Spectral Modulation Depth Detection Predicts Spoken Language Abilities of Adolescents with Normal Hearing and Cochlear Implants

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BACKGROUND

Children with CIs display disproportionately large phonological deficits, not explained by age of first implant. We need to find a way to ameliorate these deficits to improve outcomes for children with CIs.

Hypotheses

#1: Spectral processing abilities will constrain acquisition of phonological sensitivity through its effect on acoustic cues.
#2: Spectral processing abilities will be related to speech recognition in noise, suggesting a relationship to speech resolution.
#3: Spectral processing abilities will not constrain lexical or syntactic skills as much because coarse acoustic structure can support those processes.
#4: Factors related to the implant may affect spectral processing, making it possible to improve this ability.

METHOD

Stimuli

• Spectral modulation is sinusoidal in dB
• Depth defined as peak-to-valley difference (dB)
• 0.5 nipples per octave
• Speech-shaped envelope
• 500 ms long, 150 ms ramps
• Presented at 68 dB SPL
• Modulation phase varied across trials

Adaptive Procedures

• 3 interval, forced choice
• 30 dB difference at start
• 2 down, 1 up -> 70% correct
• 12 reversals
• 4 dB change, first 4
• 2 dB change, last 8
• Mean threshold across two runs used as DV

Other Measures

• Fricative vowel labeling
• Sentences in noise and quiet (NH = 3 dB; CI = 6 dB)
• Phonological Awareness (PA): Final consonant choice (FCC)
• Vocabulary: Expressive
• Syntax: Sentence Comprehension

RESULTS

MEAN OUTCOMES

<table>
<thead>
<tr>
<th>Stimulation</th>
<th>Mean</th>
<th>SD</th>
<th>Median</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>NH (30)</td>
<td>0.5</td>
<td>1</td>
<td>0.5</td>
<td>0.05</td>
</tr>
<tr>
<td>CI (20)</td>
<td>0.5</td>
<td>1</td>
<td>0.5</td>
<td>0.05</td>
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</table>

Correlation Coefficients

<table>
<thead>
<tr>
<th>Stimuli</th>
<th>PA</th>
<th>FCC</th>
<th>IQ</th>
<th>SI</th>
<th>Speech in Noise %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Threshold</td>
<td>0.07</td>
<td>0.16</td>
<td>0.21</td>
<td>0.08</td>
<td>0.03</td>
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CONCLUSIONS

1. H1 was supported because spectral processing was strongly correlated with phonological awareness; however, the effect for children with CIs was not associated with acoustic cue weighting. This outcome raises interesting questions regarding how children with CIs recover phonemic segments, if not through acoustic cues.

2. H2 was supported, because a correlation was found for SMDD thresholds and speech in noise recognition. However, a stronger relationship was found for spectral processing and speech recognition in quiet that was observed for children with CIs.

3. H3 was supported because spectral processing abilities were not correlated with vocabulary or syntactic knowledge and skill.

4. H4 was supported by the finding of a significant relationship between SMDD and aided auditory thresholds. Although this is just one implant-related measure, it suggests that further investigation could prove fruitful in identifying a way to enhance spectral processing, but any dependent variables should be phonological in nature.

What explains spectral processing (SMDD) in children with CIs? Only a factor associated with the implant: aided thresholds.

Is there significance in the real world? Yes, SMDD thresholds correlate with reading and verbal working memory, two tasks previously shown to depend on phonological awareness.

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