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

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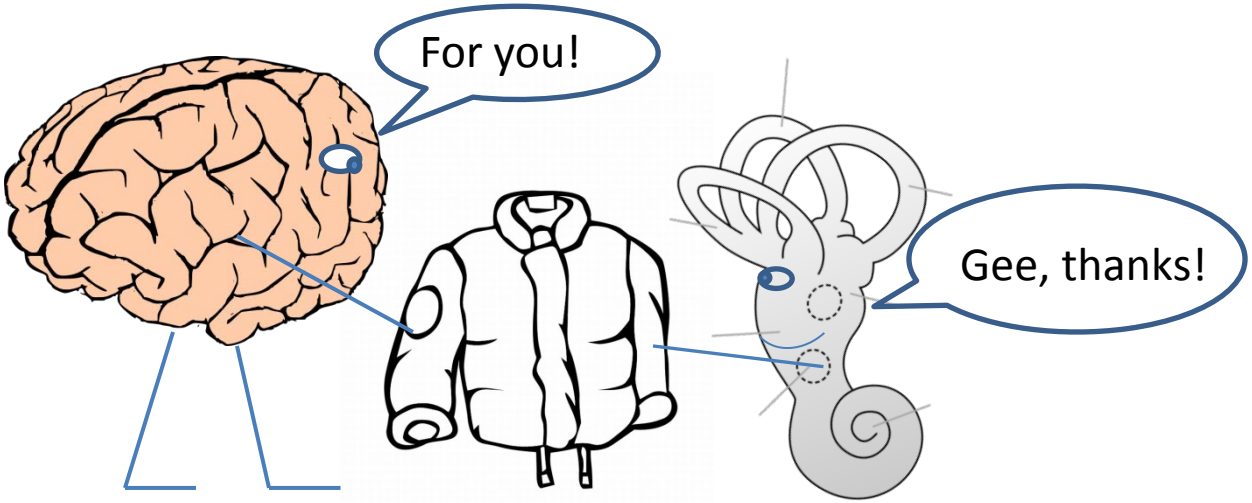
“The brain is there to keep the cochleae warm”

Michael Gorga and Steve Neely

Researchers at BTNRH



First things first

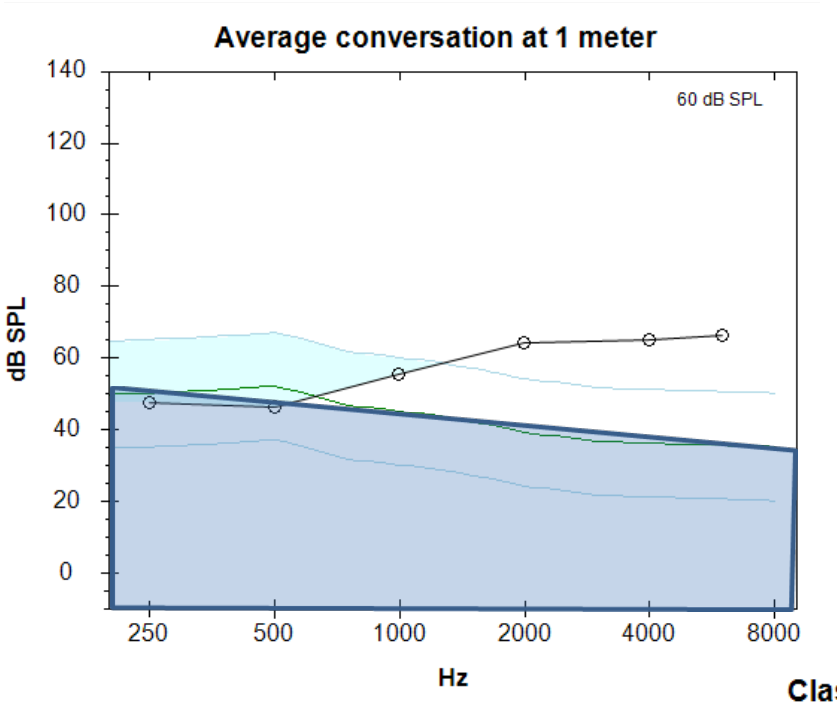
- Audibility of the incoming signal
  - Signal level
  - Degree of hearing loss
  - Amplification
  - Acoustic conditions

