How Extended High-Frequency Amplification Affects Word Learning in Children

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Background

- Combination of two previous studies
  - Bandwidth and perception
  - Word learning and hearing loss

Purpose

- To determine the affect of bandwidth on word learning in normal-hearing and hearing-impaired children
  - Standard bandwidth - 4 kHz
  - Extended bandwidth - 9 kHz
# Novel-Word Construction

<table>
<thead>
<tr>
<th>Manner</th>
<th>Bilabial</th>
<th>Labiodental</th>
<th>Dental</th>
<th>Alveola</th>
<th>Post Alveola</th>
<th>Palatal</th>
<th>Velar</th>
<th>Glottal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plosive</td>
<td>p b</td>
<td></td>
<td>t d</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>k g</td>
</tr>
<tr>
<td>Nasal</td>
<td>m</td>
<td></td>
<td>n</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>η</td>
</tr>
<tr>
<td>Fricative</td>
<td></td>
<td>f v</td>
<td>θ ō</td>
<td>s z</td>
<td>j ʒ j</td>
<td></td>
<td></td>
<td>h</td>
</tr>
<tr>
<td>Approximate</td>
<td></td>
<td>r</td>
<td></td>
<td></td>
<td></td>
<td>j</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lateral Approximate</td>
<td>w</td>
<td></td>
<td>l</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Novel-Word Construction

\[
\begin{align*}
pb & \quad td & \quad kg \\
m & \quad n & \quad \eta \\
f & \quad \Theta \delta & \quad sz & \quad \int & \quad \varsigma & \quad j & \quad h \\
r & \quad j \\
w & \quad l
\end{align*}
\]
Novel-Word Construction

bairil
juæp
dim
θogif
voin
zikin
taiou
huçif
## Novel-Word Construction

<table>
<thead>
<tr>
<th>bayrill</th>
<th>vojing</th>
</tr>
</thead>
<tbody>
<tr>
<td>youzzap</td>
<td>zeekin</td>
</tr>
<tr>
<td>deewim</td>
<td>tathus</td>
</tr>
<tr>
<td>thogish</td>
<td>hoochiff</td>
</tr>
<tr>
<td>bayrill</td>
<td>vojing</td>
</tr>
<tr>
<td>----------</td>
<td>----------</td>
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<td>hoochiff</td>
</tr>
</tbody>
</table>
Story Construction
Filtering

- Low-pass filtered the words at 4 & 9 kHz

<table>
<thead>
<tr>
<th>4 kHz</th>
<th>9 kHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>bayrill</td>
<td>vojing</td>
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<tr>
<td>thogish</td>
<td>hoochiff</td>
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</tbody>
</table>
# Filtering

- Low-pass filtered the words at 4 & 9 kHz
- Created two stories

<table>
<thead>
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<th>9 kHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>bayrill</td>
<td>vojing</td>
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<td>tathus</td>
</tr>
<tr>
<td>thogish</td>
<td>hoochiff</td>
</tr>
</tbody>
</table>
Filtering

- Low-pass filtered the words at 4 & 9 kHz
  - Created two stories
  - Presented to separate groups of children

<table>
<thead>
<tr>
<th></th>
<th>4 kHz</th>
<th>9 kHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Story 1</td>
<td>bayrill</td>
<td>vojing</td>
</tr>
<tr>
<td></td>
<td>youzzap</td>
<td>zeekin</td>
</tr>
<tr>
<td></td>
<td>deewim</td>
<td>tathus</td>
</tr>
<tr>
<td></td>
<td>thogish</td>
<td>hoochiff</td>
</tr>
</tbody>
</table>

Group 1: Story 1

Group 2: Story 2
Story Presentation

- Low-pass filtered half the words at 4-kHz and half at 9-kHz
- Each word was presented 3 times
- The 4-minute story was presented twice before testing

Word-learning parameters
- 8 words
- 6 presentations each
- 8 minute period
Participants

- 97 Children between 5- and 14-years-old
  - 60 Normal Hearing (mean age: 9yrs, SD: 2yrs)
  - 37 Hearing Impaired (mean age: 9yrs, SD: 2yrs)
- Estimated receptive vocabulary (PPVT III)
Results

Receptive Vocabulary (PPVT) vs. Age (years) for NH (red) and HI (blue) groups.
Results

The image shows a scatter plot that illustrates the relationship between age (in years) and word learning (% correct) for two groups: NH and HI. The plot uses red dots for NH and blue dots for HI, with fitted lines indicating the trend in word learning across different ages.
Results

Word Learning (% correct)

<table>
<thead>
<tr>
<th>Group</th>
<th>NH</th>
<th>HI</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 kHz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 kHz</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Word Learning (% correct)

NH | HI

4 kHz | 9 kHz
Results

Normal-Hearing Children

![Graph showing performance of normal-hearing children for 4 kHz and 9 kHz frequencies. The graph displays the percentage of correct word learning for different children grouped by NH and HI.](image)

- VOJING: 4 kHz, 50%; 9 kHz, 60%
- TATHUS: 4 kHz, 30%; 9 kHz, 40%
- DEEWIM: 4 kHz, 40%; 9 kHz, 50%
- HOOCHIFF: 4 kHz, 50%; 9 kHz, 60%
- THOGISH: 4 kHz, 40%; 9 kHz, 50%
- ZEIKIN: 4 kHz, 50%; 9 kHz, 60%
- YOUZAP: 4 kHz, 50%; 9 kHz, 60%
- BAYRILL: 4 kHz, 50%; 9 kHz, 60%
Results

Hearing-Impaired Children

- Word Learning (% correct)

- Performance (% correct)

- Group

- Group:
  - DEEWIM
  - VOJNG
  - HOOCHIFF
  - TATHUS
  - ZEEKIN
  - BAYRILL
  - THOGISH
  - YOUZZAP

- 4 kHz
- 9 kHz

- NH
- HI
Conclusions

- On average, performance improved slightly in the extended bandwidth condition for both groups.

- Both groups demonstrated more consistent word learning in the extended bandwidth condition.

- Consistent word learning was more apparent for the children with hearing loss.
Amplification

- Frequency shaping was calculated for each child using DSL
- Sensation levels were confirmed for each bandwidth condition
Results

![Graph showing the relationship between age (years) and receptive vocabulary (PPVT) for NH and HI participants.]
Background

The effect of stimulus bandwidth on the perception of /s/ in normal- and hearing-impaired children and adults

(Stelmachowicz, Pittman, Hoover, & Lewis 2001)
Background

Novel-word learning in normal-hearing and hearing-impaired children
(Stelmachowicz, Pittman, Lewis, Hoover 2004)