Divided Attention in Children with Hearing Loss using Digital Noise Reduction

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Grade-School Class Rules

- Keep hands, feet, and objects to yourself
- Use kind, respectful words
- Be quiet when someone else is talking
- Always do your very best
- Follow all directions the first time given

Children's Unique Listening Situations

- Listening situations common to children
  - Classroom
  - Gym
  - Cafeteria
  - Playground
  - Back seat of the car
- Children have little/no control over their listening environment

How can we help these children?

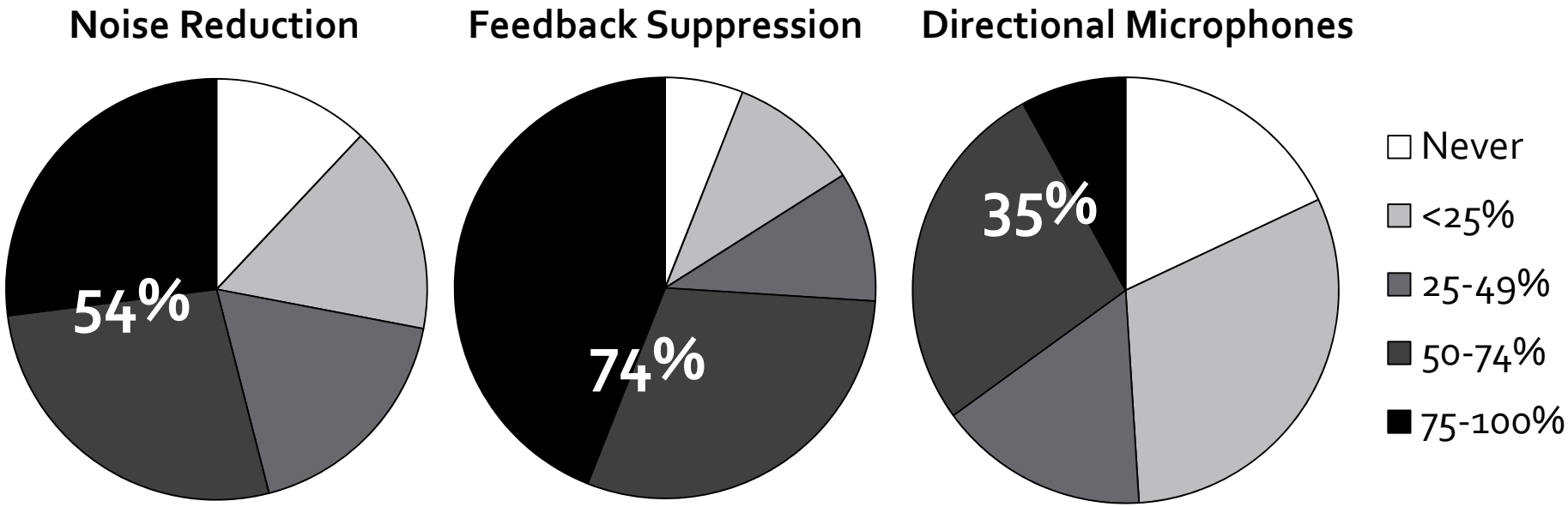
- Hearing aids now include many advanced signal processing features
  - Wide dynamic range compression
  - Directional microphones
  - Frequency lowering
  - Digital noise reduction
- Designed to improve signal audibility and listening comfort

How can we help these children?

- The way that advanced processing works is a mystery
- Development has been rapid
- No ANSI standards and few verification procedures
- Lack of research regarding effectiveness in children

How can we help these children?

- Pediatric audiologists are fitting very young children with advanced signal processing (Rigsby et al, 2008)



Advanced Signal Processing in Children with Hearing Loss

- Two-year project funded by a grant from the ASHA Foundation
- Digital Noise Reduction (DNR)
  - Elementary schools are noisy places
  - Learning /communication takes place outside the classroom

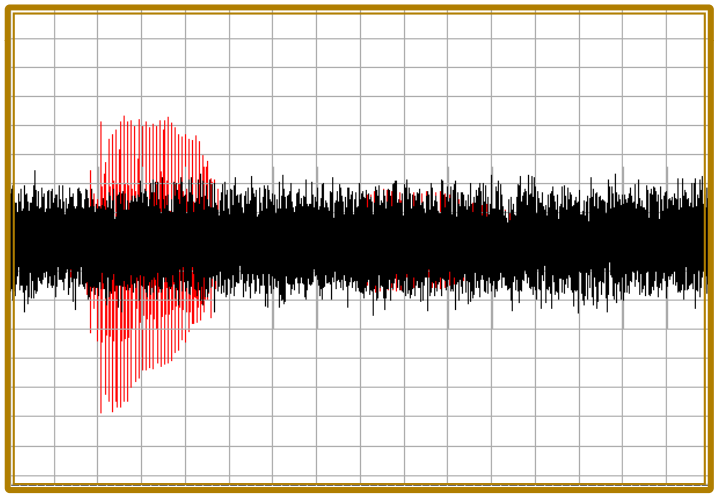
Digital Noise Reduction

- Results in adults are "not very exciting"
  (Bentler et al, 2008; Nordrum et al, 2006; Peeters et al, 2009; Ricketts & Hornsby, 2005)
  - No change in performance with the use of digital noise reduction
    - Speech perception in noise (% correct)
    - Speech recognition threshold (SRT) in noise (dB)
  - Adults prefer DNR

A Different Approach

- Task Criteria
  - Demanding perceptual tasks that are sensitive to small changes in the acoustic signal
  - Consistent with the demands of a typical classroom
- Project
  - Divided Attention
  - Word Learning