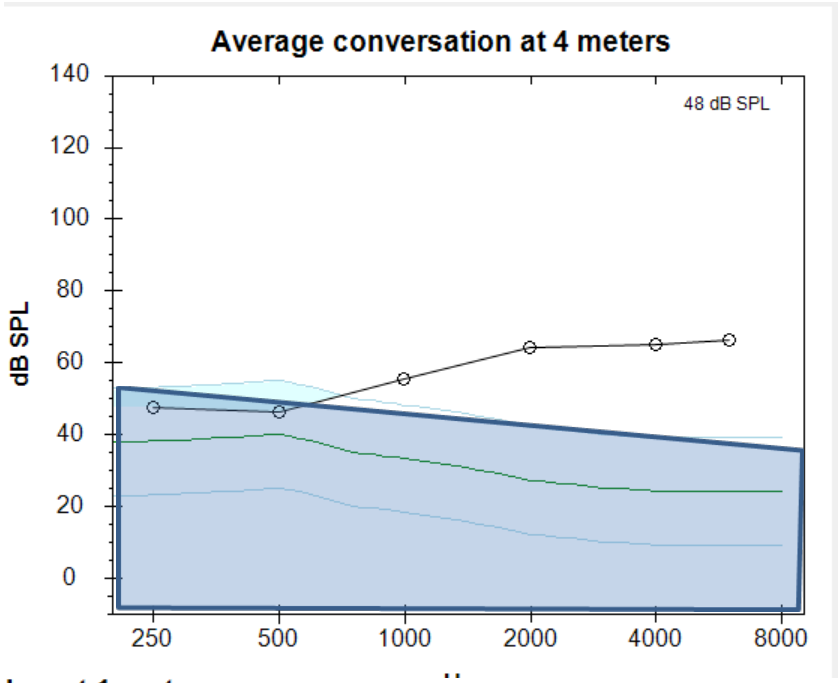
- Cumulative auditory experience
  - Access to auditory input over time

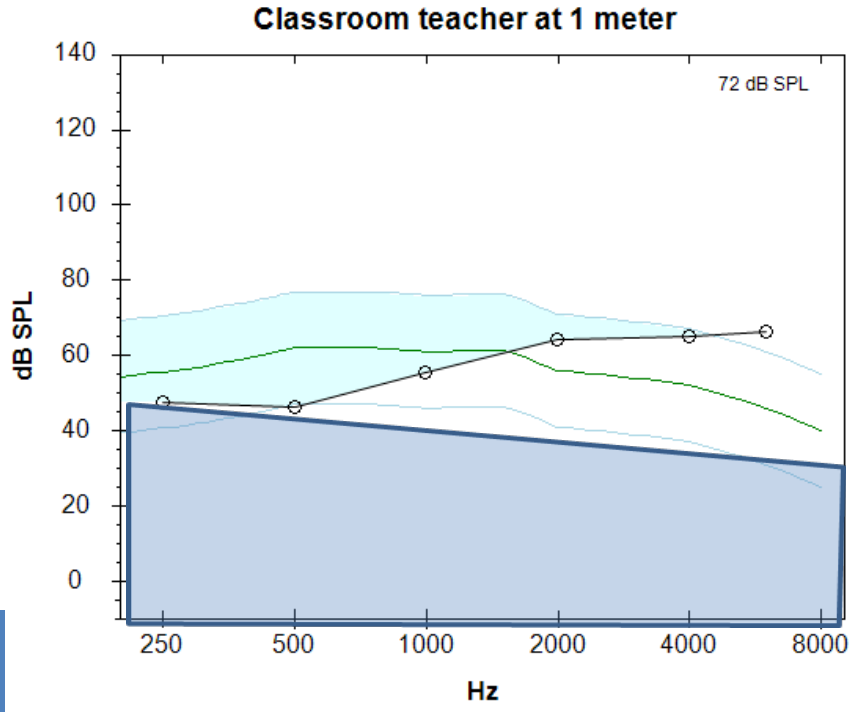
Interpreting the incoming signal in the real world

