High-Frequency Amplification: Sharpening the Pencil

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How high is high-frequency?

• Hearing Aid Studies: ≤6 kHz
  – Adults
    (Buckwald et al, 1991; Ching et al 1998; Plyer & Fleck, 2006; Mackersie et al, 2004; Simpson et al, 2005)

• Laboratory Studies: 4-10 kHz
  – Adults
    (Hogan & Turner, 1998; Horwitz et al 2008; Moore et al, 2008; 2010; Ricketts et al, 2008; Turner & Cummings, 1999)
  – Children
How high is high-frequency?

• Hearing Aid Studies: $\leq 6$ kHz
  – Determine benefit that can be achieved with commercial devices
  – Determine long-term benefit
  – Limited frequency range

• Laboratory Studies: 4-10 kHz
  – Determine benefit of the full range of speech frequencies
  – Limited to short-term exposure
What acoustic-phonetic information occurs 4-10 kHz?

Boothroyd et al (1994)
Can children do without this high-frequency information?

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Stelmachowicz et al (2007)
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Stelmachowicz et al (2007)
Does HF information impact other areas of communication?

• Indirect evidence re: speech & language development
  – Effects fricative production (Moeller et al, 2007)
    • Slower rate of production development
  – Effects morpho-syntactic development (Moeller et al, 2010)
    • Inconsistent and less accurate use of the morpheme /s/
Does HF information impact other areas of communication?

• Learning New Words
  – Critical accomplishment of childhood
    • Speak effectively
    • Read comprehensively
    • Write meaningfully
  – Children with hearing loss have smaller vocabularies
    • Average 2-3 year delay
    • Delay is related to degree of hearing loss
Rapid word-learning in NH and HI children... (Pittman et al, 2005)
Rapid word-learning in NH and HI children... (Pittman et al, 2005)

“Which one is the blag?”
Rapid word-learning in NH and HI children... (Pittman et al, 2005)

Pittman et al (2005)
SHORT-TERM WORD-LEARNING RATE IN CHILDREN... (PITTMAN, 2008)
Method: Participants

- 8- to 10-year-old children
  - 36 with NH
  - 14 with HL
    - Bilateral, moderate sensorineural hearing loss

4kHz

9kHz
### Method: Novel-Words

<table>
<thead>
<tr>
<th>Word 1</th>
<th>Word 2</th>
<th>4 kHz</th>
<th>9 kHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>saθnəd</td>
<td>sothnud</td>
<td>🎧</td>
<td>🎧</td>
</tr>
<tr>
<td>daztəl</td>
<td>doztul</td>
<td>🎧</td>
<td>🎧</td>
</tr>
<tr>
<td>fasnəʃ</td>
<td>fosnush</td>
<td>🎧</td>
<td>🎧</td>
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<tr>
<td>stamən</td>
<td>stomun</td>
<td>🎧</td>
<td>🎧</td>
</tr>
<tr>
<td>hamtəl</td>
<td>homtul</td>
<td>🎧</td>
<td>🎧</td>
</tr>
</tbody>
</table>
Method: Novel-Words

![Graph showing level (dB SPL) vs frequency (kHz). The graph includes a line for 4 kHz and 9 kHz frequencies, with a shaded area indicating a decrease in level at higher frequencies.]
Method: Learning Game
**Method: Analysis**

![Graph showing performance improvement with trials](image)
Results

![Graph showing performance over trials for different conditions and frequencies.](Image)
Results

![Graph showing performance over trials with different frequencies. The graph displays two lines representing performance at 9 kHz and 4 kHz. The line for 9 kHz intersects the performance line at a higher percentage correct compared to 4 kHz. The graph is labeled with 'NH' indicating normal hearing.](image-url)
Results

![Graph showing performance over trials for different frequencies.](image)

Performance (% Correct) vs. Trials

- HL
  - 9 kHz (circles)
  - 4 kHz (squares)

The graph illustrates the improvement in performance over trials for different frequencies in a hearing loss (HL) scenario.
Results

![Graph showing performance over trials for NH and HL conditions at 9 kHz.](image-url)
Results

Performance (% correct) vs. Trials

- NH
- HL

Frequency:
- 9 kHz
- 4 kHz
Summary

• High-frequency information effects
  – Fricative production
  – Morpheme use
  – Fricative perception
  – Word-learning rate
Summary

A wearable device is needed to examine further the short- and long-term effects of high-frequency amplification.
THE END