Cochlear implants (CIs) improve the auditory signal received by an individual with hearing loss. CIs not only improve the auditory system of a person with normal hearing (NH). CIs degrade the spectral resolution of the auditory signal.

It is difficult for children with CIs to perceive place-of-articulation contrasts, which are signaled by spectral cues.

Therefore, children with CIs have difficulty with the production of contrasts that differ in spectral cues, such as /s/ and /ʃ/.

Children with CIs have less acoustic differentiation in their productions of /s/ and /ʃ/ than their NH peers.

Some evidence suggests that vowel context affects the accuracy of /s/ and /ʃ/ in normal-hearing children.

Little research exists on this phenomenon in children with cochlear implants.

Research Questions

1. Does vowel context influence the accuracy of sibilant fricative production in young children with cochlear implants, and is this influence different for productions of word-initial /s/ and /ʃ/?

2. Is the influence of vowel context on sibilant fricative production different for children with normal hearing and children with cochlear implants?

Participants

- 24 (12 females) English-speaking children between 34—65 months of age with cochlear implants
- Control group of children with normal hearing, matched for chronological age, sex, and maternal education level

<table>
<thead>
<tr>
<th>Group</th>
<th>Age</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children with CIs</td>
<td>46.5±9</td>
<td>34-65</td>
</tr>
<tr>
<td>Children with NH</td>
<td>46.5±9</td>
<td>34-65</td>
</tr>
</tbody>
</table>

PPVT-4 SS: 92 (24) Children with CIs, 119 (14) Children with NH
EVV-2 SS: 88 (24) Children with CIs, 117 (16)

Materials

- Elicitation words:
  - Words familiar to young children
  - Target consonants (/s/ and /ʃ/) always word-initial and followed by a vowel
  - Multiple Elicitations (2-5) in each vowel quadrant: high-front, high-back, low-front, low back

- Audiovisual stimuli:
  - Recordings of the words in child-directed speech.
  - Color photographs of objects
  - Pseudo-randomized order

Procedure:

- Picture-prompted, auditory word repetition task.
- Children’s productions recorded.

Analysis

- Consonants transcribed with a stepwise procedure, guided by a custom Praat script:
  1. The transcriber selected the type of consonant (e.g., sibilant fricative, nonsibilant fricative, oral stop)
  2. The transcriber selected a symbolic transcription among available options for the selected type

Visual stimuli presented along with the auditory stimuli: "sandwich" (top left), "slater" (top right), "sharing" (bottom left), and "sad" (bottom right).

Data Analysis

- 3 separate mixed-effects logistic regression models
  - Fixed effects of age (in months), group (CI), consonant (/s/), and vowel context (high-front)
  - Child-level random intercepts
  - Child-level random slopes for consonant and vowel context

- 3 dependent variables
  - Accuracy
  - Stopping errors
  - Fronting errors

Results

1. Across vowel contexts, productions by older children were produced more accurately than those by younger children.
2. Children with CIs produced both /s/ and /ʃ/ less accurately than children with NH.
3. Children with CIs produced /ʃ/ more accurately than /s/, but the opposite pattern was true of children with NH.
4. For children with CIs, /s/ was produced less accurately than /ʃ/, but the opposite pattern was true of children with NH.
5. For children with CIs, the difference between accuracy for target /ʃ/ relative to that of target /s/ was significantly diminished in back vowel contexts as compared to front vowel contexts.

Discussion

- Vowel context influenced accuracy of /s/ productions for children with CIs.
- This result has implications for both assessment and intervention.
  - The most difficult context was high-back vowels (e.g., soup, soap, suitcase).
  - The easiest context was low back vowels.
  - This result was unexpected; previous research suggests that perception of /s/ is most accurate in high back vowels.
- Assessment: /s/ is often measured in only one vowel context on standardized articulation tests.
  - Additional assessment in other vowel contexts may be needed to accurately assess /s/ productions of children with CIs.
- Intervention: Vowel context should be considered when selecting target words that are facilitating or more challenging for correct productions.

This research was supported by NIDCD grant PRJ144-46QC to Jan Edwards, Mary Beckman, and Ben Munson

Additional assessment in other vowel contexts may be needed to accurately assess /s/ productions of children with CIs.

Intervention: Vowel context should be considered when selecting target words that are facilitating or more challenging for correct productions.