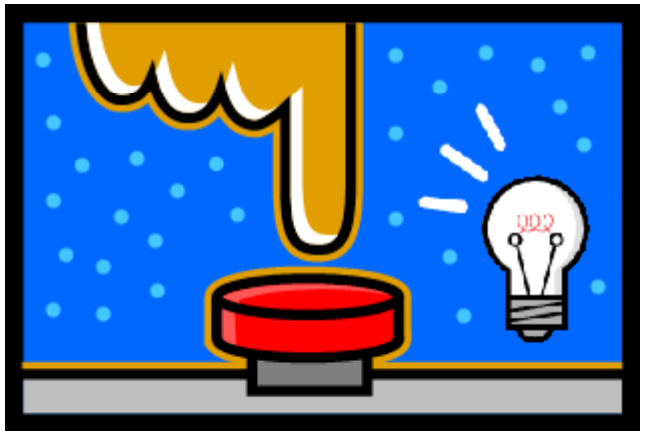
Divided Attention



Divided Attention

- Hicks & Tharpe (2002)

Auditory	Visual
Word repetition	Button pushing
Percent words correct	Reaction time
Varied signal-to-noise	



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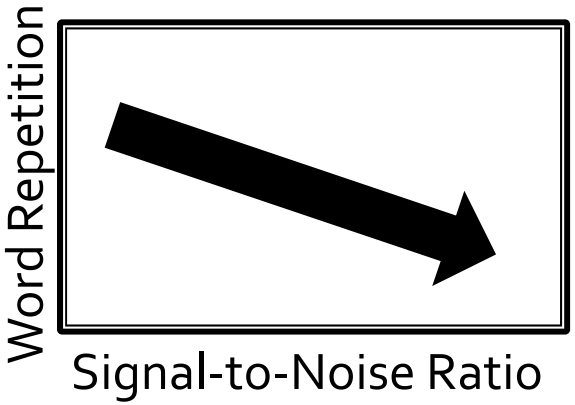
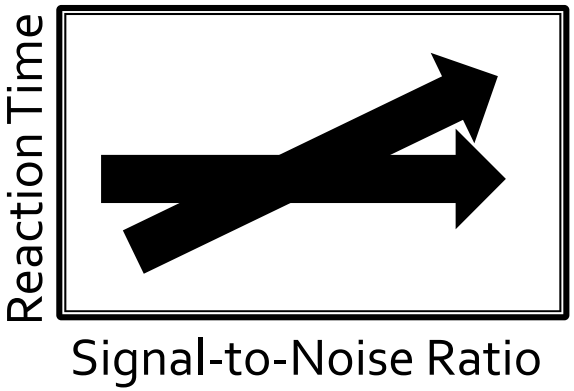
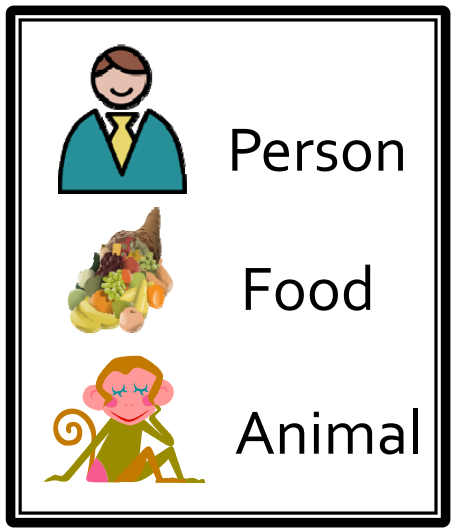


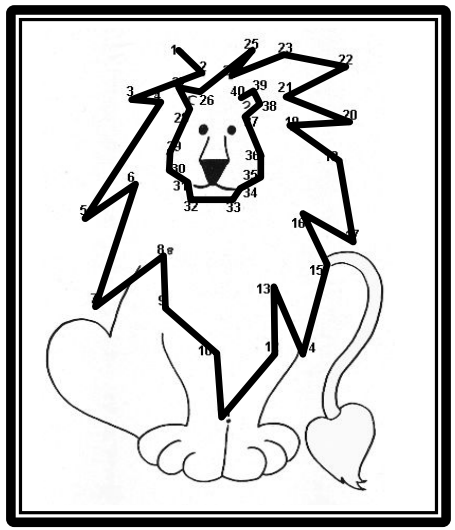


Divided Attention

- McFadden & Pittman (2008)

Auditory	Visual
Word categorization	Dot-to-dot games
Percent words correct	Dots/minute
Varied signal-to-noise	





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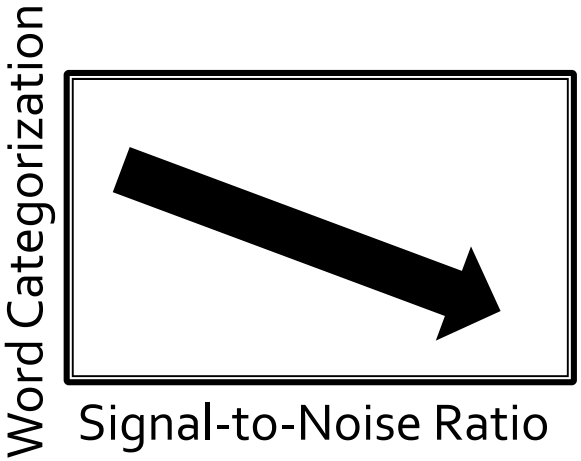
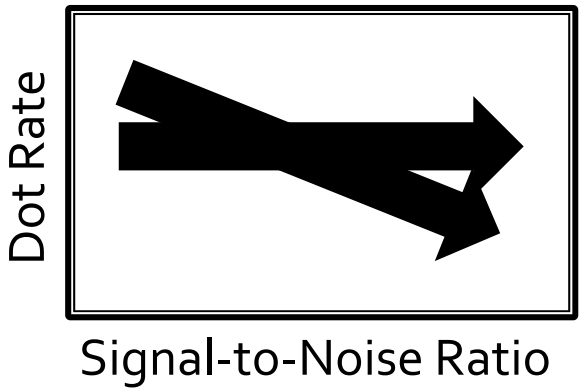




Divided Attention

- We know that children's ability to engage in a visual task **is not** influenced by the difficulty of a concurrent auditory task.