- 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

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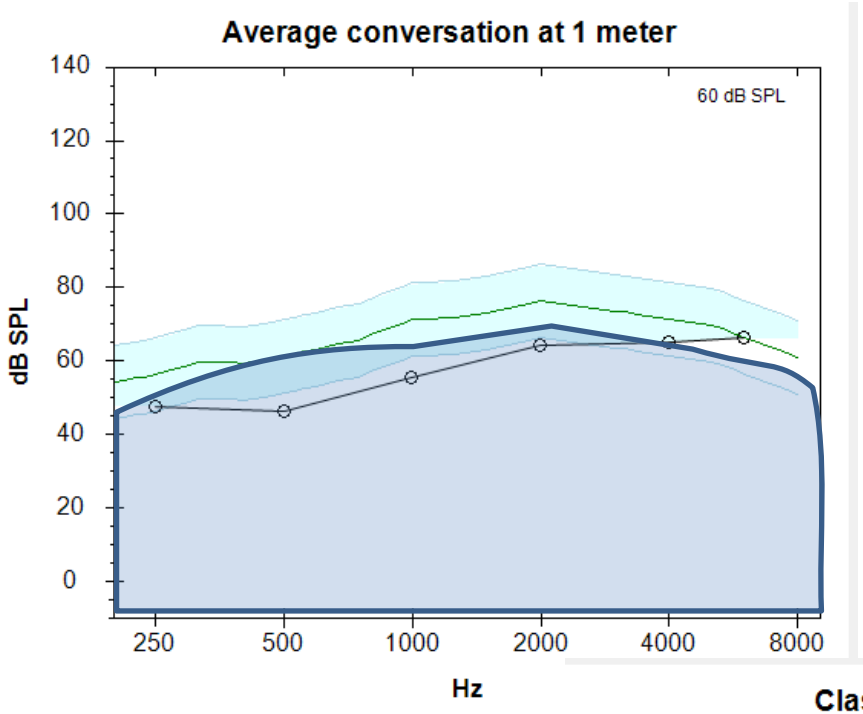
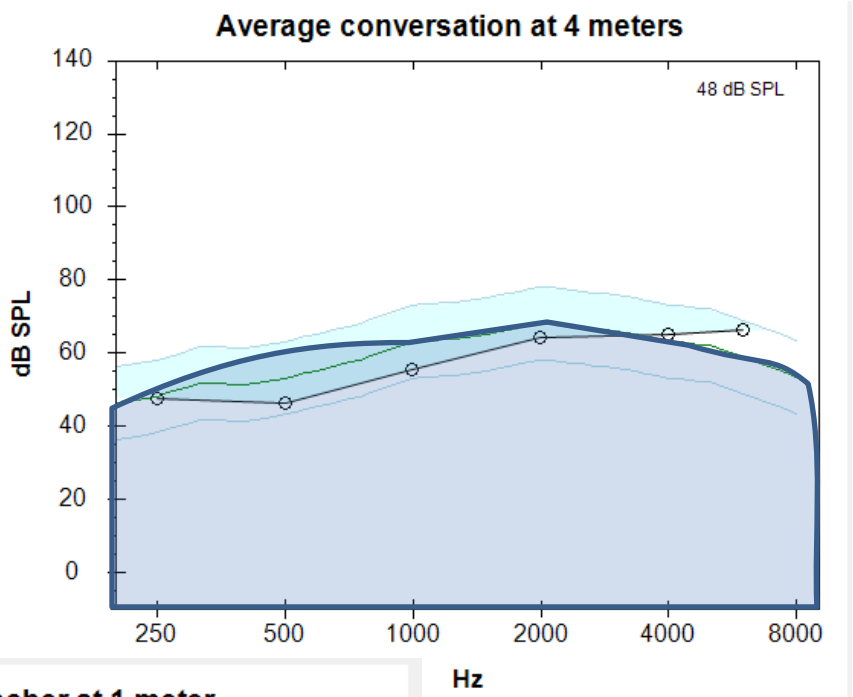
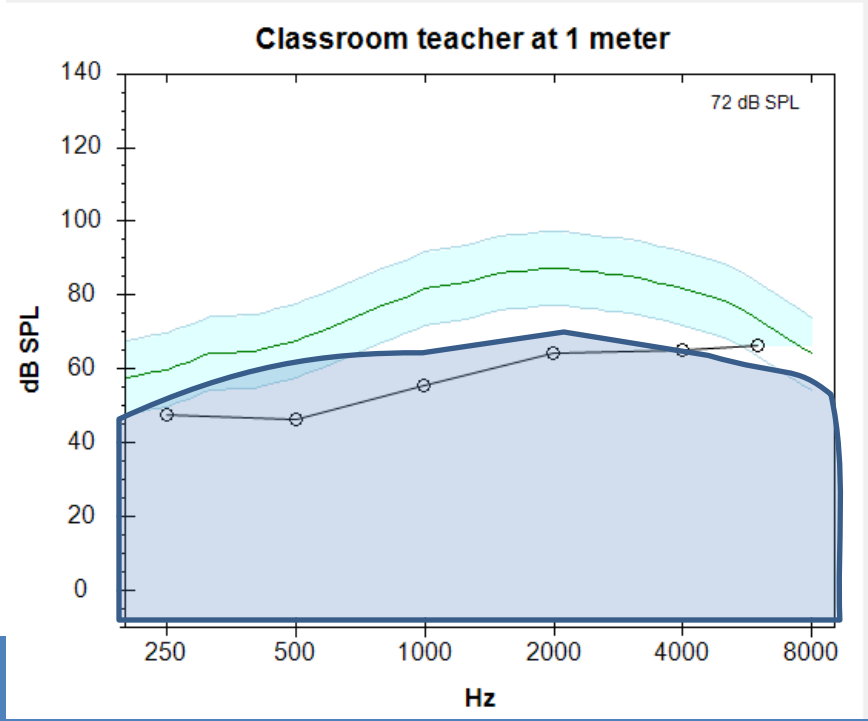

