Benefits of Hearing Aids with Digital Noise Reduction to Children with Hearing Loss

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Children’s Unique Listening Situations

- **School**
  - Classroom (multiple talkers)
  - Playground (multiple talkers, distance)
  - Gym (multiple talkers, reverberation)
  - Cafeteria (multiple talkers, reverberation, food)
  - Bathroom (multiple talker, reverberation, distraction)

- **Other**
  - Backseat of the car (noise, no visual cues)

- Children have little/no control over their listening environment
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/or listening comfort
How can we help these children?

- The way that some advanced signal processing works is a mystery
  - Technology developed rapidly
  - There are no ANSI standards and few verification procedures

- Little evidence 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
- Effects of digital noise reduction (DNR) on:
  - The management of complex listening conditions
  - The speed with which children learn new words
Results in adults have not been 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)

- Even so, adults prefer DNR
1. Managing Complex Environments
1. Managing Complex Environments

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

- Chose a dual-task paradigm
1. Managing Complex Environments

- Hicks & Tharpe (2002)
  - Auditory
    - Word repetition
    - Percent words correct
    - Varied signal-to-noise
  - Visual
    - Button pushing
    - Reaction time
1. Managing Complex Environments

- Hicks & Tharpe (2002)
  - Auditory
    - Word repetition
    - Percent words correct
    - Varied signal-to-noise
  - Visual
    - Button pushing
    - Reaction time

![Diagram](Image)
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?
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
Method

- 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

- 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
  - Overall 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
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
Results - Auditory Task

Word Categorization (%)

Group

NHC

HIC

Auditory
Auditory + Visual
Auditory + Noise
Auditory + Visual + Noise
Results - Auditory Task

Word Categorization (%)

- Auditory
- Auditory + Visual
- Auditory + Noise
- Auditory + Visual + Noise
- Auditory + Visual + Noise + DNR

HIC
### Results - Speech Intelligibility Index

<table>
<thead>
<tr>
<th></th>
<th>Average</th>
<th>SD</th>
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<tbody>
<tr>
<td>Quiet</td>
<td>0.58</td>
<td>0.26</td>
</tr>
<tr>
<td>Noise</td>
<td>0.35</td>
<td>0.15</td>
</tr>
<tr>
<td>Noise Reduction</td>
<td>0.36</td>
<td>0.17</td>
</tr>
</tbody>
</table>

![Waveform Comparison](image1.png)  

- Noise Reduction Off
- Noise Reduction On
Example

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

<table>
<thead>
<tr>
<th></th>
<th>SII</th>
<th>%</th>
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<tbody>
<tr>
<td>Quiet</td>
<td>0.70</td>
<td>100</td>
</tr>
<tr>
<td>Noise</td>
<td>0.32</td>
<td>73</td>
</tr>
<tr>
<td>Noise Reduction</td>
<td>0.33</td>
<td>73</td>
</tr>
</tbody>
</table>
Performance is poorer for HIC than for NHC

Performance decreases for all children as difficulty increases

HIC are affected more by the addition of competing tasks

There is no effect of digital noise reduction
2. Learning New Words
2. Learning New Words

- Critical accomplishment of childhood
  - Speak effectively
  - Read comprehensively
  - Write meaningfully

- Children with hearing loss have smaller vocabularies
  - Average 2-3 year delay
  - Delay is related to degree of hearing loss
Rapid word-learning in NH and HI children... (Pittman et al, 2005)
Rapid word-learning in NH and HI children... (Pittman et al, 2005)

“Which one is the blag?”
Rapid word-learning in NH and HI children... (Pittman et al, 2005)
Short-term word-learning rate in children... (Pittman, 2008)
Method

- 8-9 & 11-12 year-old children
  - 40 children with normal hearing
  - 26 children with hearing loss
  - Mild to moderately-severe
Method

- **8-9 & 11-12 year-old children**
  - 40 children with normal hearing
  - 26 children with hearing loss
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- **Receptive Vocabulary**
  - PPVT IIIIB
Method

In noise without DNR

daztɛl  doztul
fasnɛʃ  fosnush
səθnɛp  sothnud
stamən  stomun
hamtɛl  homtul

In noise with DNR
Method

- Presented in the sound field
  - 0 degrees azimuth
  - 50 dB SPL
  - Broadband noise at 0 dB SNR

- Noise Reduction On
  - Overall level -5 dB
  - Overall SNR +2 dB
Learning Game
Analysis
Results – NH Children

8 & 9-YR-OLDS

11 & 12-YR-OLDS

PROPORTION CORRECT

TRIALS
Results – HI Children

8 & 9-YR-OLDS

- QUIET
- NOISE

11 & 12-YR-OLDS
Results – HI Children

8 & 9-YR-OLDS

- QUIET
- NOISE

11 & 12-YR-OLDS

TRIALS

PROPORTION CORRECT
Results – HI Children

8 & 9-YR-OLDS

- QUIET
- NOISE
- NOISE REDUCTION

11 & 12-YR-OLDS

PROPORTION CORRECT

TRIALS
Results – HI Children

8 & 9-YR-OLDS
- QUIET
- NOISE
- NOISE REDUCTION

11 & 12-YR-OLDS

PROPORTION CORRECT

TRIALS
Conclusion

- Word learning improves with age
- Word learning is poorer for HIC than for NHC
- Noise reduces learning for HIC but not for NHC
- There are age-related benefits of digital noise reduction
Is Digital Noise Reduction Appropriate for Children?

- Yes
  - There is no evidence that digital noise reduction is detrimental to performance in children.
  - There is now evidence that it is beneficial to older children (>10 years).
  - Digital noise reduction improves listening comfort without sacrificing intelligibility.
  - Provides children with an option in noise.
People
- Samantha Gustafson
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