More than speech perception: Benefits of amplification for listening and learning

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Statement of Support

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Hearing Loss and Vocabulary

(Pittman & Latto, 1998-2012)
(Blamey et al, 2001)
Merging Word Recognition with Word Learning

Stimulus Input → Acoustic Phonetic Pattern Activation → Lexical Processing (Neighborhood Activation) → Unknown Lexical Decision → Word Recognition

Engagement → Higher Level Lexical Information → Rapid Word Learning

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Purpose

…to evaluate the benefits of amplification for auditory tasks that involve the detection and learning of new information.
Methodology

Testing
52 dB SPL in quiet
0° azimuth

Data collection
Computer interface
Digital audio recordings

Three visits
1 Unaided session
2-3 Aided sessions
Participants

19 children with normal hearing
22 children with hearing loss
8 to 12 years of age
Mainstreamed at grade level
Native speakers of English
Participants

15 adults with normal hearing
18 adults with hearing loss
50 to 78 years of age
Hearing aid users or candidates
Amplification

1. Bandwidth
2. Frequency Lowering
3. Digital Noise Reduction
Standard Amplification

- HEARING LEVEL (dB)
- FREQUENCY (Hz)

Unaided

Aided

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Wide-Band Amplification

[Graph showing hearing levels for unaided and aided conditions across different frequencies.]
Amplification

Oticon miniAlta RITE
Word Recognition

**Children**

- Aided-WB
- Aided-NB
- Unaided

**Adults**

- Aided-WB
- Aided-NB
- Unaided

Performance (% Correct)

Word Recognition Task
Word Recognition

Children

Wideband (% Correct)

Narrowband (% Correct)

Adults

Wideband (% Correct)

Narrowband (% Correct)

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Auditory Lexical Decision
Auditory Lexical Decision
Auditory Lexical Decision

Children

Adults

Performance (% Correct)

Task

Word Recognition

Lexical Decision

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Auditory Lexical Decision

Children

Wideband (% Correct) vs Narrowband (% Correct)

Adults

Wideband (% Correct) vs Narrowband (% Correct)
Auditory Lexical Decision

Children

- Misperception
- Ambiguity
- Misconception
- NR

Listening Conditions:
- Unaided
- NB
- WB
- NH

Errors (%)

<table>
<thead>
<tr>
<th>Condition</th>
<th>Misperception</th>
<th>Ambiguity</th>
<th>Misconception</th>
<th>NR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unaided</td>
<td>11%</td>
<td>8%</td>
<td>17%</td>
<td>28%</td>
</tr>
<tr>
<td>NB</td>
<td>2%</td>
<td>4%</td>
<td>1%</td>
<td>16%</td>
</tr>
<tr>
<td>WB</td>
<td>4%</td>
<td>7%</td>
<td>3%</td>
<td>1%</td>
</tr>
<tr>
<td>NH</td>
<td>0%</td>
<td>2%</td>
<td>1%</td>
<td>0%</td>
</tr>
</tbody>
</table>

Adults

- Misperception
- Ambiguity
- Misconception
- NR

Listening Conditions:
- Unaided
- NB
- WB
- NH

Errors (%)

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</tr>
</thead>
<tbody>
<tr>
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<td>12%</td>
<td>7%</td>
<td>16%</td>
<td>18%</td>
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<tr>
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<td>6%</td>
<td>20%</td>
<td>1%</td>
</tr>
<tr>
<td>WB</td>
<td>2%</td>
<td>3%</td>
<td>16%</td>
<td>2%</td>
</tr>
<tr>
<td>NH</td>
<td>0%</td>
<td>4%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>
Rapid Word Learning

\[ P_c = 1 - 0.8e^{-n/c} \]
Rapid Word Learning

Children

Adults

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Rapid Word Learning

Children

Adults

Performance (% Correct)

0 20 40 60 80 100

Aided-WB
Aided-NB
Unaided

Word Recognition
Lexical Decision

Task

Word Learning Speed (log 1000/n)

0 1 2 3

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Rapid Word Learning

Children

- Wideband (Speed) vs. Narrowband (Speed)

Adults

- Wideband (Speed) vs. Narrowband (Speed)

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Rapid Word Learning

SINGULAR

PLURAL

WORD1

WORD2

WORD3
Rapid Word Learning

Children

Adults

Wideband (Speed) vs. Narrowband (Speed) for Children and Adults.
Bandwidth

**Children**

- **Task**: Word Recognition, Lexical Decision
- **Performance (% Correct)**
- **Speed (log 1000/n)**

**Adults**

- **Task**: Word Recognition, Lexical Decision
- **Performance (% Correct)**
- **Speed (log 1000/n)**

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What have we learned?

1. Listening and learning are significantly improved with amplification.
2. Maximizing the bandwidth improves listening and learning further.
3. Benefit of bandwidth increases as the difficulty of the task increases.
4. Potential for benefit can go undetected if judged by word recognition alone.
What about Frequency Lowering?
Frequency Lowering

Phonak Bolero Q70-P

Level (dB SPL)

Frequency (Hz)
Frequency Lowering

Adults

- **Word Recognition**
  - Unaided
  - Aided-FC OFF
  - Aided-FC ON

- **Lexical Decision**
  - Unaided
  - Aided-FC OFF
  - Aided-FC ON

- **Word Learning**
  - Unaided
  - Aided-FC OFF
  - Aided-FC ON

Performance (% Correct) vs. Speed (log 1000/n)
Frequency Lowering

Word Recognition

Lexical Decision

Word Learning

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And then there’s noise...
The thing about noise...

1. Hearing aids make the signal-to-noise ratio worse.
2. DNR differs across manufactures.
3. Noise makes listening and learning difficult for everyone.
Digital Noise Reduction – broadband noise

SNR Output for +3dB SNR Input

Hearing Aid Manufacturer

- Resound Verso 9
- Widex Dream 440
- Phonak Bolero
- Starkey 3 Series
- Siemens Motion 7
- Oticon Alta Pro

DNR Off
DNR On

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Digital Noise Reduction – multi-talker babble

SNR Output for +3dB SNR Input

Hearing Aid Manufacturer

- Resound Verso 9
- Widex Dream 440
- Phonak Bolero
- Starkey 3 Series
- Siemens Motion 7
- Oticon Alta Pro

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Digital Noise Reduction – broadband noise

Starkey 3 Series 110

Level (dB SPL)

Frequency (Hz)

DNR OFF

DNR ON

FF Thresholds

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Digital Noise Reduction – broadband noise

Children

- Word Recognition
- Lexical Decision

Adults

- Word Recognition
- Lexical Decision

Task

Performance (% Correct)

Speed (log 1000/n)
Digital Noise Reduction – broadband noise

Children

Word Recognition

Lexical Decision

Word Learning

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Digital Noise Reduction – broadband noise

Adults

Word Recognition

Lexical Decision

Word Learning

Wideband (% Correct)

Narrowband (% Correct)

DNR On (% Correct)

DNR Off (% Correct)

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What else have we learned?

1. Optimizing the amplification bandwidth significantly benefits both children and adults.

2. No benefit or detriment to performance was found with frequency lowering or digital noise reduction.
   [Disclaimer: Other manufacturer’s devices may produce different results]

3. Cognitively demanding listening and learning tasks are sensitive to the benefits of subtle amplification features.
Thanks for listening!
(and learning)