There’s a Brain Between Those Cochleae: Cognitive Factors That Impact Speech Understanding in Children with Hearing Loss

Dawna Lewis, Ph.D.
Director, Listening and Learning Laboratory
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dawna.lewis@boystown.org
“The brain is there to keep the cochleae warm”

Michael Gorga and Steve Neely

Researchers at BTNRH

For you!

Gee, thanks!
First things first

• Audibility of the incoming signal
  – Signal level
  – Degree of hearing loss
  – Amplification
  – Acoustic conditions

• Cumulative auditory experience
  – Access to auditory input over time
Interpreting the incoming signal in the real world

• Auditory grouping/streaming of the signal
  – Localization of signals
  – Segregating sounds
  – Selective attention

• Processing the input
  – Listening effort
  – Language
  – Memory
  – World Knowledge
SHARP can be downloaded from http://AUDRES.org
• **Speech recognition in noise and reverberation**
  – Children with HL perform more poorly than those with NH
    (e.g., Anderson & Goldstein 2004; Anderson et al. 2005; Bess et al. 1986; Blair et al. 1985; Crandell, 1993; Finitzo-Heiber & Tillman, 1978; Leibold et al., 2013; Rance et al., 2007; Ruscetta et al. 2005)

• **Segregation/selective attention for speech**
  – Effects of spatial separation of target and masker signals (spatial release from masking)
  – Children with bilateral hearing loss may not show the same benefit from spatial separation as those with NH (e.g., Ching et al., 2011)
• Speech recognition in noise and reverberation
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    (e.g., Anderson & Goldstein 2004; Anderson et al. 2005; Bess et al. 1986; Blair et al. 1985; Crandell, 1993; Finitzo-Heiber & Tillman, 1978; Leibold et al., 2013; Rance et al., 2007; Ruscetta et al. 2005)

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• Segregation/selective attention for speech
  – Masking effects
    • Energetic versus informational
  – Both speech noise and 2-talker maskers negatively affect speech recognition in children with HL relative to those with group but effect is greater for 2 talkers (Leibold et al., 2013)
  – Speech recognition with 2-talker but not speech masker strongly related to parents’ perceptions of children’s auditory development (Hillock-Dunn et al., 2015)
Auditory Experience and Outcomes

• Different aspects of auditory experience have been examined across a wide range of studies
  – timely intervention, audibility, consistent use of amplification

• These may differentially affect outcomes individually or in combination
  – Auditory-skill development
  – Speech perception
  – Speech/language development
  – Academic skills
  – Psychosocial development

http://www.speechdevelopment.org/EDCHL.html
Task Complexity

Categories from Erber (1982) re: Auditory Skill Development
Complex Listening Tasks

Recent studies examining speech understanding in children with HL have used a variety of cognitively demanding tasks to more closely represent real-world listening.

Measures beyond speech understanding to address HL effects.
• Word learning
  (Stelmachowicz et al., 2004; Pittman et al., 2005; Pittman & Rash, 2015)

• Dual-task paradigms
  (Hicks & Tharpe, 2002; McFadden & Pittman, 2008)

• Verbal processing time measures
  (Lewis et al., in press; McCreery & Stelmachowicz, 2013)

• Comprehension tasks
  (Jerger et al., 2006; Lewis et al., 2015; Lewis et al., in review;)

• Fatigue
  (Bess et al., 2016; Hicks & Tharpe, 2002; Hornsby et al., 2014)

• Functional Health
  (Bess et al., 1998; Davis et al., 2002)
Listening and Learning Lab

- Complex Listening Tasks
- Evaluating the influence of dynamic features of multi-source environments that impact speech understanding in isolation and in combination for children with hearing loss
Comprehension and sentence recognition in a simulated classroom environment

(Lewis et al., 2015)
• 18 children (8-12 yrs) with NH and 18 with MBHL/UHL
  – 8 with bilateral HL
  – 10 with unilateral HL
• Age-matched
• WASI 2FSIQ within 1.25 SD of mean
• All testing completed without amplification
• **Realistic classroom learning task**
  • *video recordings* of talkers positioned around the subject,
  • Teacher + 4 Students
• **Speech recognition task**
  • Sentence repetition by single talker
  • Auditory-only from 5 loudspeakers
• **Acoustical environment**
  • Background noise at 50 dBA; Talkers presented at 60 dBA (+10 dB SNR)
  • 600 ms RT60 at 1 kHz
• **Looking Behavior**
• Despite performing at or near ceiling on the sentence recognition task, children with MBHL/UHL performed more poorly than children with NH on more complex listening tasks.

• Individual looking behaviors vary
  – Children with MBHL/UHL showed a different pattern of looking behavior than the NH children.

• Attempting to visualize the talker may inefficiently utilize cognitive resources.
Looking Behavior and AV Speech Understanding in Children with NH and Children with MBHL/UHL (Lewis, Smith, Spalding & Valente, in review)

- Listener instructed to follow verbal directions for placing objects on a mat
- Speech = 60 dB SPL
- MTB = 55 dB SPL
- Eye-tracking to monitor looking behavior
Possible Strategies for Visual Attention

• Children track individual talkers in detail, with focused attention on relevant sources of information

• Children adopt a more diffuse attentional stance, monitoring the environment as a whole

• Children focus attention on task rather than talkers
Results

NH group > MBHL/UHL group
No differences between MBHL and UHL
ST > MT > MTC
- NH group > MBHL/UHL group
- No differences between MBHL and UHL
- No effect of condition
• Children with MBHL/UHL performed more poorly than children with NH as the listening requirements became more complex

• Visual attention differed for children with MBHL/UHL and children with NH
  – May represent different strategies during a complex task

• There were no differences between children with MBHL vs. UHL
Effect of UHL Localization and Speech Recognition

_Preliminary results_ from my lab for children with UHL or NH (8-12 yrs)

- Low-predictability sentences presented from 5 locations around listener
- Speech presented at 65 dBA
- SNR: 0 dB for NH; 3 dB for UHL
- RT: 0.6 sec
What if We Add Visual Cues?
• Results thus far suggest......
  – Children with UHL need a better SNR than those with NH to achieve similar speech recognition for AO presentations
    • However, variability greater for children with UHL
  – For AV presentations, improvements may be greater for children with NH
  – Locating talkers shows more improvement for children with UHL when going from AO to AV but that doesn’t necessarily translate to better performance
Summary

• In children with hearing loss, speech understanding will be impacted by the signal entering the ears and how that signal is processed, interpreted and understood
• Multiple factors play a role peripherally and centrally
  – Present and cumulative
• Understanding the roles and interactions of these factors is critical for providing communication access for children with hearing loss
• Tasks that are representative of children’s real-world listening requirements are needed as well as consideration of both current and cumulative auditory experiences
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