Average conversation at 1 meter
60 dB SPL
dB SPL
140
120
100
80
60
40
20
0
250
500
1000
2000
4000
8000
Hz


Average conversation at 4 meters
48 dB SPL
dB SPL
140
120
100
80
60
40
20
0
250
500
1000
2000
4000
8000
Hz


Classroom teacher at 1 meter
72 dB SPL
dB SPL
140
120
100
80
60
40
20
0
250
500
1000
2000
4000
8000
Hz

- **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)

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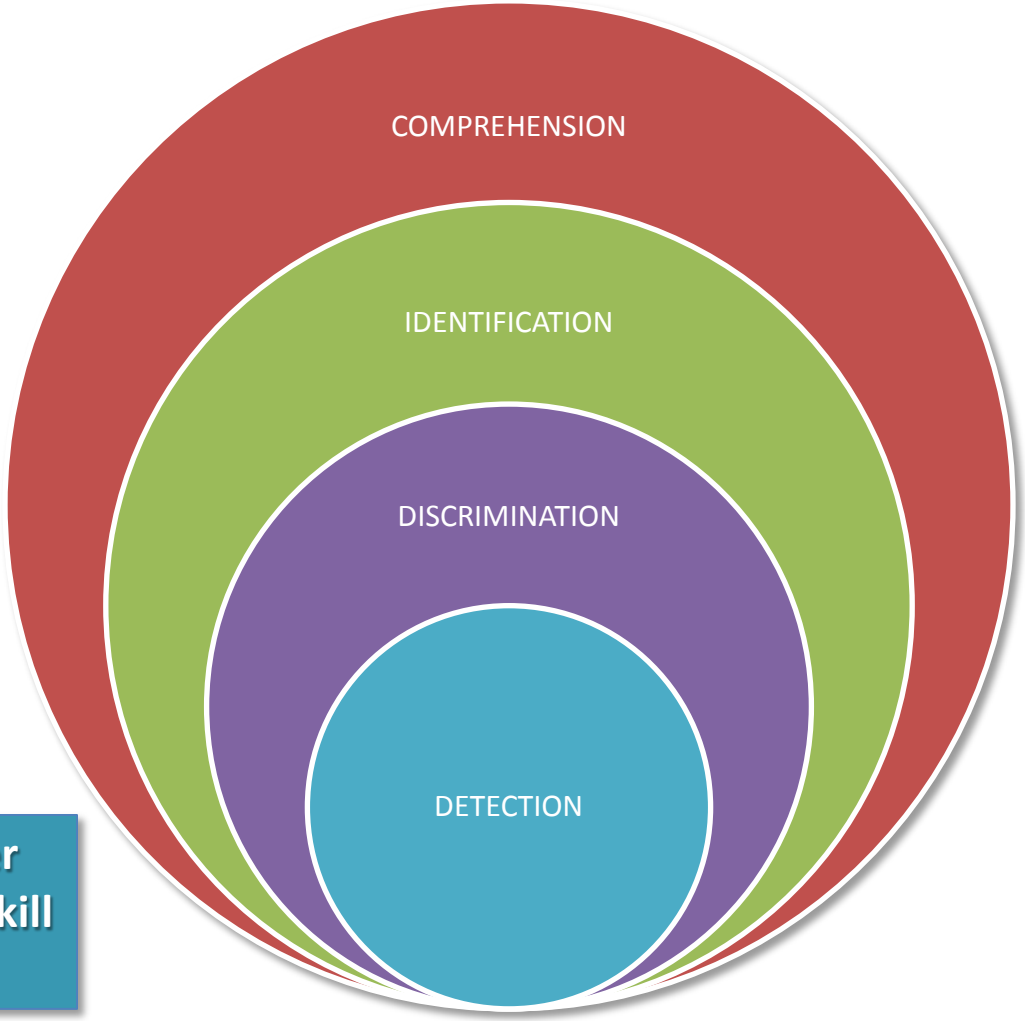
- **Segregation/selective attention for speech**
  - Masking effects
    - Energetic versus informational
  - Both speech noise and 2-talker maskers negatively affect speech recognition in children with HL relative to those with group but effect is greater for 2 talkers (Leibold et al., 2013)
  - Speech 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://ochlstudy.org/index.html ; http://outcomes.nal.gov.au/ ; https://www.mariondowns.com/necap-national-early-childhood-assessment-project ; 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