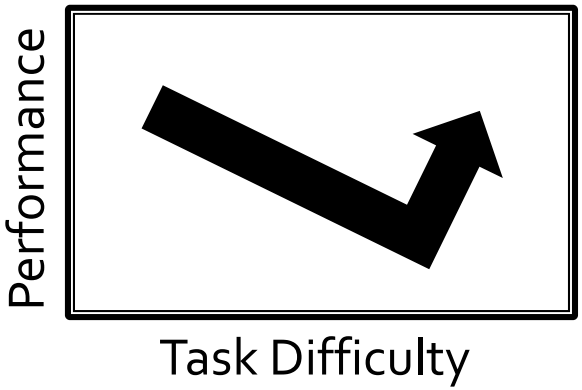
- Is a child's ability to engage in an auditory task influenced by visual and auditory competitors?

Purpose

- To determine the effect of hearing loss on children's ability to process auditory information under complex conditions
- To determine the benefits of digital noise reduction in the management of those complex conditions

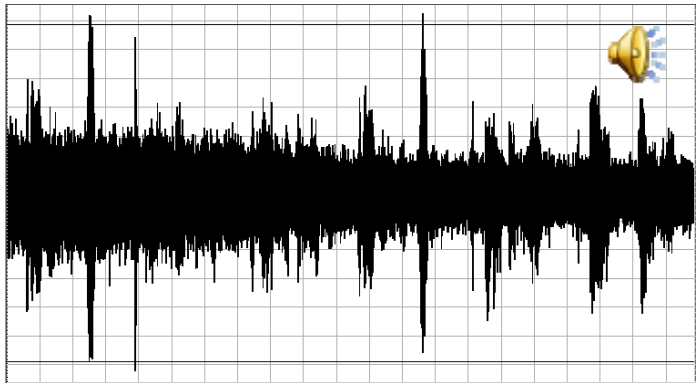
Method

- Progressively demanding conditions
  - Used noise and a visual task as competitors to an auditory task
    - Auditory
    - Auditory + visual
    - Auditory + visual + noise
    - Auditory + visual + noise + digital noise reduction

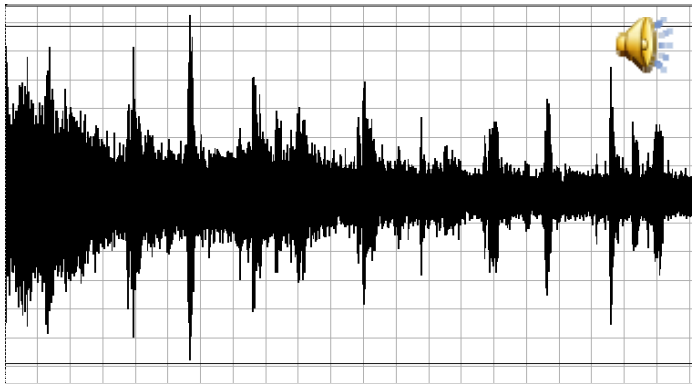


Which hearing aid to use?

