Hearing Loss, Hearing Devices, and the Business of Learning

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Liz Presson – Oticon Medical, US

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oticon | Because sound matters

Hearing Industry Research Consortium

Arizona Community Foundation
Kids with Hearing Loss
227 Children (6 years old)

Sensorineural hearing loss

- **Mild** (15-40 dB HL)
- **Moderate** (41-60 dB HL)
- **Severe** (61-80 dB HL)
- **Profound** (>80 dB HL)

317 children (6 months to 7 years of age)

Better-ear PTA

Degree of Hearing Loss

- Slight: 5%
- Mild: 32%
- Moderate: 40%
- Moderate-Severe: 20%
- Severe: 3%
134 children (0 to 6 years)

Better ear PTA

Hearing loss requiring amplification


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Hearing and Age

<table>
<thead>
<tr>
<th>AGE (years)</th>
<th>HEARING LOSS (degree)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Profound</td>
</tr>
<tr>
<td>5</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Mild</td>
</tr>
</tbody>
</table>

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The Business of Learning
Vocabulary Development in Early Childhood

Children
317 HI Children
117 NH Children

Fig. 2. Average predicted language scores based on mixed model across ages 2 to 6 years for CNH and children who are hard of hearing grouped by severity of unaided hearing loss. CNH, children with normal hearing.
Vocabulary Development

PPVT Vocabulary Age (years) vs. Chronological Age (years)

99 HI Children
116 NH Children

Secretly Awesome

Pittman & Latto (1998-2008)
Vocabulary Development

College Students
97 Normal Hearing
93 Mild to Profound Hearing Loss

Vocabulary Knowledge and Hearing Loss

Actual Vocabulary Knowledge

<table>
<thead>
<tr>
<th>PPVT Standard Score</th>
<th>NH</th>
<th>HL</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>106</td>
<td>82</td>
</tr>
</tbody>
</table>

Overestimate Knowledge of Vocabulary

<table>
<thead>
<tr>
<th>PPVT Overestimate (120 items)</th>
<th>NH</th>
<th>HL</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>7.7</td>
<td>15.5</td>
</tr>
</tbody>
</table>


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Vocabulary Knowledge and Hearing Loss

College Students
89 Normal Hearing
25 w/Cochlear Implants <3.5 yrs
68 w/Cochlear Implants >3.5 yrs

Actual Vocabulary Knowledge

PPVT Standard Score

NH CI CI
<3.5yrs >3.5yrs
104 78 84

World Knowledge (History)

History Score

NH CI CI
<3.5yrs >3.5yrs
27 15 14

Covertino et al (2014) Word and World Knowledge Among Deaf Learners With and Without Cochlear Implants, J Deaf Studies and Deaf Ed, 19;4

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The average college student knows between 15,000 and 200,000 words (D’Anna et al 1991).

Oxford Dictionary of American English

- 430,000 total entries
- 1000+ new entries each year
  - new words
  - new definitions to existing words
What does this mean?

Children have a lot of word-learning to do.

50,000 words
learned over 18 years (3 to 22 years)
= 7 new words everyday

Adults need to update their vocabularies too.

1,000 words per year
= 3 new words every day
52% of the words we read in books are lexical “dark matter”; they are undocumented in standard dictionaries.

(A) The size of the English lexicon over time. Tick marks show the number of single words in three dictionaries. p. 177
What about adults?
On standardized vocabulary tests, older adults outperformed younger adults (Verhaeghen, 2003).

Better vocabulary scores with increasing age may be due to a cohort effect that favors the earlier born (Flynn effect).