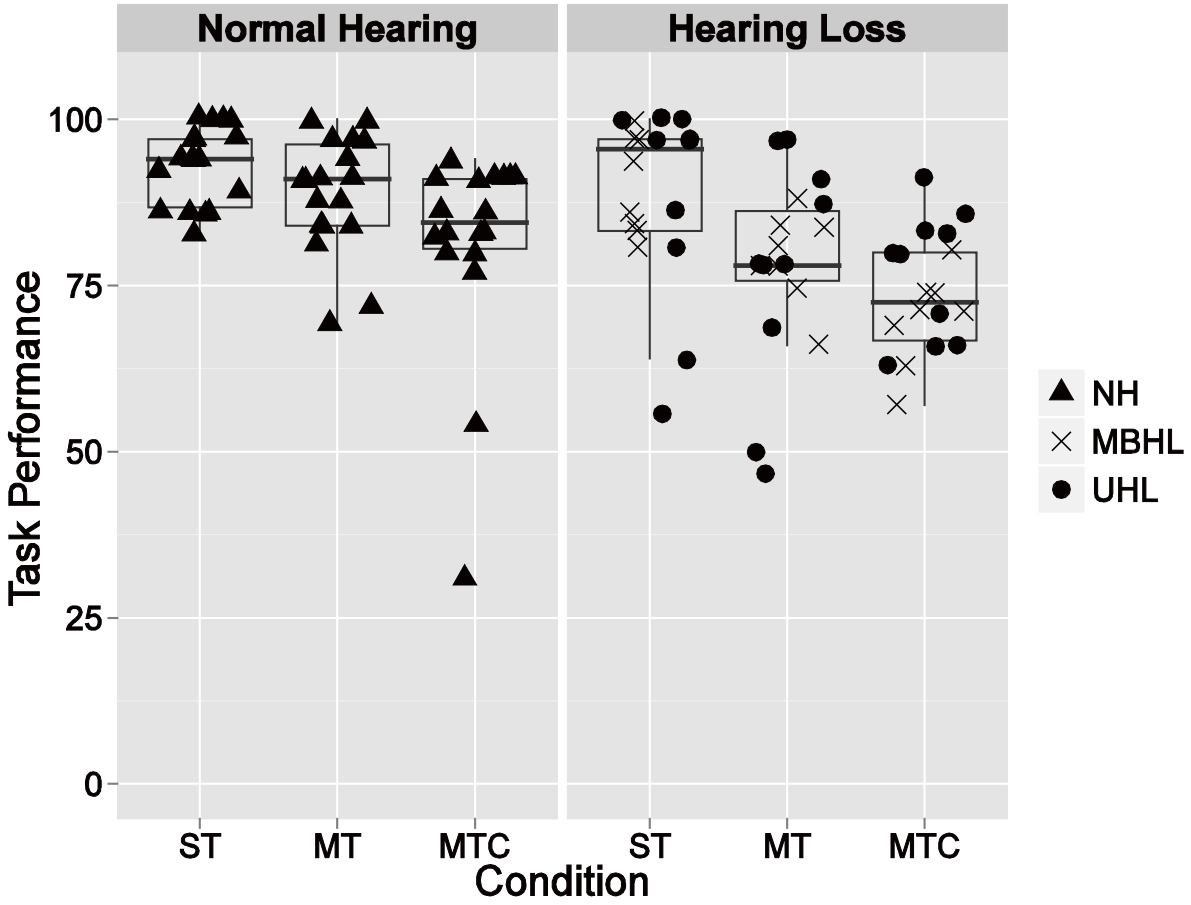
(Lewis, Smith, Spalding & Valente, in review)

