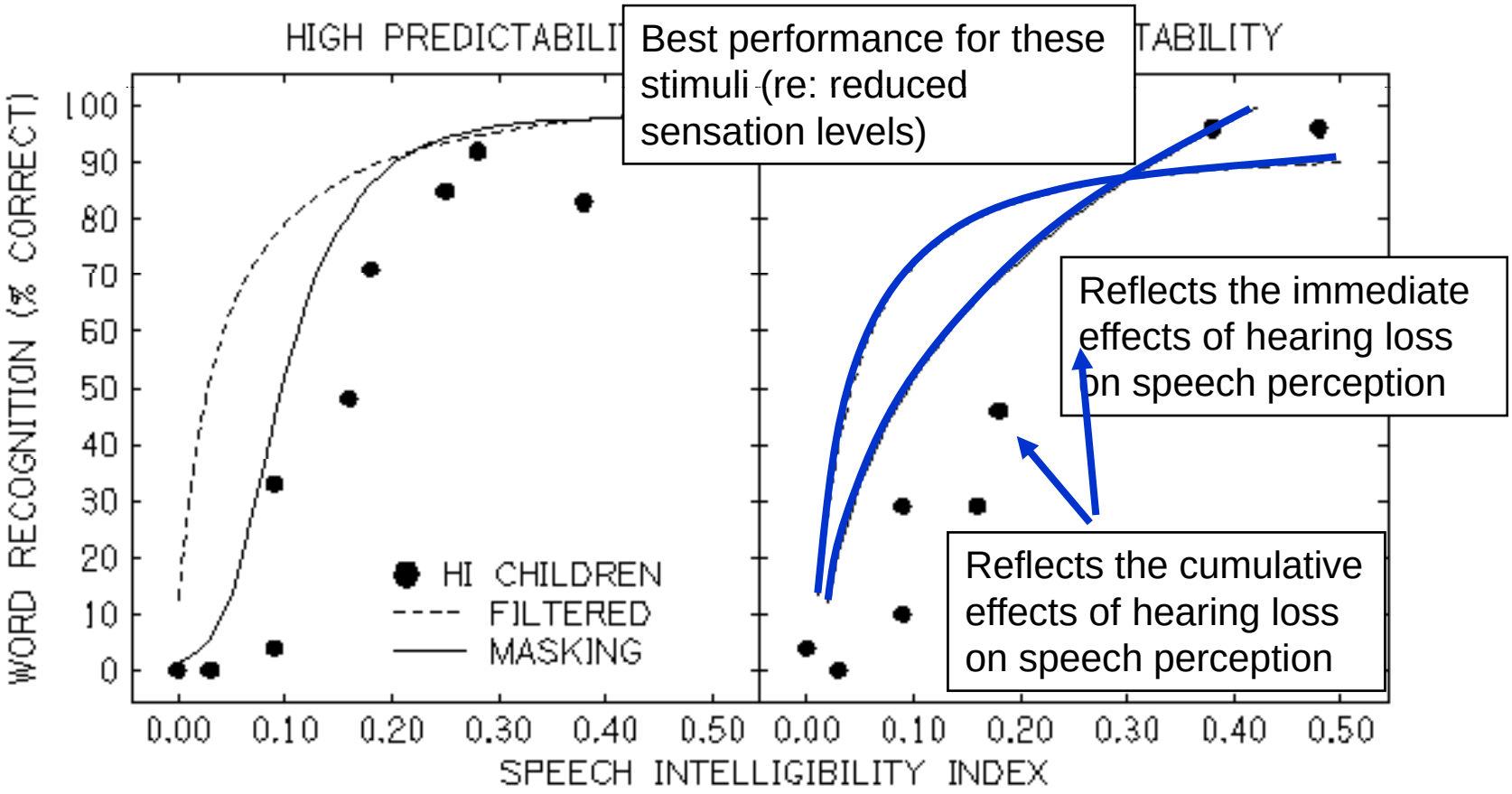
