Children, Hearing Aids, and Cognitive Demand

UWO 2012
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Children with Hearing Loss

30 million adults
1 million children

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Age
Hearing Level
(Pittman & Stelmachowicz, 2002)

Adults (n=248)

Children (n=227)
Hearing Level
(Pittman & Stelmachowicz, 2002)

- 39% Mild (15-40 dB HL)
- 21% Severe (61-80 dB HL)
- 10% Profound (>80 dB HL)
- 30% Moderate (41-60 dB HL)

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Age & Hearing Loss

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Managing Complex Environments
Listening Effort and Fatigue
(Hicks & Tharpe, 2002)

Children
14 HI Children
14 NH Children

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Listening Effort and Fatigue
(Hicks & Tharpe, 2002)

Auditory
Word repetition
Percent words correct
Varied signal-to-noise

Visual
Button pushing
Reaction time

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Listening Effort and Fatigue
(Hicks & Tharpe, 2002)

Auditory
Word repetition
Percent words correct
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Visual
Button pushing
Reaction time

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Listening Effort and Fatigue
(Hicks & Tharpe, 2002)

Auditory
Word repetition
Percent words correct

Visual
Button pushing
Reaction time

Figure 4. Average reaction time difference scores by condition for children with hearing loss (HL) and children with normal hearing (NH). Bars represent 1 standard deviation.

Figure 5. Speech recognition (PBK) scores by condition for children with hearing loss (HL) and children with normal hearing (NH). Bars represent 1 standard deviation.
Managing Complex Tasks
(Pittman, 2011)

Children
30 HI Children
50 NH Children
Managing Complex Tasks
(Pittman, 2011)

Auditory
Word categorization
Percent words correct
0 dB SNR

Visual
Dot-to-dot games
Dots/minute

Person
Food
Animal

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Managing Complex Tasks
(Pittman, 2011)

• Auditory Task
• Auditory Task + Visual Task
• Auditory Task + Noise
• Auditory Task + Visual Task + Noise
• Auditory Task + Visual Task + Noise (DNR)
Managing Complex Tasks
(Pittman, 2011)

Figure 7. Average (+1 SD) word categorization (percentage correct) as a function of listening condition (in order of difficulty) for the children with NH (filled bars) and the children with HL (open bars).
Auditory/Visual Task Preference
(Pittman et al, fresh from the booth)

Children
23 HI Children
32 NH Children

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Auditory/Visual Task Preference
(Pittman et al, fresh from the booth)

CHILDREN WITH NORMAL HEARING

CHILDREN WITH HEARING LOSS

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Auditory/Visual Task Preference
(Pittman et al, fresh from the booth)
Conclusions

• Children with hearing loss excel at visual tasks.
• Visual tasks detract from auditory task performance.
• Complex environments appear to be most detrimental to a child’s weakest modality.
Receptive Vocabulary
(Pittman, 1998-2008)

Children
76 HI Children
137 NH Children

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Receptive Vocabulary
(Blamey et al., 2001)

Children
40 HA Children
47 CI Children
The Word Learning Process

• Word Learning Model (Storkel & Lee 2011)
  – Triggering
    • Detection of a new word
  – Configuration
    • Form a stable acoustic representation
    • Form a semantic representation
  – Engagement
    • Using the new word with other words
Non-word Detection
(Pittman & Schuett, in press)

Children
19 HI Children
29 NH Children
Non-word Detection
(Pittman & Schuett, in press)

Close all three doors.

Cooks make hot foo\textit{m}.

They want \textit{pum gorn}.
Non-word Detection
(Pittman & Schuett, in press)

- Overall performance (percent correct)
- Error analyses
  - Under-triggering
  - Over-triggering

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Non-word Detection
(Pittman & Schuett, in press)
Non-Word Detection and Bandwidth
(Pittman et al, in process)

Children
19 HI Children
33 NH Children
31 HI Adults
18 NH Adults

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## Non-Word Detection and Bandwidth

*(Pittman et al, in process)*

<table>
<thead>
<tr>
<th>4 kHz</th>
<th>9 kHz</th>
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<th>Close all three doors.</th>
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<tr>
<td>Cooks make hot foo<em>mn</em>.</td>
</tr>
<tr>
<td>They want <em>pum gorn</em>.</td>
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Non-Word Detection and Bandwidth
(Pittman et al, in process)
Non-Word Detection and Bandwidth
(Pittman et al, in process)

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Conclusions

• Hearing loss disrupts the detection of new words, possibly prolonging the word learning process.

• A subtle hearing aid feature, like extended bandwidth, may significantly improve the detection of new words.
Word Learning and Bandwidth  
(Pittman, 2008)

Children  
26 HI Children  
41 NH Children
Word Learning and Bandwidth
(Pittman, 2008)

\[ P_c = 1 - 0.8e^{-n/c} \]
Word Learning and Bandwidth
(Pittman, 2008)

![Graph showing the relationship between performance and trials. The graph plots performance (%) on the y-axis against trials on the x-axis. The data points are connected by a line to illustrate the trend. The graph includes a note that the averaged data is plotted as blue dots, and the averaged fits are plotted as a black line.]
## Word Learning and Bandwidth

*(Pittman, 2008)*

<table>
<thead>
<tr>
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<th>4 kHz</th>
<th>9 kHz</th>
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<tr>
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<td>homtul</td>
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Word Learning and Bandwidth
(Pittman, 2008)
Word Learning and Noise Reduction (Pittman, 2011)

Children
26 HI Children
40 NH Children

Noise Reduction Off

Noise Reduction On

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Digital Noise Reduction

Hearing Aid 1

Hearing Aid 2

Hearing Aid 3

Hearing Aid 4

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Word Learning and Noise Reduction
(Pittman, 2011)

Normal Hearing

8-9 YEAR OLDS

11-12 YEAR OLDS

PERFORMANCE (%)

TRIAL

QUIET

NOISE

0 10 20 30 40 50 60 70 80 90 100

5 15 25 35 45 55 65 75 85 95

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Word Learning and Noise Reduction
(Pittman, 2011)

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SO WHAT CAN WE CONCLUDE?
Advanced Hearing Aid Features

Digital noise reduction
1. Maintains auditory task performance in a complex environment
2. Promotes word learning in older grade-school children with hearing loss

Extended high-frequency bandwidth
1. Aides in the detection of new words
2. Promotes word learning in younger and older grade-school children.
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