- 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

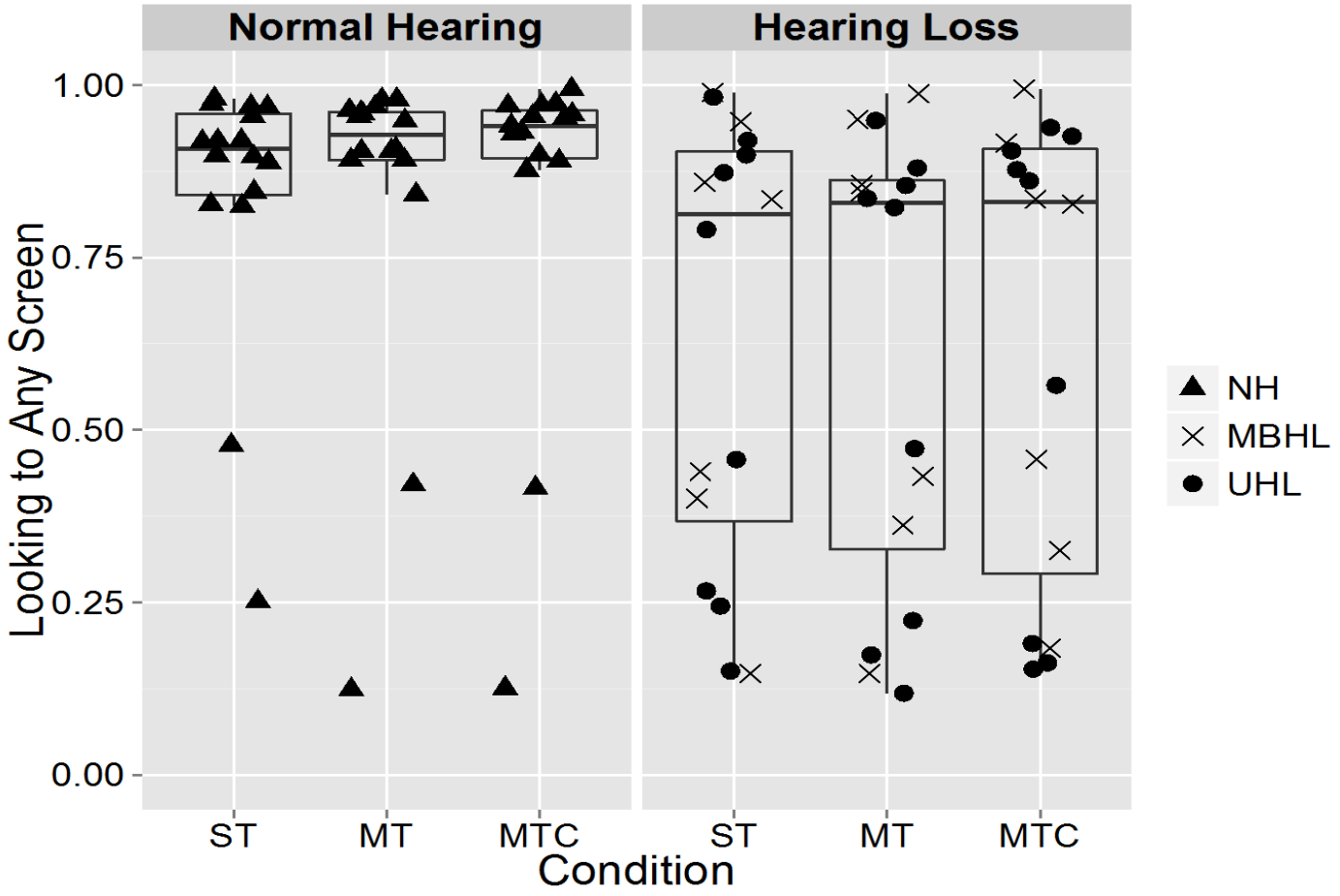
Results



NH group > MBHL/UHL group

No differences between MBHL and UHL

ST > MT > MTC



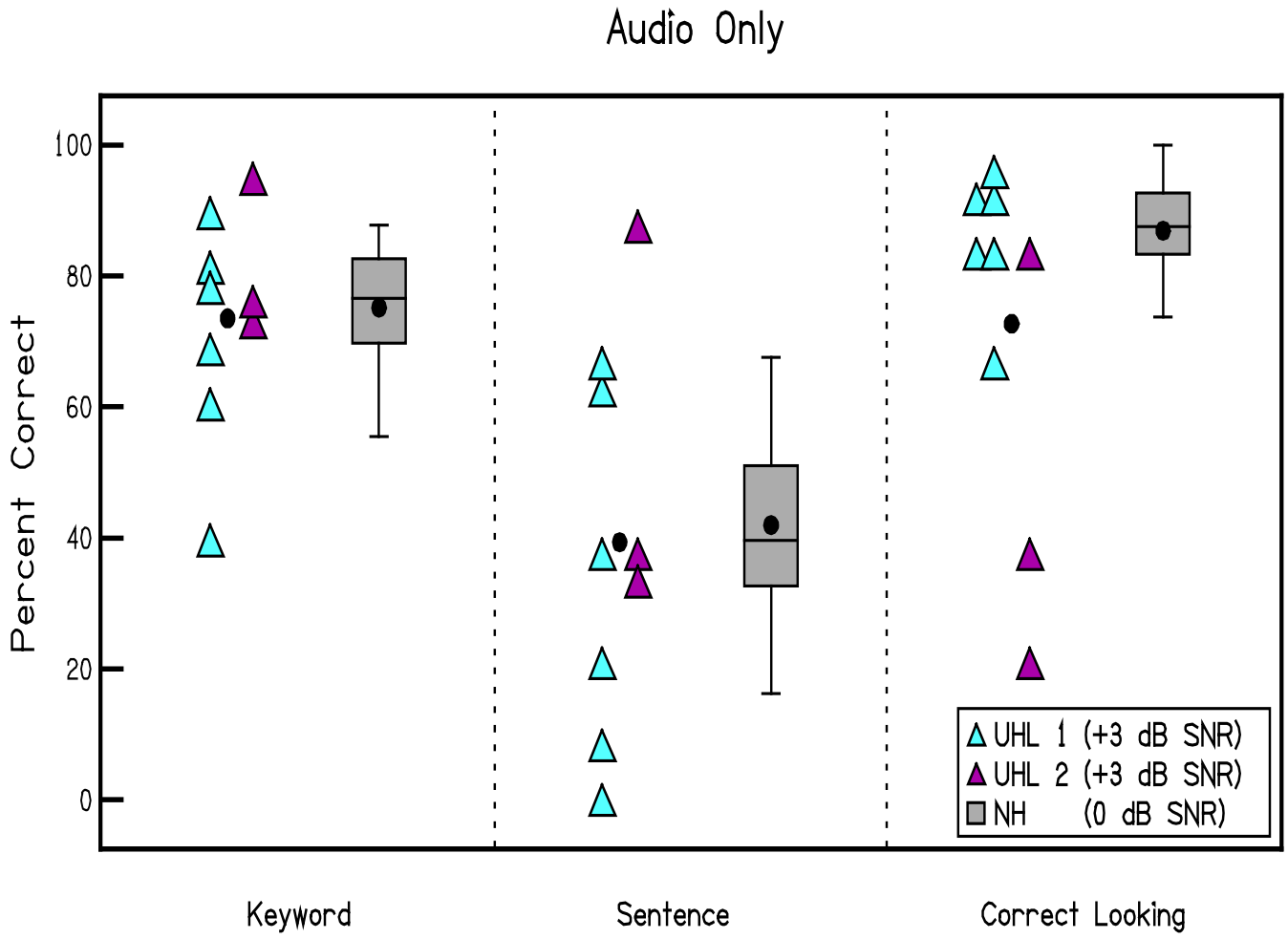
- NH group > MBHL/UHL group
- No differences between MBHL and UHL
- No effect of condition

