The Dimensions of Real-Time Spoken Word Recognition in Cochlear Implant Users

Sarah Colby¹,², Francis X. Smith²,³, Marissa Huffman², Charlotte Jeppsen¹, John B. Muegge¹, Ethan Kutlu¹,⁴, & Bob McMurray¹,²,³,⁴
¹Department of Psychological & Brain Sciences, ²Department of Otolaryngology – Head and Neck Surgery, ³Department of Communication Sciences & Disorders, ⁴Department of Linguistics, University of Iowa, Iowa City, IA

Background
Cochlear Implants (CIs) restore a sense of sound to individuals with profound hearing loss through electric stimulation of the auditory nerve. CI users must learn to adapt to the novel input from their CI, which is spectrally degraded compared to acoustic hearing:
- Poorer input quality impacts how words are recognized
In normal hearing adults, word recognition begins immediately and proceeds incrementally (Alipertana et al., 1998; Marslen-Wilson, 1987)

In CI users, lexical access is delayed, leading to differences in how competition is resolved between competitors (Farris-Tondre et al., 2014; McMurray et al., 2017):
- Wait-and-See: characterized by slower activation of candidates, reduced competition
- Sustained Activation: characterized by increased activation of cohort competitors for longer than typical
These processing strategies have so far only been identified with small clinical samples and it is unclear if they are distinct strategies or two ends of a continuum

Research Questions
RQ1: What are the underlying dimensions of real-time word recognition among CI users?
RQ2: What are the factors that influence where listeners fall along these dimensions?
RQ3: Do these dimensions relate to clinical/real-world outcomes?

Participants (N=101)

<table>
<thead>
<tr>
<th>Device Configuration</th>
<th>N</th>
<th>Mean Age (SD)</th>
<th>Mean Device Experience (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acoustic + Electric</td>
<td>25</td>
<td>58.2 (17.7)</td>
<td>4.9 (4.2)</td>
</tr>
<tr>
<td>Hybrid</td>
<td>38</td>
<td>61.1 (12.0)</td>
<td>5.9 (3.8)</td>
</tr>
<tr>
<td>Bilateral</td>
<td>18</td>
<td>51.4 (16.6)</td>
<td>6.8 (5.7)</td>
</tr>
<tr>
<td>Unilateral</td>
<td>20</td>
<td>54.3 (15.3)</td>
<td>12.6 (9.3)</td>
</tr>
</tbody>
</table>

Methods

Participants click on the picture that best matches the word they heard
Visual display presents target, cohort, rhyme, and unrelated item (e.g., sandwich, candle, penguin)
60 item sets x 4 items/set x 1.25 repetitions/set = 300 trials (Each item from a set is the target word once + one randomly repeated)

Principal Component Analysis (PCA)
Used to identify orthogonal dimensions from parameters of non-linear curves fit to Visual World Paradigm data +/- 1.5 SDs of the first three principal components (PCs)

Results

Distribution of participants across Wait & See and Sustained Activation dimensions based on onset of deafness (Shaded area represents 95% confidence interval)

Listeners fall along similar processing dimensions
Normal hearing listeners (from Colby & McMurray, 2022) project onto smaller area of CI users’ processing space

Principal Component Analysis

PC1: Wait & See (28.6% var.)
PC2: Sustained Activation (21.5% var.)
PC3: Activation Rate (11.9% var.)

Additional PCs do not relate to word recognition

Summary & Conclusion

Previously identified processing profiles emerged as independent dimensions:
- Wait & See predicted by onset of deafness, device experience, and functional acoustic hearing
- Sustained Activation predicted by age and onset of deafness

Clinical outcomes of word and sentence recognition predicted by processing dimensions identified by PCA
- Wait & See predicts word and sentence recognition
- Sustained Activation predicts word, sentence recognition and real-world satisfaction (SSQ)
- Activation Rate predicts sentence recognition

These processing profiles are not adaptive, but may be overcompensation to hearing loss
- Listeners who have high PC values have worse outcomes

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References


*Department of Psychological & Brain Sciences, ²Department of Otolaryngology – Head and Neck Surgery, ³Department of Communication Sciences & Disorders, ⁴Department of Linguistics, University of Iowa, Iowa City, IA*