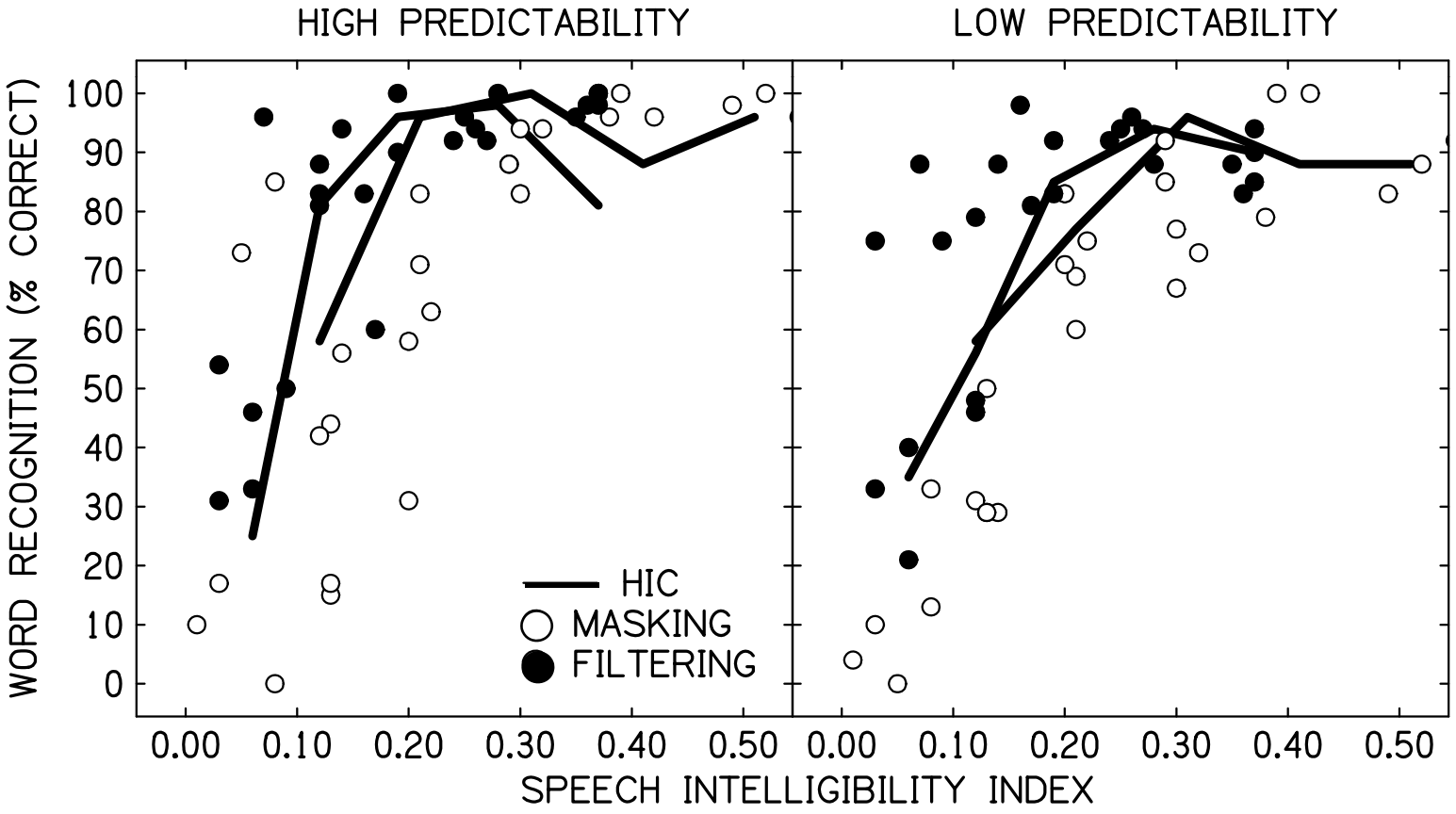