Stahl, Marzan, and Pittman (in process)
Henriksen’s (1999) lexical knowledge model:
1. *Size* - how many words are known
2. *Depth* - how well the words are known
3. *Mastery* - comprehension and production of the words

Ashley Wagner, Editor
Oxford Dictionary of American English

Stahl, Marzan, and Pittman (in process)
<table>
<thead>
<tr>
<th>Word Type</th>
<th>#</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Longstanding words with established definitions</td>
<td>15</td>
<td>Aghast: Filled with horror or shock</td>
</tr>
<tr>
<td>Longstanding words with new definitions</td>
<td>15</td>
<td>Ship: The desire of a fan for two fictional characters to be in a romantic relationship</td>
</tr>
<tr>
<td>New words</td>
<td>5</td>
<td>Senioritis: An affliction of students in their final year of high school or college, characterized by a decline in motivation or performance.</td>
</tr>
<tr>
<td>Nonsense words</td>
<td>5</td>
<td>Desill</td>
</tr>
</tbody>
</table>

Vocabulary Then and Now Test (VTNT)
Updates to Adult Vocabulary

1. **Affirmative**
   a) To have an effect on; to make a difference to
   b) Agreeing with a statement or to a request
   c) Making an assertion
   d) To move someone emotionally
   e) I don’t know
Updates to Adult Vocabulary

1. **Affirmative**
   a) To have an effect on; to make a difference to
   b) Agreeing with a statement or to a request
   c) Making an assertion
   d) To move someone emotionally
   e) I don’t know
2. Voluntourism
   a) To freely offer services in support of a cause.
   b) The commercial organization of vacations and visits to places of interest.
   c) To enter into the military service voluntarily.
   d) A form of tourism in which travelers participate in voluntary humanitarian work.
   e) I don’t know.
Updates to Adult Vocabulary

2. **Voluntourism**
   a) To freely offer services in support of a cause.
   b) The commercial organization of vacations and visits to places of interest.
   c) To enter into the military service voluntarily.
   d) A form of tourism in which travelers participate in voluntary humanitarian work.
   e) I don’t know.
Vocabulary Then and Now Test (VTNT)

<table>
<thead>
<tr>
<th>Hearing Status</th>
<th>Age (yrs)</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unknown</td>
<td>20-39</td>
<td>68</td>
</tr>
<tr>
<td></td>
<td>40-59</td>
<td>63</td>
</tr>
<tr>
<td></td>
<td>60-74</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>144</td>
</tr>
</tbody>
</table>

Stahl (2016) Updates to adults vocabulary. ARES
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Vocabulary Then and Now Test (VTNT)

### Adults 20-92 years

<table>
<thead>
<tr>
<th>PTA (dB HL)</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-20</td>
<td>49</td>
</tr>
<tr>
<td>21-40</td>
<td>18</td>
</tr>
<tr>
<td>41-60</td>
<td>15</td>
</tr>
<tr>
<td>81-100</td>
<td>8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>94</strong></td>
</tr>
</tbody>
</table>

Performance (proportion correct)

- Old Definitions
- New Definitions

Marzan & Hutton (2018)

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When do adults and children learn new words?

Children
- School
- Home
- Friends
- Activities
- Social Media

Adults
- Second language learning
- Medical terminology
- Meeting new people
- Traveling to new places
- On the job training
- Professional conferences
Hearing Loss and Learning
Auditory Learning Tasks

- **Word Recognition**: How well they can recognize words they already know.
- **Lexical Decision Task**: How well they can recognize words they don’t know.
- **Non-Word Detection**: How well they can detect words they don’t know in context.
- **Rapid Word Learning**: How well they can learn new words.
To determine if differences in device output (like bandwidth) improve performance for auditory tasks important to learning new information.
Air-Conduction Devices

**Oticon miniAlta RITE**

<table>
<thead>
<tr>
<th>Group</th>
<th>Age (yrs)</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children w/HL</td>
<td>8-12</td>
<td>21</td>
</tr>
<tr>
<td>Adults w/HL</td>
<td>52-78</td>
<td>17</td>
</tr>
</tbody>
</table>

4 kHz: sothnud, doztul, fosnush, stomun, homtul

10 kHz: sothnud, doztul, fosnush, stomun, homtul

Level (dB SPL) vs. Frequency (Hz) graph showing FF Thresholds at 4 kHz and 10 kHz.
Bone-Conduction Devices

Conventional Skin-Drive

Percutaneous Direct-Drive

Participants
17 children
10 boys, 7 girls
7 – 15 years
14 bilateral conductive
1 unilateral conductive
2 unilateral profound