- 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

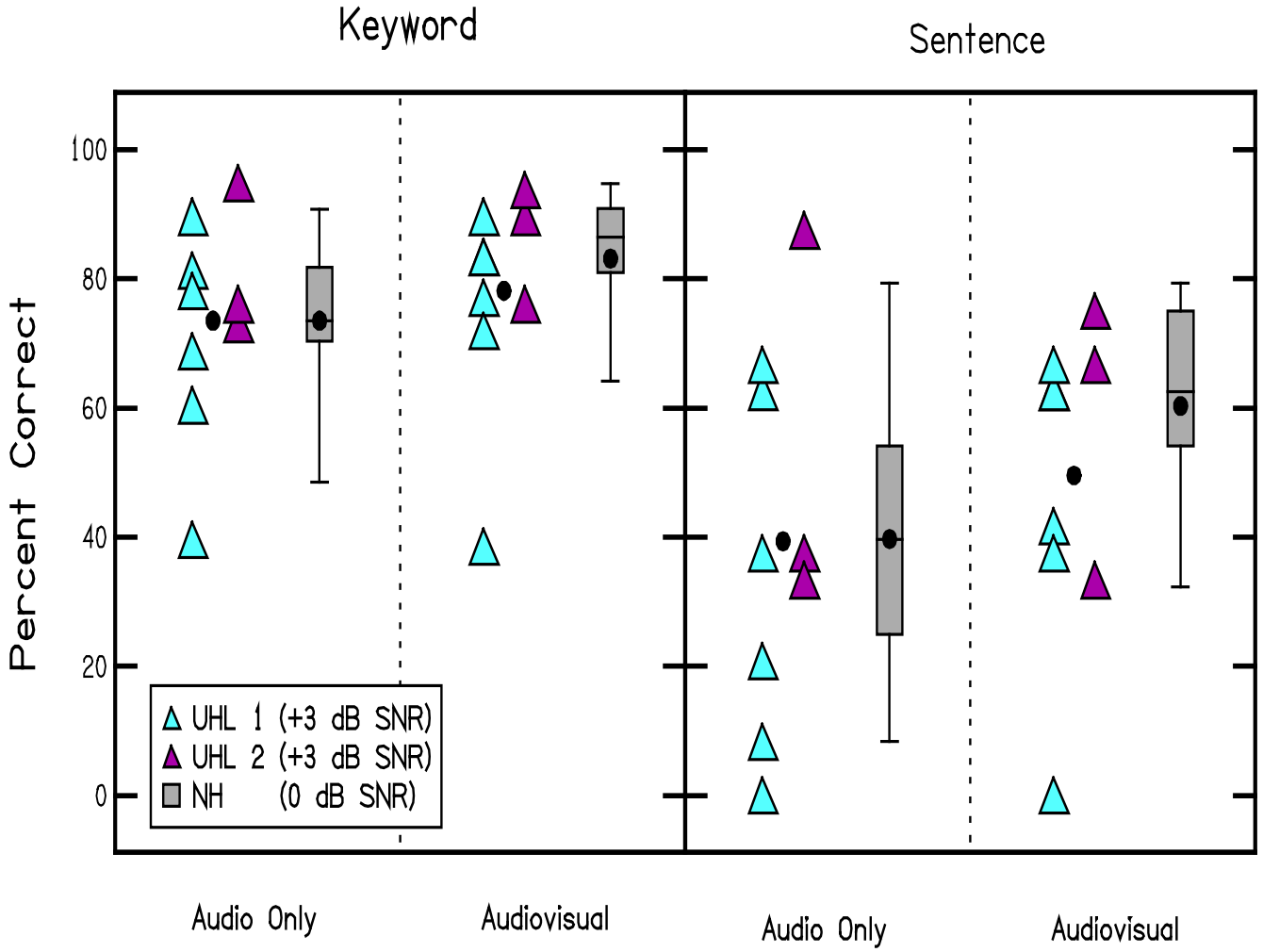
Effect of UHL Localization and Speech Recognition