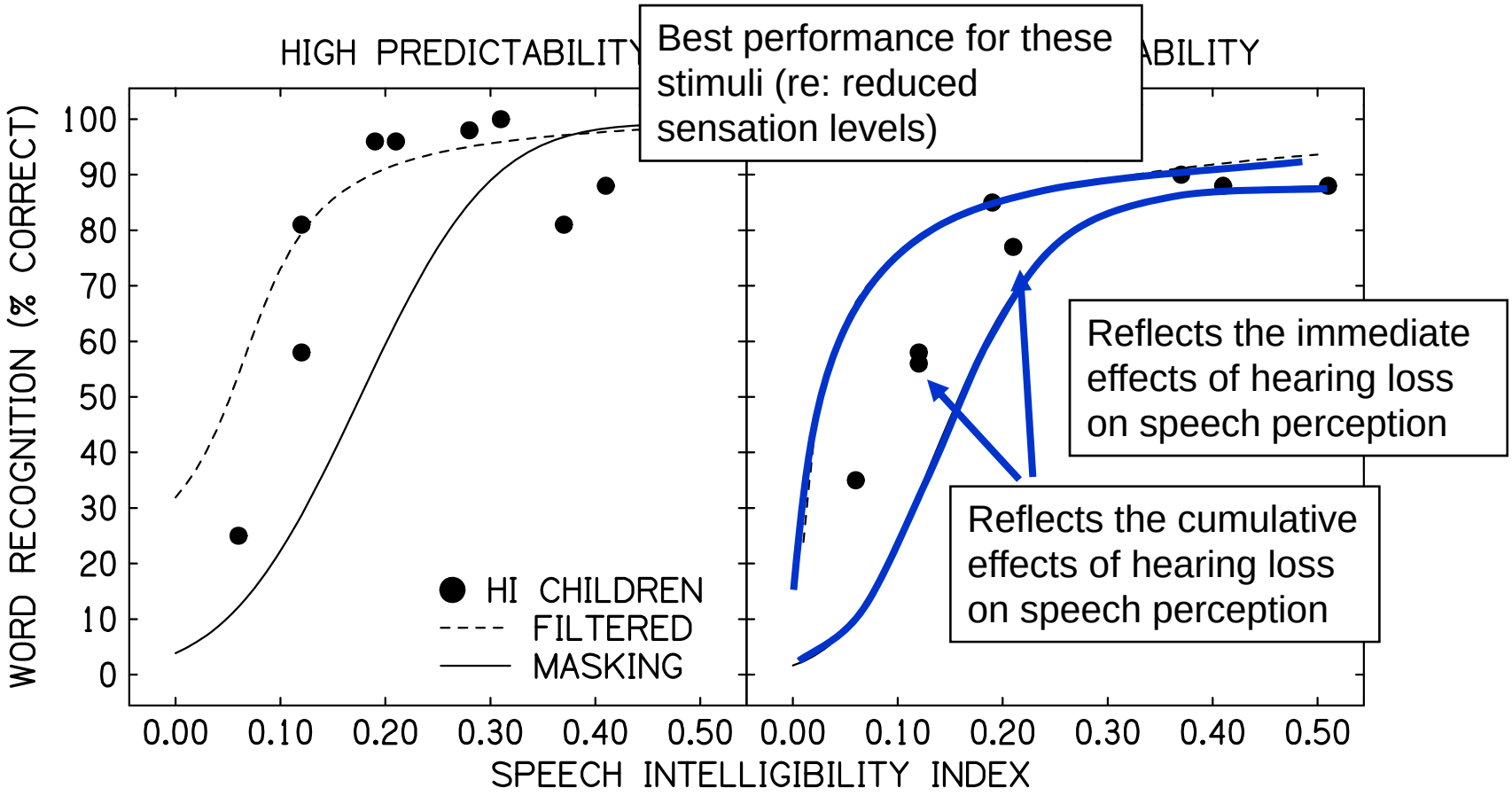
Results

- High-Frequency Hearing Losses

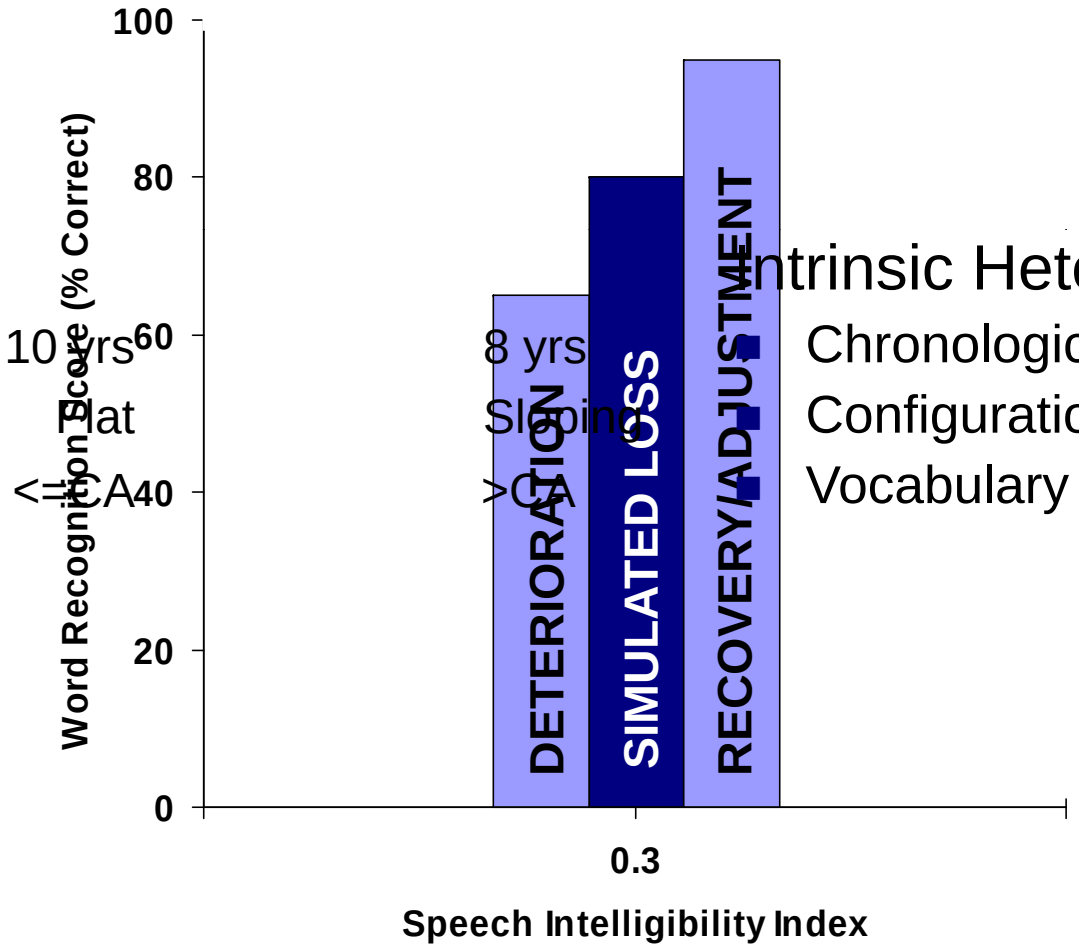


Results

