Children With Cochlear Implants: Cognitive and Language Factors Towards Speech Understanding in Noise

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Disclaimer

I declare that I have no proprietary interest in any product, instrument, device, service, or material related to this presentation.
The Speech Chain

Top down – cognitive processing impacts how sensory information is decoded

Bottom up – saliency of speech impacts access to linguistic and semantic content

Denes & Pinson, 1993
The problem: speech in noise

• Cochlear implant (CI) users listen through a degraded system (impaired ear, electrical hearing with limited spectral and temporal detail)

• Speech understanding is made worse by noise and reverberation

• Speech in noise understanding is more difficult among young children; auditory development continues through adolescence (Werner, 2007)

• Opportunities for improving speech in noise exist
• **Acoustic enhancements: clear speech**
  - characterized by a wide range of acoustic-articulatory adjustments
  - enhances intelligibility for various listener populations
    - Adults with hearing loss, children with and without learning impairments, low proficiency non-native listeners (Bradlow et al., 2003; Bradlow and Bent 2002, Cassie et al., 2001)
• **Semantic enhancements: highly predictive, contextual information**
  
  • Children less effective in noise compared to adults (Nittrouer & Boothroyd, 1990; Elliot, 1979)
    • Young children’s limited knowledge
  
  • Children equally effective as adults when noise levels adjusted (Fallon, Trehub & Schneider, 2002)
    • Comparable gains from context
Goals:

• Word recognition in adverse conditions (noise) for children and adult CI listeners and control groups of children and adults with normal or near normal hearing (NH)

• Do CI children and adults apply similar strategies for listening to speech in noise compared to NH children and adults

• Do these groups use acoustic enhancements, semantic enhancements independently and combined?
• Participants:
  • Production:
    • 2 adults (1 male, 1 female)
    • 60 HP + 60 LP sentences
    • Conversational and clear speaking style
    • Total of 480 sentences
  • Perception
    • 15 children with cochlear implants (7;0 -12;0 years of age)
    • 18 children with normal hearing (6;9 – 12;6 years of age)
• Materials:
  • 120 sentences designed specifically for use with children (Fallon, Trehub & Schneider, 2002)
    • 60 high predictability (HP) sentences spoken in conversational speech, and again in clear speech
    • 60 low predictability (LP) sentences spoken in conversational speech, and again in clear speech
  • HP
    • Mice like to eat cheese.
    • Rain poured from the cloud.
  • LP
    • He looked at the cheese.
    • We pointed at the cloud.
Results: Production

Target word duration

Talker

Female

Male

context
LP
HP

duration (ms)

conv clear conv clear

style

200 400 600 800
Results: Production

Target vowel duration

Talker

Female

Male

context

LP

HP

duration (ms)

style

conv

clear

conv

clear

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Participants: Experimental Tasks

*NH Children* (n = 18)

- Hearing thresholds better than 20 dB HL .5-4KHz

*CI Children* (n = 15)

- 11 cochlear (6 bilateral, 5 bimodal), 4 AB (2 bilateral, 2 bimodal)
- The cochlear children all used ADRO and ASC
- Tested in their preferred listening program
Procedures

1) Cognitive, language testing
   - LEITER-R Performance Scale (non-verbal IQ)
   - Oral Written Language Scale (OWLS)
   - Wide Range Assessment of Memory and Learning (WRAML)
     - Attention subtest
   - Comprehensive Test of Phonological Processing (CTOPP)
     - Phonological awareness
     - Phonological memory
     - Phonological naming

2) Speech in noise testing
   - 240 sentences: blocked by talker, style and context; order of blocks pseudo-random
   - Repeat the final word; recorded by the experimenter
   - Target sentences mixed with spectrally matched noise
   - Noise presented at 60 dB SPL (A)
   - SNR determined individually by adaptive pre-test
Results: Clear Speech

[Graph showing RAU for Plain Low, Plain High, Clear Low, and Clear High categories with CI and NH conditions.]
Cognitive and language tests

<table>
<thead>
<tr>
<th>Test</th>
<th>NH</th>
<th>CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>OWLS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Receptive</td>
<td>104.6*</td>
<td>92.0 (SD 14.9)</td>
</tr>
<tr>
<td>Expressive</td>
<td>109.5*</td>
<td>97.0 (SD 15.0)</td>
</tr>
<tr>
<td>WRAML</td>
<td>Attention</td>
<td>102.6</td>
</tr>
<tr>
<td>CTOPP</td>
<td>Awareness</td>
<td>103.0*</td>
</tr>
<tr>
<td></td>
<td>Memory</td>
<td>93.3</td>
</tr>
<tr>
<td></td>
<td>Naming</td>
<td>100.8</td>
</tr>
<tr>
<td>LEITER</td>
<td>Non-verbal</td>
<td>104.4</td>
</tr>
</tbody>
</table>
Results: Clear Speech

- Phonological awareness, $p = .04$
- Phonological memory, $p = .009$
- Phonological naming, $p = .02$
- Attention, $p = .04$
Summary

• Children with cochlear implants and children with normal hearing benefit from acoustic enhancement of speech

• Benefits from semantic enhancement are realized in combination with clear speech

• This may demonstrate that improved lower level sensory input allow access to higher order processing