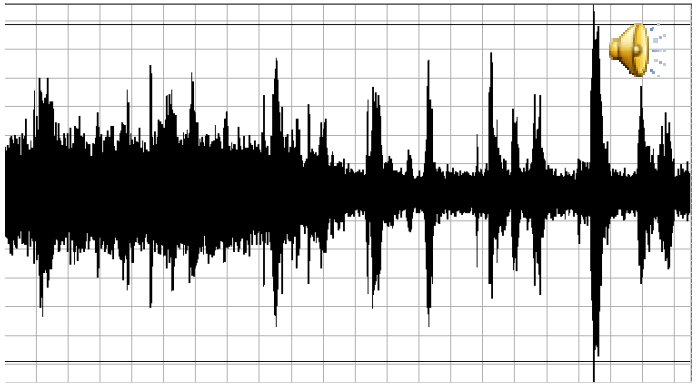
Phonak Naida



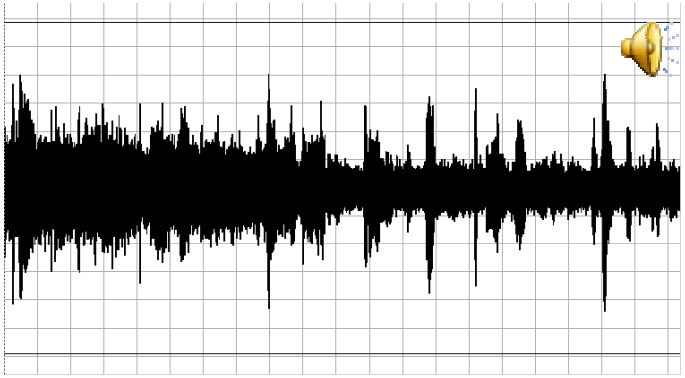
Widex Mind



ReSound Azure



Siemens Explorer



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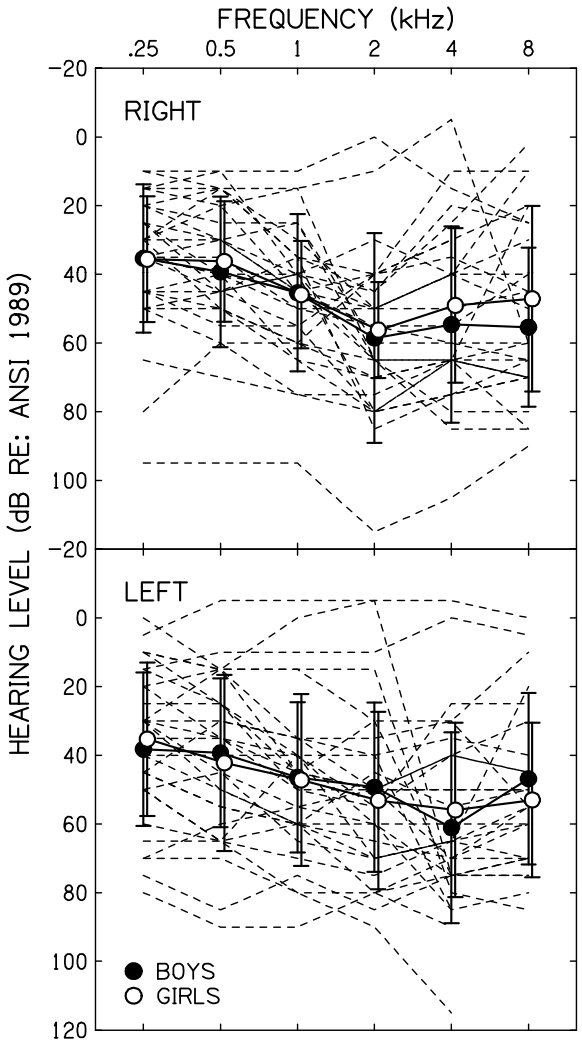
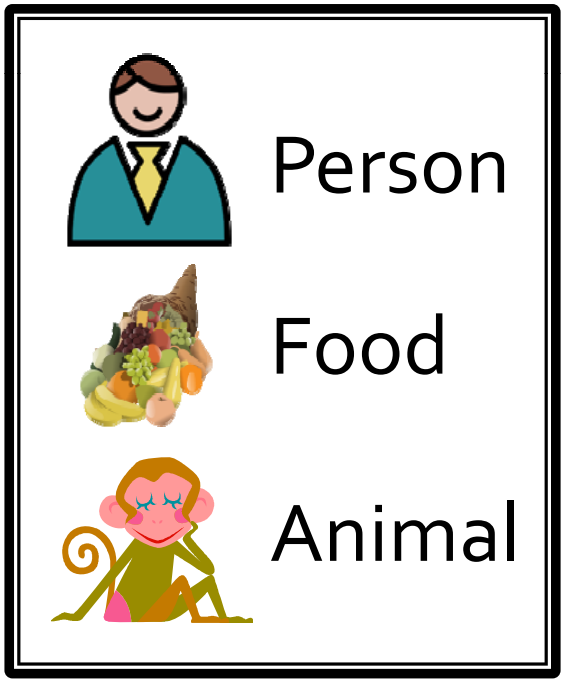


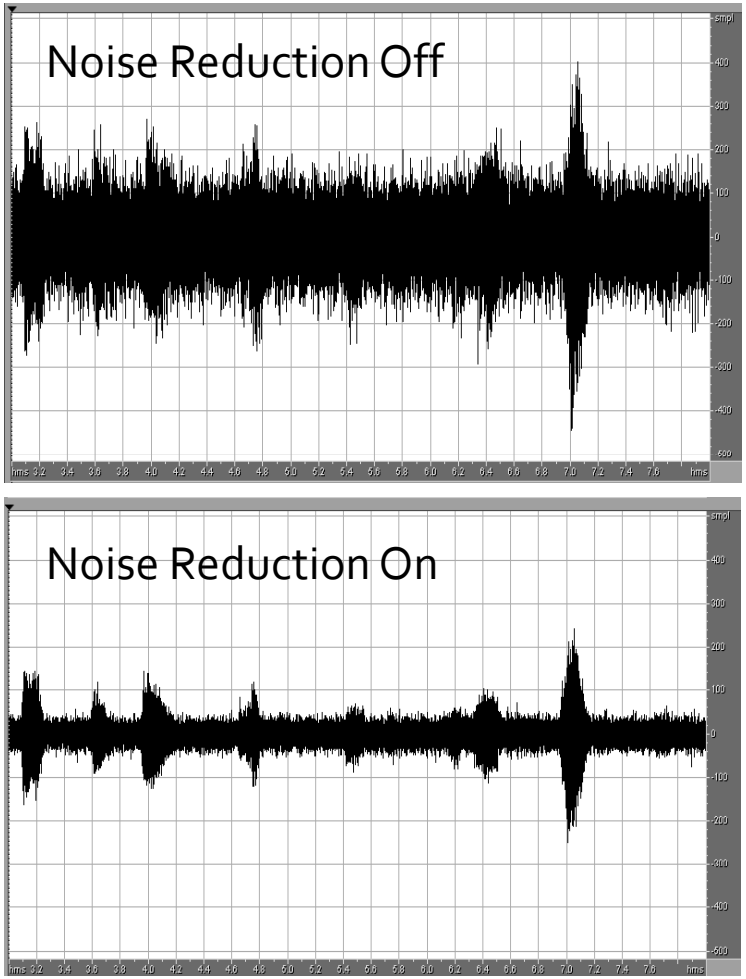
- 8-12 year-old children
  - 50 children with normal hearing
  - 30 children with hearing loss
    - Mild to moderately-severe
    - Degree of loss appropriate for amplification
- Receptive Vocabulary
  - PPVT IIIB
- Speech Intelligibility Index (SII)
  - Audibility in quiet and noise

Auditory Task

- 5 lists of 30 words
  - Common to children
  - Drawn from three categories
    - Person (exp: policeman, uncle)
    - Food (exp: donut, hamburger)
    - Animal (exp: frog, cat, gopher)
- Children indicated the category to which each word belonged