- High-Frequency Hearing Losses



Application



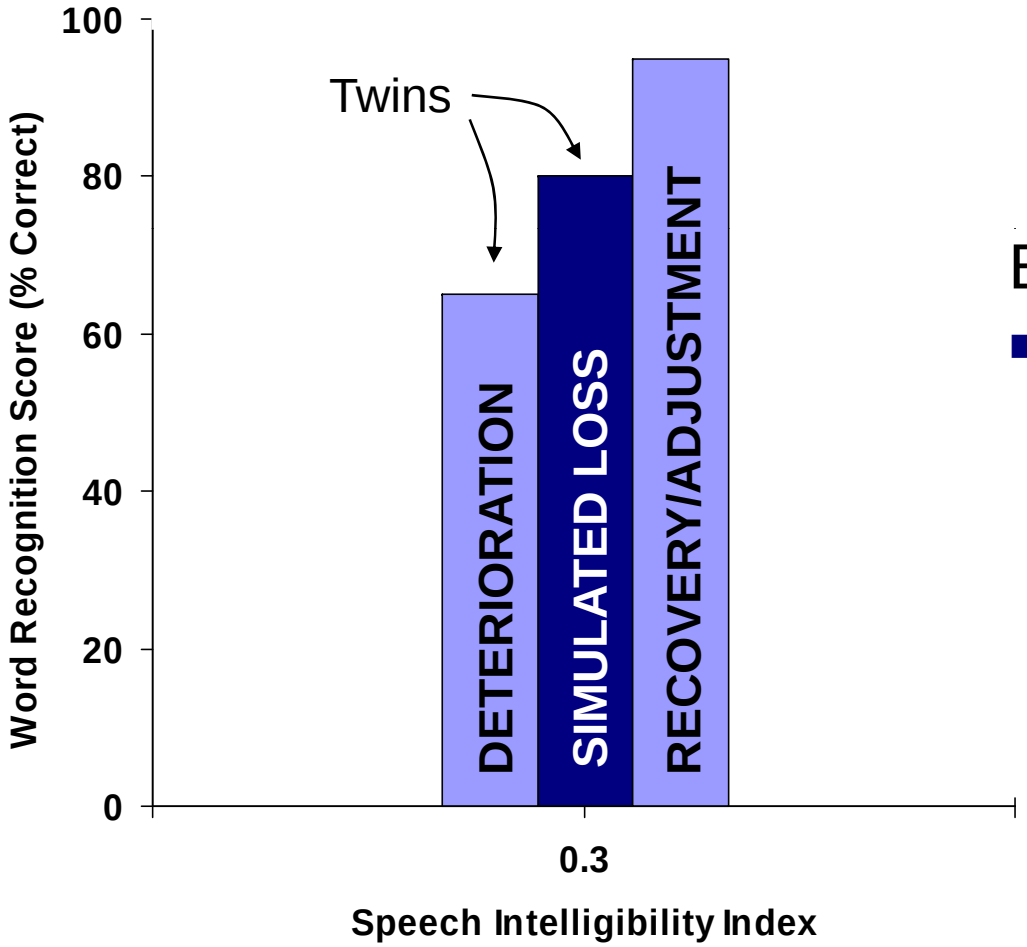
Intrinsic Heterogeneity

- Chronological age
- Configuration of hearing loss