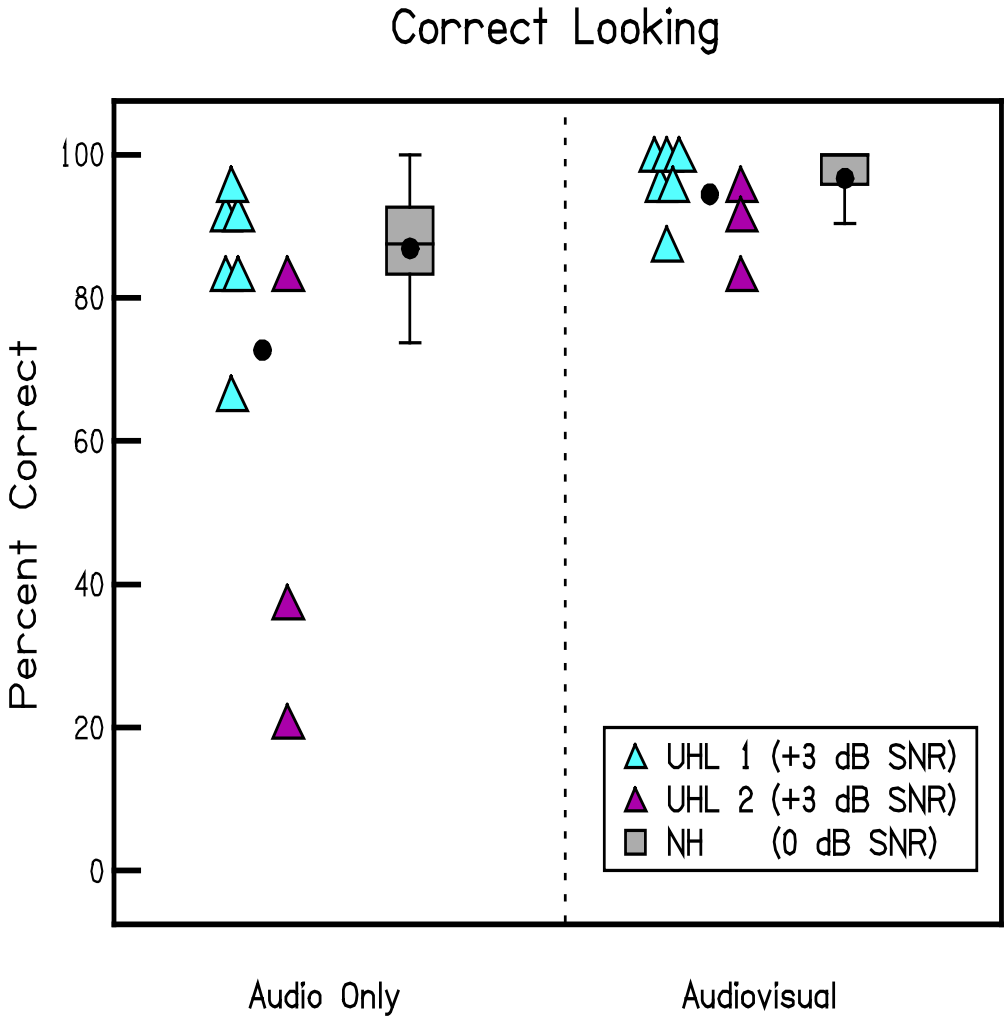
Preliminary results from my lab for children with UHL or NH (8-12 yrs)

- 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


Audio Only
Percent Correct
100
80
60
40
20
0
Keyword
Sentence
Correct Looking
UHL 1 (+3 dB SNR)
UHL 2 (+3 dB SNR)
NH (0 dB SNR)

What if We Add Visual Cues?




Correct Looking
Percent Correct
100
80
60
40
20
0
UHL 1 (+3 dB SNR)
UHL 2 (+3 dB SNR)
NH (0 dB SNR)
Audio Only
Audiovisual

- 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

- Thanks to current and past members of my lab, students and colleagues who have contributed to my work:

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- Daniel Valente

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Thank
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