Method

Fitting & Testing

Direct Drive

Skin Drive

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Method

Verification

![Graph showing device output and difference between Skin Drive and Direct Drive methods.](image)

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Method

Verification

![Graph showing aided sound-field thresholds for Skin Drive and Direct Drive methods. The graph includes error bars and difference values.](image-url)

- Aided Sound-Field Thresholds
  - Skin Drive
  - Direct Drive

<table>
<thead>
<tr>
<th>Frequency (kHz)</th>
<th>Difference (Skin-Direct)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25</td>
<td>-2</td>
</tr>
<tr>
<td>0.5</td>
<td>-6</td>
</tr>
<tr>
<td>1</td>
<td>-14</td>
</tr>
<tr>
<td>2</td>
<td>-11</td>
</tr>
<tr>
<td>4</td>
<td>-16</td>
</tr>
<tr>
<td>8</td>
<td>-20</td>
</tr>
</tbody>
</table>

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Test Parameters
   53 dB SPL in quiet
   0° azimuth

Data collection
   Computer interface
   Digital audio recordings
Word Recognition


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Word Recognition

Aided Sound-Field Thresholds

Group | Age (yrs) | n
---|---|---
Bilateral | 7-15 | 14
Unilateral | 7-15 | 3

Δ7%

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Auditory Lexical Decision

<table>
<thead>
<tr>
<th>Repeat</th>
<th>Categorize</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swim</td>
<td>Real</td>
</tr>
<tr>
<td>Swim</td>
<td>Not Real</td>
</tr>
<tr>
<td>Srim</td>
<td>Real</td>
</tr>
<tr>
<td>Srim</td>
<td>Not Real</td>
</tr>
<tr>
<td>Whim</td>
<td>Real</td>
</tr>
<tr>
<td>Whim</td>
<td>Not Real</td>
</tr>
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Auditory Lexical Decision Task
Auditory Lexical Decision


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Auditory Lexical Decision

Aided Sound-Field Thresholds

- Skin Drive
- Direct Drive

Group | Age (yrs) | n
---|---|---
Bilateral | 7-15 | 14
Unilateral | 7-15 | 3

Skin Drive (% correct) vs. Direct Drive (% correct)

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## Non-Word Detection 2.0

<table>
<thead>
<tr>
<th># of nonsense words</th>
<th>Example phrase</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Clocks tick on time.</td>
</tr>
<tr>
<td>1</td>
<td>Birds <em>rike</em> long worms.</td>
</tr>
<tr>
<td>2</td>
<td><em>Dats</em> catch slow <em>bice</em>.</td>
</tr>
<tr>
<td>3</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>-</td>
</tr>
</tbody>
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*Pittman & Daliri (in press) Vocal biomarkers of mild-to-moderate hearing loss in children and adults: Voiceless sibilants, *JSLHR* © 2018 A. Pittman All rights reserved*
Non-Word Detection 2.0

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Non-Word Detection 2.0

Aided Sound-Field Thresholds

- Skin Drive
- Direct Drive

Difference (Skin-Direct)

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</tr>
<tr>
<td>8</td>
<td>-20</td>
</tr>
</tbody>
</table>

Group | Age (yrs) | n
--- | ------- | ----
Bilateral | 7-15 | 14
Unilateral | 7-15 | 3

Sensitivity via Direct Drive (d')

Sensitivity via Skin Drive (d')
Rapid Word Learning

\[ P_c = 1 - 0.80e^{-n/c} \]

Learning Speed:
3 = 1 trial (perfect learning)
2 = 10 trials
1 = 100 trials
0 = 1000 trials (no learning)
Rapid Word Learning


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Rapid Word Learning

Rapid Word Learning


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Speech Perception vs. Word Learning

Pittman et al. (2017) Detecting and Learning New Words: The Impact of Advancing Age and Hearing Loss, AJA, 26, 318-327.
Detecting and learning new words is...

... is essential for keeping vocabulary current

... independent of the type of amplification device

... determined by the quality of the auditory input.
Thanks for learning

http://pedamp.asu.edu/presentations