- Vocabulary Age

10 yrs
Flat
<= CA

8 yrs
Sloping
> CA

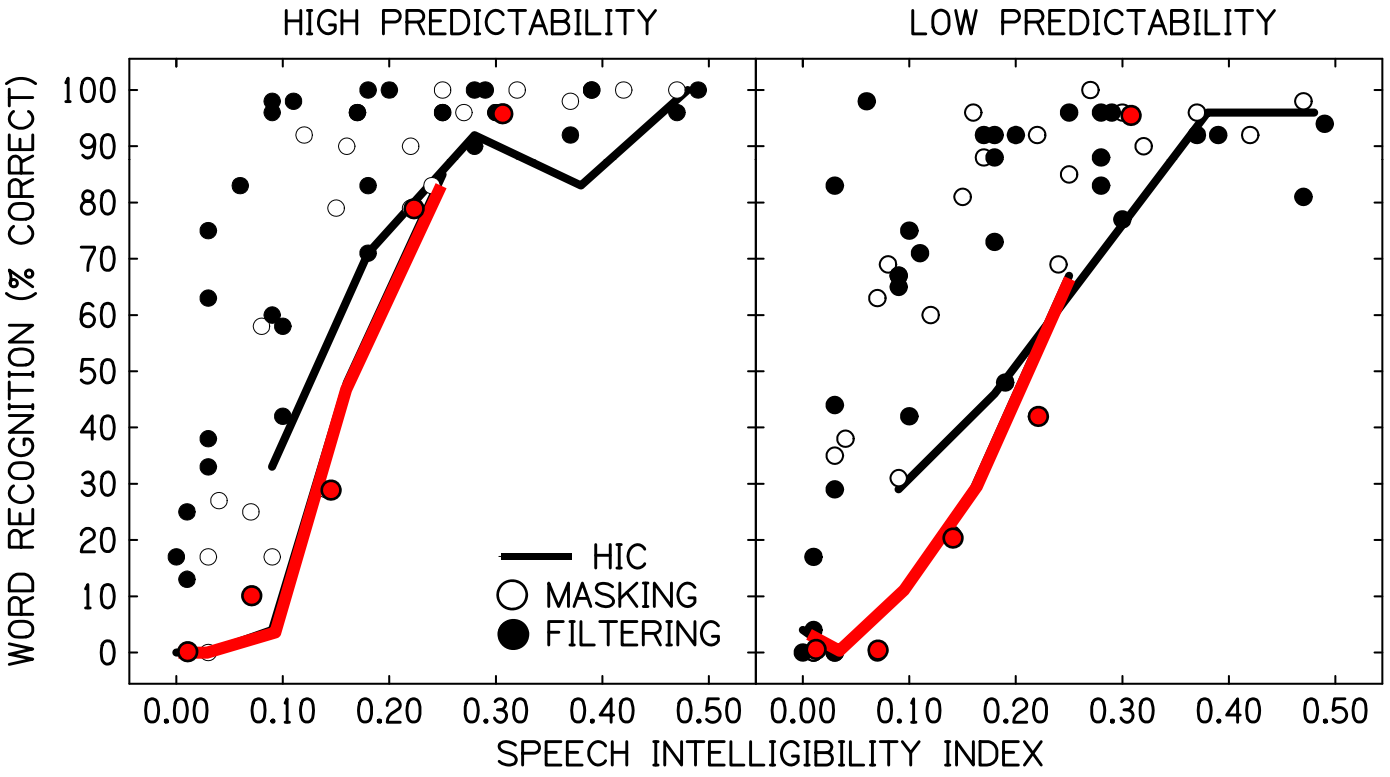
Application



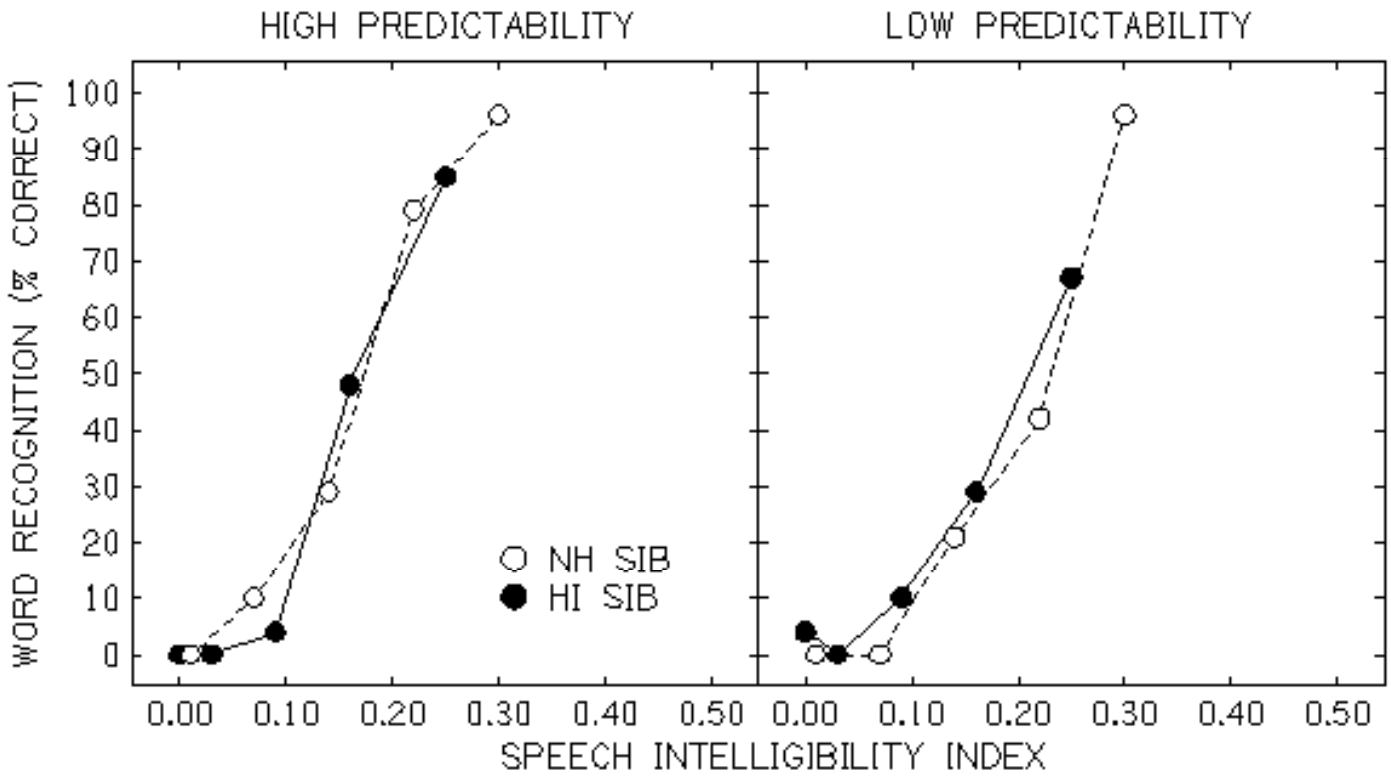
Extrinsic Heterogeneity

- Hearing History

Application



Application



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