Word-Learning in Children with Hearing Loss using Digital Noise Reduction

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Why study word learning?

• Critical accomplishment of childhood
• Cognitively demanding
• Word learning is vulnerable to listener and stimulus characteristics
• Children with hearing loss have smaller vocabularies than children with normal hearing
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
TRIGGERING PARADIGM
Stimuli

Close all three doors  x0

Cooks make hot foo m  x1

They want pome gorn  x2
Triggering Paradigm
Scoring

- Overall performance (percent correct)
- Error analyses
  - Under-triggering
  - Over-triggering
E&H (in press)

EFFECTS OF SEMANTIC AND ACOUSTIC CONTEXT ON NON-WORD DETECTION IN CHILDREN WITH HEARING LOSS
Participants

45 children (7-12 years)
- 29 children with normal hearing
- 16 children with hearing loss
  - Mild to moderately-severe losses

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Results
EFFECTS OF NARROW AND WIDEBAND LISTENING CONDITIONS ON NON-WORD DETECTION

(in process)
Stimulus Bandwidth

![Graph showing stimulus bandwidth with level in dB SPL on the Y-axis and frequency in Hz on the X-axis. The graph indicates a bandwidth of 4 kHz, with different levels for narrowband (NB) and wideband (WB) frequencies.]
Preliminary Results
Normal-Hearing Children

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Preliminary Results
Hearing-Impaired Children

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Summary

• Children with hearing loss have difficulty detecting new words

• Signal degradation further reduces detection and inhibits the advantages of age
CONFIGURATION PARADIGM
Configuration Paradigm

- Novel words are created
- Novel images are obtained or created
- Paradigm relating the words to the images is administered
- Learning (performance) is assessed
Learning Game
Data Reduction

![Graph showing data reduction performance over trials](image-url)
Data Reduction

\[ P_c = 1 - 0.8e^{-n/c} \]
Data Reduction

![Graph showing performance over trials with averaged data and averaged fits.](image-url)
SHORT-TERM WORD LEARNING RATE IN CHILDREN WITH NORMAL HEARING AND CHILDREN WITH HEARING LOSS IN LIMITED AND EXTENDED BANDWIDTHS
### Stimuli

<table>
<thead>
<tr>
<th></th>
<th>4 kHz</th>
<th>9 kHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>sothnud</td>
<td><img src="speaker_icon.png" alt="Speaker" /></td>
<td><img src="speaker_icon.png" alt="Speaker" /></td>
</tr>
<tr>
<td>doztul</td>
<td><img src="speaker_icon.png" alt="Speaker" /></td>
<td><img src="speaker_icon.png" alt="Speaker" /></td>
</tr>
<tr>
<td>fosnush</td>
<td><img src="speaker_icon.png" alt="Speaker" /></td>
<td><img src="speaker_icon.png" alt="Speaker" /></td>
</tr>
<tr>
<td>stomun</td>
<td><img src="speaker_icon.png" alt="Speaker" /></td>
<td><img src="speaker_icon.png" alt="Speaker" /></td>
</tr>
<tr>
<td>homtul</td>
<td><img src="speaker_icon.png" alt="Speaker" /></td>
<td><img src="speaker_icon.png" alt="Speaker" /></td>
</tr>
</tbody>
</table>
Results

NORMAL HEARING

HEARING LOSS

PERFORMANCE (%)

TRIALS

TRIALS

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AGE-RELATED BENEFITS OF DIGITAL NOISE REDUCTION FOR SHORT-TERM WORD LEARNING IN CHILDREN WITH HEARING LOSS
Which hearing aid to use?

Hearing Aid 1

Hearing Aid 2

Hearing Aid 3

Hearing Aid 4

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### Stimuli

| List 1 | daystin  
gaysmit  
maystill  
tayskit  
kaystill |
|--------|----------|
| List 2 | smentos  
pedton  
depmost  
sentop  
kensom   |
| List 3 | sothnud  
doztul  
fonshush  
stomun  
homtul |  

Stimuli were presented in the sound field

- 0 degrees azimuth
- 50 dB SPL
- Broadband noise at 0 dB SNR
Results
Normal-Hearing Children

8-9 YEAR OLDS

11-12 YEAR OLDS

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Results
Hearing-Impaired Children

8-9 YEAR OLDS

11-12 YEAR OLDS

PERFORMANCE (%)

TRIAL

TRIAL

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There’s good news and there’s bad new.
The bad news...

- Hearing loss slows word learning
- Acoustic degradation slows word learning further
  - Narrowing the bandwidth
  - The presence of noise
- Benefits of age are reduced
The good news...

• Subtle forms of signal processing improve word learning
  • Widening the bandwidth
  • Digital noise reduction
• AND... the benefits of age are restored
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