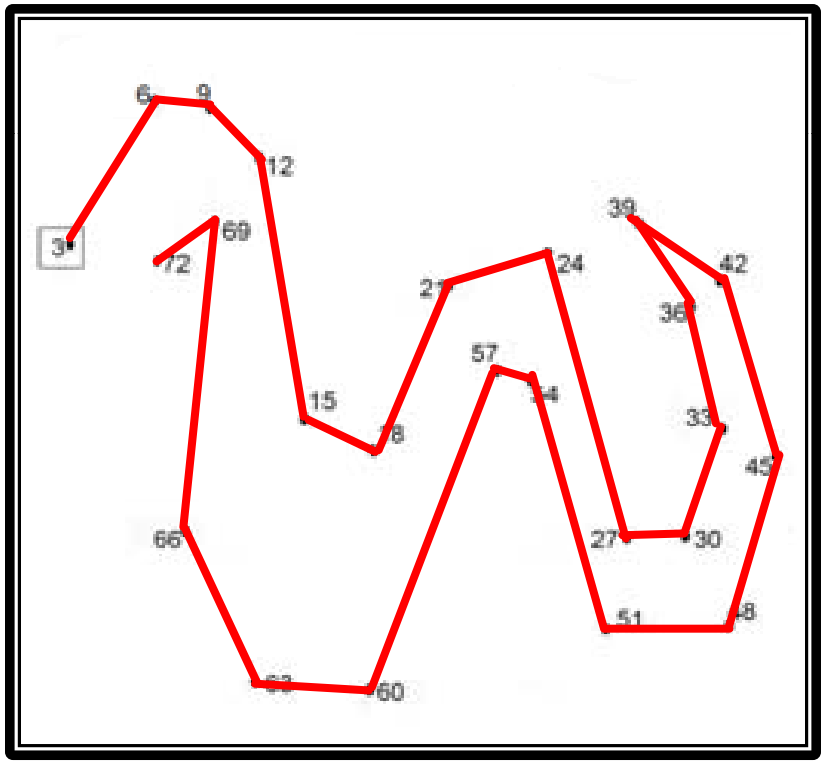
Auditory Task



- Presented in the sound field
  - 0 degrees azimuth
  - 50 dB SPL
  - Broadband noise at 0 dB SNR
- Noise Reduction On
  - Overall level -4 dB
  - SNR +2 dB

Visual Task

- Dot-to-dot games
  - Dots numbered in increments of 3
  - Starting point of each game was identified by a box
- Performance was scored in dots/min



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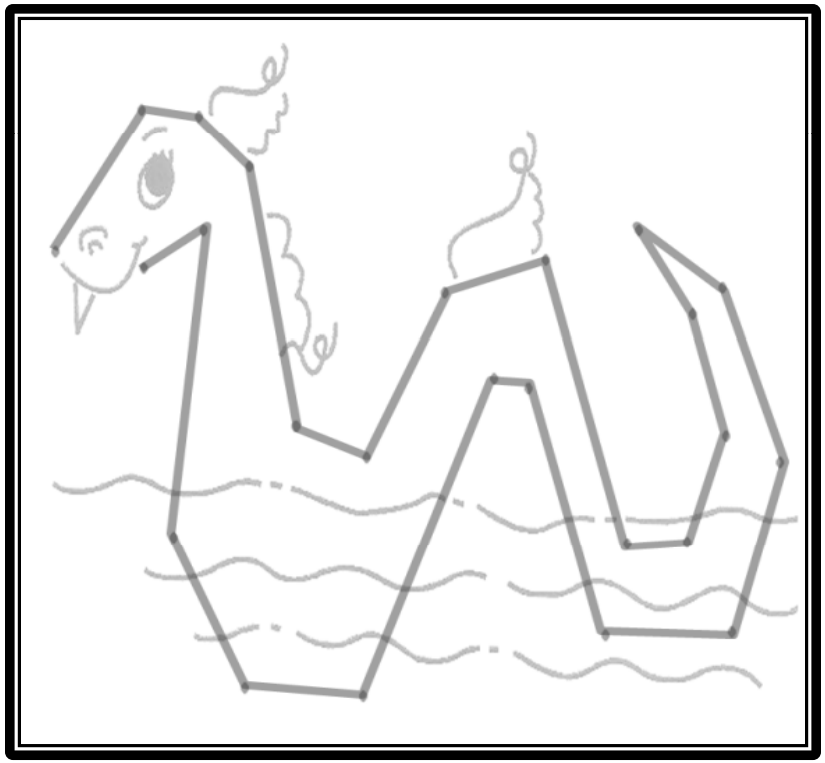
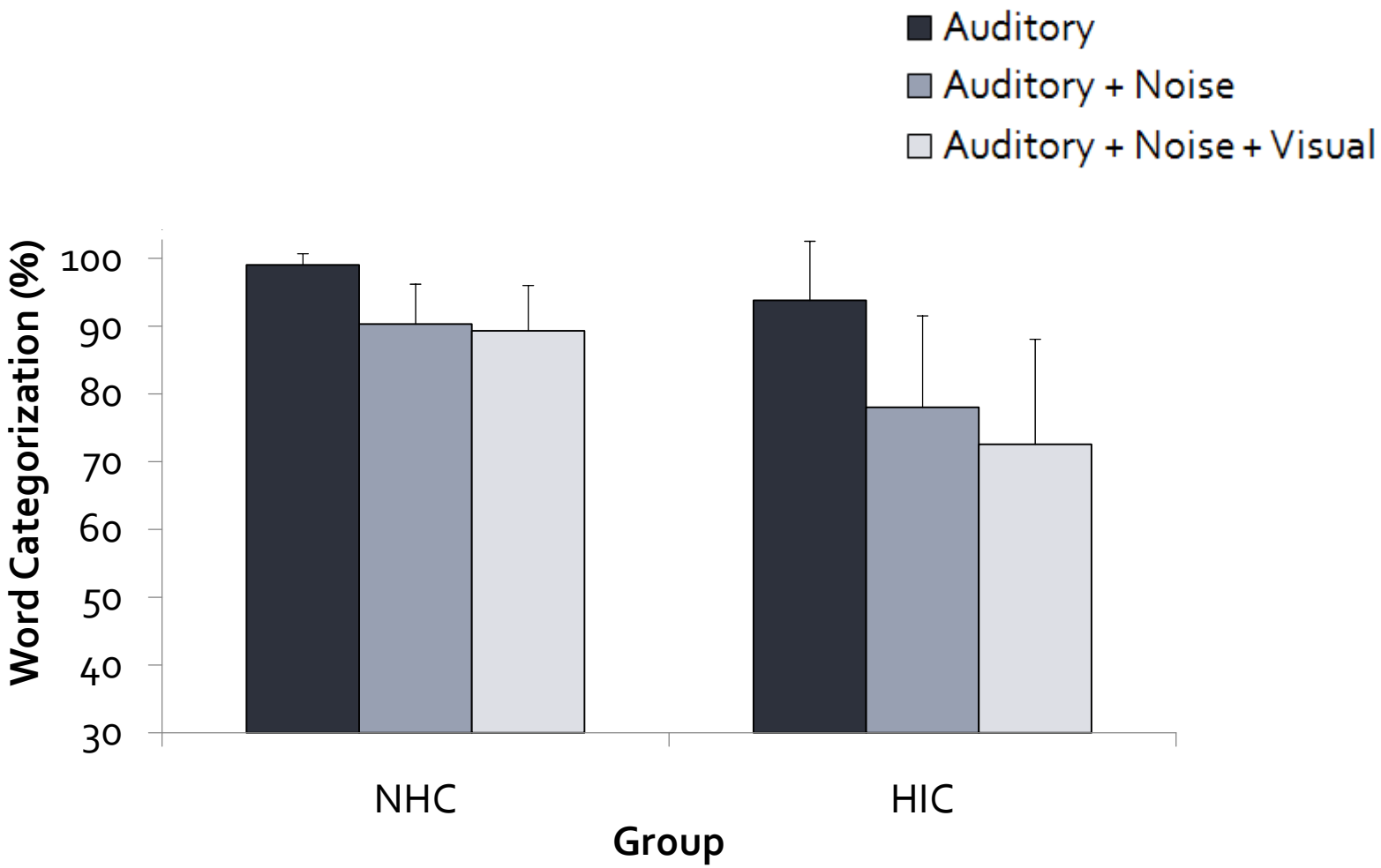


