Children, Hearing Aids, and Cognitive Demand

Part II

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Children vs. Adults

Adults use their hearing aids to \textit{continue} to communicate while children use their hearing aids to \textit{learn} to communicate.
What do they need to learn?

1. Manage complex environments
2. Learn new vocabulary
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
Listening Effort and Fatigue
(Hicks & Tharpe, 2002)

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

Visual
Button pushing
Reaction time

Word Repetition
Signal-to-Noise Ratio

Reaction Time
Signal-to-Noise Ratio
Listening Effort and Fatigue
(Hicks & Tharpe, 2002)

Auditory
Word repetition
Percent words correct

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.

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.
Managing Complex Tasks
(Pittman, 2011)

Children
30 HI Children
50 NH Children

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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
Word categorization
Percent words correct
0 dB SNR

Noise Reduction Off

Noise Reduction On

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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

AGE (years)
HEARING LOSS (degree)
Auditory/Visual Task Preference
(Pittman et al, fresh from the booth)

CHILDREN WITH NORMAL HEARING

CHILDREN WITH HEARING LOSS

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Conclusions

• Children with hearing loss excel at visual tasks.
• In children with hearing loss, visual competitors detract from auditory task performance.
• Complex environments appear to be most detrimental to a child’s weakest modality.
LEARNING NEW WORDS
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
Non-word Detection
(Pittman & Schuett, in press)

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Non-Word Detection and Bandwidth
(Pittman et al, in process)

Children
19 HI Children
33 NH Children
31 HI Adults
18 NH Adults
Non-Word Detection and Bandwidth
(Pittman et al, in process)

Close all three doors.

Cooks make hot foom.

They want pum gorn.

4 kHz  9 kHz
Non-Word Detection and Bandwidth

(Pittman et al, in process)
Non-Word Detection and Bandwidth
(Pittman et al, in process)
Conclusions

• Hearing loss disrupts the detection of new words and may prolong 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

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Word Learning and Bandwidth 
(Pittman, 2008)
Word Learning and Bandwidth
(Pittman, 2008)

\[ P_c = 1 - 0.8e^{-n/c} \]
Word Learning and Bandwidth
(Pittman, 2008)
Word Learning and Bandwidth
(Pittman, 2008)
Word Learning and Bandwidth
(Pittman, 2008)
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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Word Learning and Noise Reduction
(Pittman, 2011)

Normal Hearing

8-9 YEAR OLDS

11-12 YEAR OLDS

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Word Learning and Noise Reduction
(Pittman, 2011)

Hearing Loss

8-9 YEAR OLDS

11-12 YEAR OLDS

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SO WHAT CAN WE CONCLUDE?
Conclusions

• Speech perception tests are sensitive to the overall effects of amplification.
• Cognitively demanding tasks are sensitive to the subtle effects of advanced hearing aid features.
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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