Development of linguistic duration in hearing impaired children

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Main Issues

1. Describe duration of linguistic productions in hearing impaired kids.

2. Describe developmental course at 4 and 5 years old.

3. Compare hearing impaired kids with normal hearing kids.

4. Look into reasons for differences.
Main Questions

Hearing impaired kids sound different from normal hearing kids.

Are phonetic productions longer for HI kids?

What is the developmental trajectory of HI kids?
Development of phonology

overall vowel space

spectral space

utterance duration

Consonant inventory

Brown (1973)

Vorperian & Kent (2007)

Peterson & Barney (1952)

Yoshinaga-Itano (2006)
Development of consonants

Smith & Kenney (1999)
Development of vowels

Lee, Potamianos, & Narayanan (1999)

duration reduction

variability reduction
Hearing impaired consonants

HI longer than NH, and might interact with degree of hearing

May (1996)
Hearing impaired vowels

Monsen (1974)

Uchanski and Geers (2003)
Point vowels $i u a \alpha \varepsilon$

...define articulation space

...show extreme developmental reduction

![Diagram of articulation space with symbols for different vowels]

Daniel Jones

Lee, Potamianos, & Narayanan (1999)

...are important to assess articulation via spectral information (future work on this with these samples)

![Graph showing duration of vowels with age groups]

Vorperian & Kent (2007)

Kent, Osberger, Netsell, & Hustedde (1987)
Point vowels: \textit{i u}

HI kids have bigger production differences with /i/ and /u/ than with other vowels.

Stevens, Nickerson, Rollins (1983)
Children

- Normal Hearing (n=12)
- Hearing Impaired (n=8)
  - Early-ID (n=5)
    ID at 6.5 months
    avg loss +90dBHL
  - Late-ID (n=3)
    ID at 29.3 months
    avg loss ~42dBHL
- Cochlear Implant (n=4)
- Hearing Aid (n=4)
Task

listen-and-repeat game, single word
## Consonant targets

<table>
<thead>
<tr>
<th>Stop</th>
<th>Continuant</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Obstruent</strong></td>
<td><strong>Sonorant</strong></td>
</tr>
<tr>
<td><em>pat</em></td>
<td><em>tea</em></td>
</tr>
<tr>
<td><em>pie</em></td>
<td><em>tap</em></td>
</tr>
<tr>
<td><em>pot</em></td>
<td><em>tie</em></td>
</tr>
<tr>
<td><em>tong</em></td>
<td><em>cap</em></td>
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<td></td>
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</tr>
</tbody>
</table>
## Vowel targets

<table>
<thead>
<tr>
<th>ø</th>
<th>u</th>
<th>a</th>
<th>i</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>bat</em></td>
<td><em>do</em></td>
<td><em>pot</em></td>
<td><em>beat</em></td>
</tr>
<tr>
<td><em>pat</em></td>
<td><em>zoo</em></td>
<td><em>spot</em></td>
<td><em>tea</em></td>
</tr>
<tr>
<td><em>tap</em></td>
<td><em>hoop</em></td>
<td><em>hop</em></td>
<td><em>key</em></td>
</tr>
<tr>
<td><em>cap</em></td>
<td><em>moon</em></td>
<td></td>
<td><em>see</em></td>
</tr>
<tr>
<td></td>
<td><em>new</em></td>
<td></td>
<td><em>mean</em></td>
</tr>
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Data

- about 2000 consonants
- about 2000 vowels
- MATLAB and PRAAT scripts customized for kids
- non-parametric model: >40% of 384+ groups fail F-test ($\sigma^2$), Lilliefors/Jarque-Bera tests (normality), $\chi^2$ (independence)
- bootstrapped mean and confidence intervals
Results
Consonant targets

**normal hearing**
- HI, all pooled
- HI, C.I., early-ID, >90 dB-HL
- HI, aided, late-ID, <45 dB-HL

4 year old – 5 year old
Consonants, summary

1. HI kids have longer consonants in general

2. HI kids have more durational variability

3. Development is toward shorter consonants, and early-ID/CI kids appear to have an advantage
Vowels
### Vowel targets

<table>
<thead>
<tr>
<th>🅏️</th>
<th>🅐️</th>
<th>🅑️</th>
<th>🅒️</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>æ</strong></td>
<td><strong>u</strong></td>
<td><strong>a</strong></td>
<td><strong>i</strong></td>
</tr>
<tr>
<td><em>bat</em></td>
<td><em>do</em></td>
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Vowel targets

- normal hearing
- HI, all pooled
- HI, C.I., early-ID, >90 dB-HL
- HI, aided, late-ID, <45 dB-HL

4 year old – 5 year old
Vowels, summary

1. HI kids generally have longer vowels

2. HI kids have more variable vowels

3. High vowels [i] and [u] are longer and more variable for all kids, possibly indicating those are harder for kids to master

4. Development is toward shorter vowels, and early-ID/CI kids appear to have an advantage
Main Questions

Hearing impaired kids sound different from normal hearing kids.

Are phonetic productions longer for HI kids?

yes, and more variable
durations of vowels [i] and [u] stand out

What is the developmental trajectory of HI kids?

Not too bad, although early-ID/CI kids seem to have an advantage over late-ID kids