Results - Auditory Task



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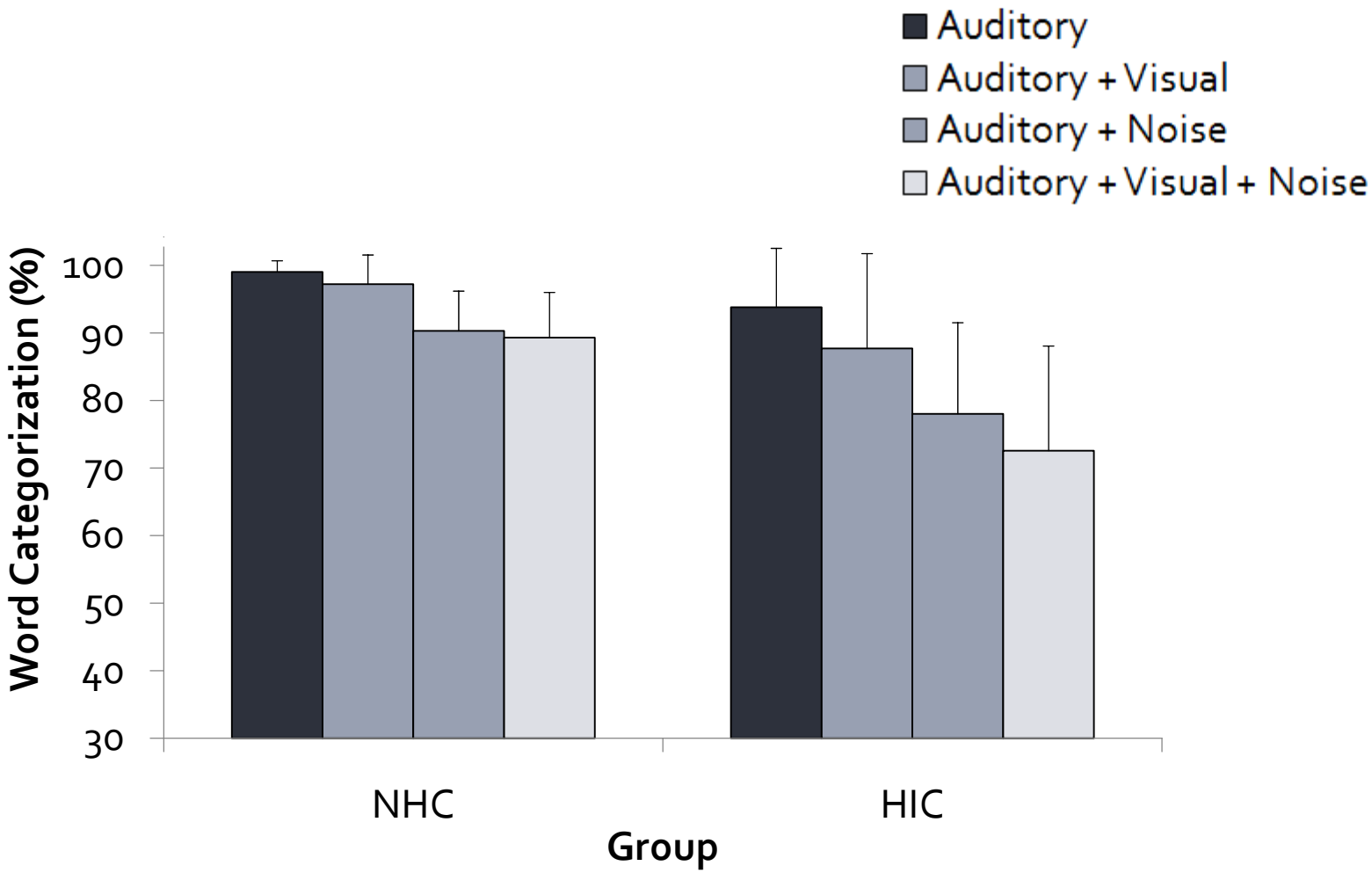
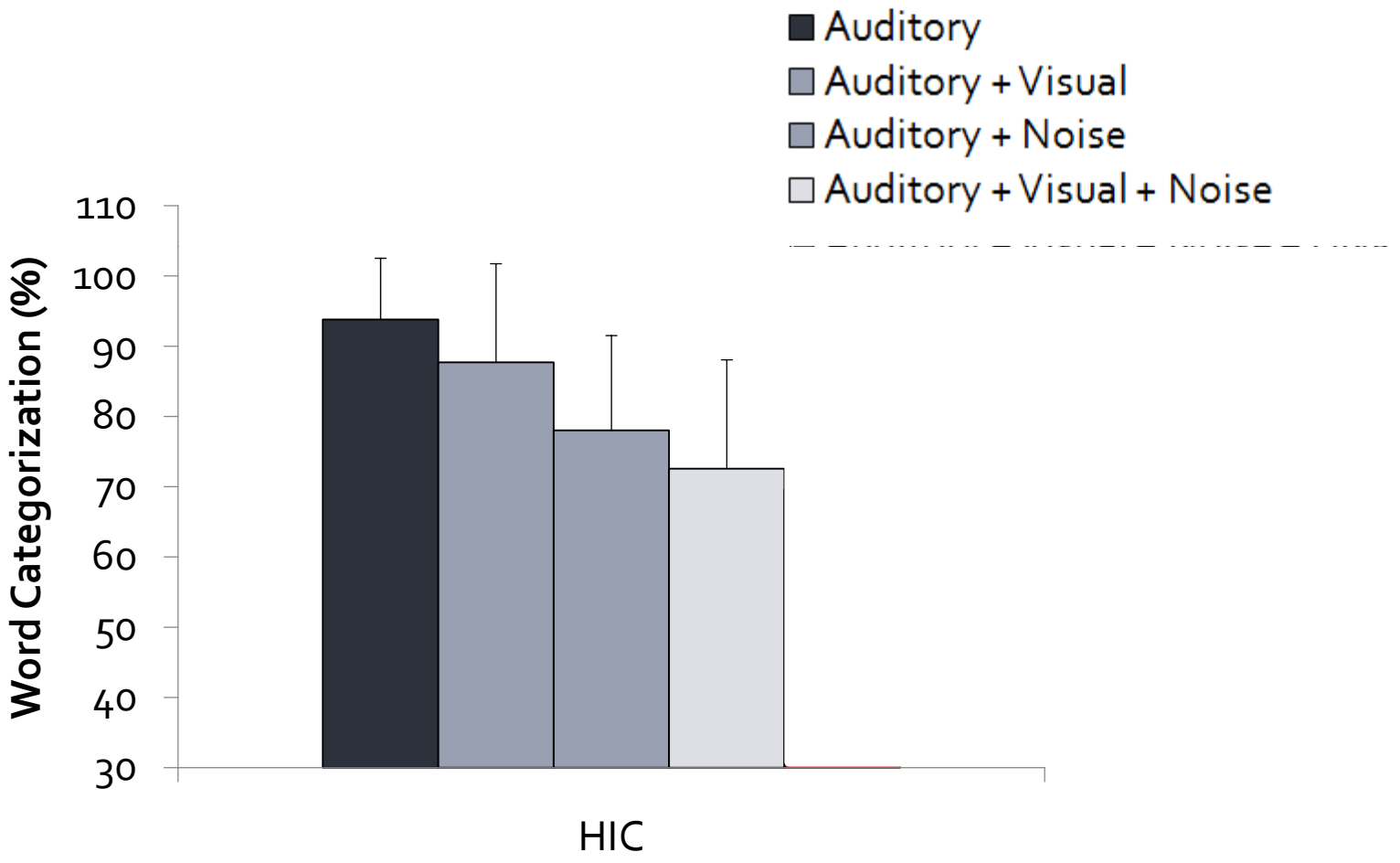


Results - Auditory Task

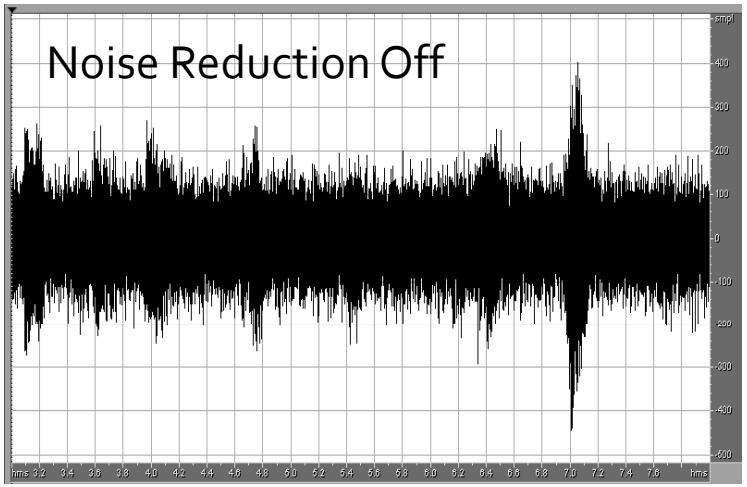
- Significant main effects of group and listening condition.
  - The performance of the children with hearing loss was poorer than that of the children with normal hearing.
  - Performance decreased with task difficulty.
- Significant group x listening condition interaction.
  - The effects of noise and the visual task was greater for the children with hearing loss.

