High-Frequency Amplification: Sharpening the Pencil

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How high is high-frequency?

• Hearing Aid Studies: \(\leq 6\) 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: ≤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
    - Slower rate of production development
  - Effects morpho-syntactic development
    - 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></th>
<th>4 kHz</th>
<th>9 kHz</th>
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<tbody>
<tr>
<td>soθnəd</td>
<td>🎧</td>
<td>🎧</td>
</tr>
<tr>
<td>doztul</td>
<td>🎧</td>
<td>🎧</td>
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<tr>
<td>fosnush</td>
<td>🎧</td>
<td>🎧</td>
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<tr>
<td>stomun</td>
<td>🎧</td>
<td>🎧</td>
</tr>
<tr>
<td>homtul</td>
<td>🎧</td>
<td>🎧</td>
</tr>
</tbody>
</table>

**Novel-Words**

- soθnəd
- doztul
- fosnush
- stomun
- homtul
Method: Novel-Words

![Graph showing frequency levels](image)

- 9 kHz
- 4 kHz

LEVEL (dB SPL) vs. FREQUENCY (kHz)
Method: Learning Game
Method: Analysis

The graph shows the relationship between performance (in percentage of correct responses) and trials. The data points are plotted on a curve, indicating an increase in performance as the number of trials increases.
Results

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

- **NH HL**
- 9 kHz
- 4 kHz

Performance (% Correct) vs. Trials
Results

![Graph showing performance (%) correct over trials for NH, 9 kHz, and 4 kHz frequencies. The graph compares the performance of normal hearing (NH) subjects at 9 kHz and 4 kHz frequencies, with data points indicating an increase in performance with more trials.](image)
Results

![Graph showing performance over trials for 9 kHz and 4 kHz]

- **PERFORMANCE (% CORRECT)**
- **TRIALS**
- **HL**
  - ○ 9 kHz
  - □ 4 kHz
Results

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

![Graph showing performance (percentage correct) over trials. The graph compares NH and HL conditions at 9 kHz and 4 kHz frequencies.](image)
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