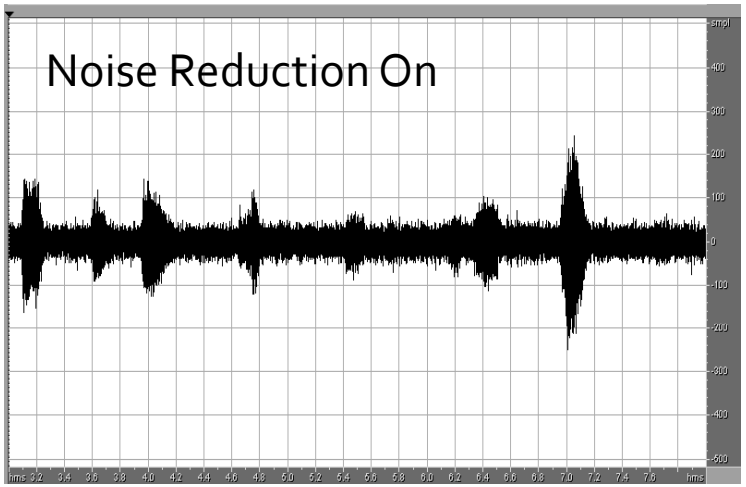
Results - Auditory Task



Results - Speech Intelligibility Index

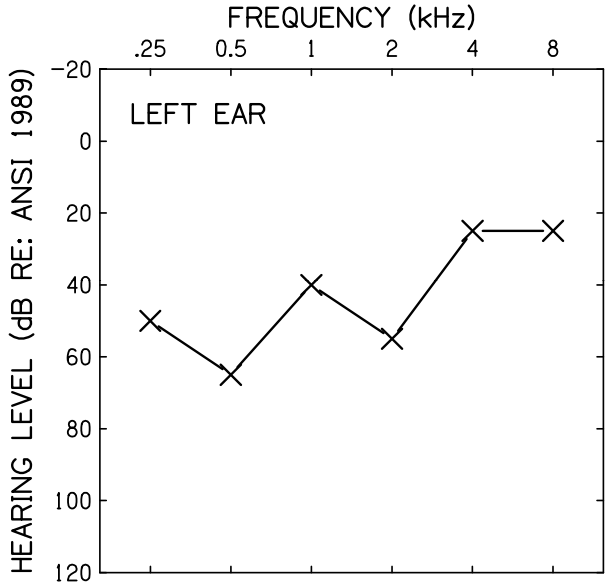
	Average	SD



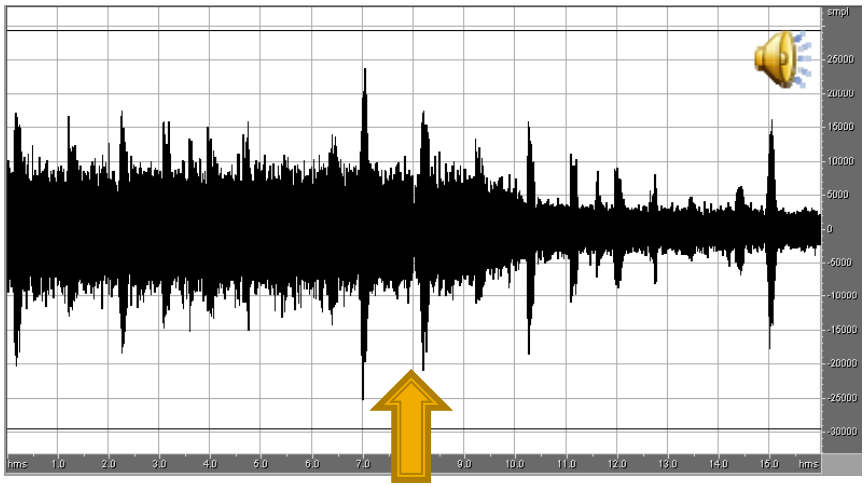


Example

- 9-year-old girl
  - 8-year-old vocabulary
  - Identified at 4 years
  - Amplified at 4 years



	SII	%
Quiet	0.70	100
Noise	0.32	73
Noise Reduction	0.33	73



Results - Factor Analysis (HIC only)

Principal Component	Description	% Variability Accounted for
Age	PPVT, chrono age	30%
Audibility	SII in quiet/noise, PTA	28%
Hearing History	Age at ID, age at amp	21%
Total		79.6%

Results - Factor Analysis (HIC only)

Principal Component	A	A +V	A +N	A +V +N	A +V +N +DNR
Age	0.29	**0.42***	**0.48***	**0.51***	**0.45***
Audibility	**0.58***	**0.49***	**0.54***	**0.54***	**0.55***
Hearing History	0.03	-0.04	0.04	-0.03	0.07

A=Auditory, V=Visual, N=Noise, DNR=digital noise reduction

Conclusions

- To determine the effect of hearing loss on children's ability to process auditory information under complex conditions
  - Significant effect of hearing status
  - Performance was significantly related to:
    - Age
    - Audibility of the signal
  - Performance was not related to:
    - Previous hearing aid experience

Conclusions

- To determine the benefits of digital noise reduction in the management of those complex conditions
  - No improvement or reduction in performance with DNR

Is Digital Noise Reduction Appropriate for Children?

- Yes
  - No evidence that digital noise reduction is detrimental to performance in children.
  - Digital noise reduction maintains the audibility of the signal while decreasing the overall level.
    - May improve listening comfort without sacrificing intelligibility.
  - Provides children with an option in noise.

Thanks to…

- People
  - Samantha Gustafson
  - Devin Anderson
  - Kristi Petersen
  - Sara Bos
  - Christine Page
  - Robert Fanning
  - Lylis Olsen
- Places
  - Phoenix Children's Hospital
  - Children's Rehabilitative Services
  - Mesa School District
- ASHA FOUNDATION