Using the Entire Tool Box: Improving Cochlear Implant Outcomes

Jace Wolfe, PhD
The Hearts for Hearing Team

Audiologists
Jace Wolfe, Ph.D., CCC-A
Krystal Hudgens, AuD
Megan Marsh, AuD
Sara Neumann, AuD
Mila Duke, AuD
Elizabeth Musgrave, AuD
Rachel Magan-Faivre, AuD
Johnna Wallace, AuD
Sarah Cain, B.S., AuD Intern
Emily Mills, B.S., AuD Student

Speech-Language Pathologists
Joanna T. Smith, M.S., CCC-SLP, LSLS Cert. AVT
Tamara Elder, M.S. CCC-SLP, LSLS Cert. AVT
Darcy Stowe, M.S. CCC-SLP, LSLS Cert. AVT
Lindsay Hannah, M.S., CCC-SLP, LSLS Cert. AVT
Carly Graham, M.S., CCC-SLP, LSLS Cert. AVT
Casey Banks, M.S., CCC-SLP
Jenn Bryngelson, CCC-SLP
Jenna Reese, M.S., CCC-SLP
Tessa Hixon, M.S., CCC-SLP

Additional Team Members
Kris Hopper
Sherry Edwards
Reyna Romero
Darlene Hale
Jackie Keathly
Julie Serven

Kerri Brumley
Susan LaFleur
Kristi Murphy
Kelsey Kuehn
Sabrina Calise

Pati Burns
Megan Miller
Christian Boone
Verneda Osborne
Rachel Odor
Shoot for the Moon!

Shoot for the moon…
Even if you miss, you will land amongst the stars!

RIP
For persons with hearing loss, we should shoot for the moon!
Just preaching to the choir...
• Points of Discussion
  
  – Why HAT?

  – HAT for whom?

  – Optimizing performance
A Noisy World!

- Living Room: The SNR in these environments is typically -5 to +5 dB
  - 37 dB A (with A.C. = 52 dBA)
- Classroom Lecture:
  - 61 dBA
- Small Groups:
  - 66 dBA
- School Assembly:
  - 76 dBA
- School Cafeteria:
  - 83 dBA
- OKC Thunder Basketball:
  - 100 dBA
An Exploration of Non-Quiet Listening at School

Jeffrey Crukely, Ph.D.
Susan Scollie, Ph.D.
Vijay Parra, Ph.D.
University of Western Ontario
London Ontario Canada

The first goal of this study was to describe acoustic properties across an entire day in each of three educational environments: daycare (pre-kindergarten), an elementary school (kindergarten to grade 8), and a high school (grades 9 through 12). Instructional and non-instructional listening situations were included in this description. Second, we classified the various listening situations experienced by the cohorts at each school. These sites participated in this study. At each site, empty room measurements were obtained, including noise floor and reverberation levels, across the various rooms frequently occupied by the participating cohorts of children. Next, the first author followed the cohorts throughout their regular school routine, recording sound level data with a dosimeter and documenting observations of the type of listening situations encountered by the children. Noise floor, reverberation, and sound levels were compared to classroom standards and large scale classroom studies. The cohorts in this study encountered highly variable acoustic environments throughout the day, for signal levels, noise sources, and reverberation properties. These results have implications for digital signal processing and hearing instrument fitting approaches for school-aged children. Furthermore, the results of this exploratory study may impact on future research on classroom acoustics.

Introduction

The purpose of the present study was to gather detailed information about the school-day listening environments of three cohorts of children in mainstream educational environments. This study served as a precursor to a larger study investigating hearing instrument fitting strategies for children in non-quiet listening environments and situations. Modern hearing instruments typically offer some combination of frequency-gain adjustment, directional microphones, and digital noise reduction (DNR) with the goal of providing better speech recognition and listening comfort/tolerance in noise. While research has demonstrated that directional microphones can improve children’s speech recognition in noise performance (Austenro et al., 2009; Gravel, Faunel, Latchow, & Chochet, 1999; Kuk, Kolotlfi, Brown, Melan, & Roseenthal, 1999), the use of DNR with children has not demonstrated any measurable improvement (Pitmann, 2011; Stelmachowicz et al., 2010). These results are consistent with similar findings in adult listeners, and have led to mixed recommendations regarding the use of directional microphones and DNR in pediatric hearing instrument fittings. Some guidelines do not recommend using these features (AAA, 2003), whereas others consider them viable options (Bagatto, Scollie, Hyde, & Seewald, 2010; CASEP, 2002; Foley, Cameron, & Hostler, 2008) or recommend directional microphones universally (Kling, 2010).

As part of an overall project investigating strategies to improve children’s hearing instrument fittings for non-quiet listening, the current study explored the daily listening experiences of children over an entire school day. This exploration included situations beyond the classroom situation of listening to a teacher.

This may be an informative first step in determining optimal signal processing for children in non-quiet environments. Studies of adults who wear hearing instruments have applied the concept of auditory ecology (Gatehouse, Elberling, & Nayler, 1999; Gatehouse, Nayler, & Elberling, 2002, 2006a, b). A concept in which the sound levels across a real-life, real-time sample from an individual hearing instrument wearer are used to inform hearing instrument signal processing choices. This study used an auditory ecology measurement approach in a small number of classroom cohorts. We measured reverberation time (RT) and noise floor levels across the many school environments. Additionally, we measured sound levels across an entire day, rather than a large scale sampling of sound levels during only targeted (typically classroom) listening situations. This ecological approach allowed the description of both instructional and non-instructional parts of the day, which may serve to improve hearing instrument fitting practices for children attending school. For example, listening to a friend while playing outside is an important listening situation, and one that is not well described in the classroom ecology literature. This paper presents data across all listening environments and situations encountered by these three cohorts of children.

Auditory Ecology: Children in Non-Quiet Environments

Auditory ecology has been defined as the range of acoustic environments that a person experiences, the auditory demands of those environments, and the importance of those demands to an individual’s daily life (Gatehouse, et al., 1999; Gatehouse, et al., 2003, 2006a, b). A hearing instrument’s ability to support multi-environment listening is a significant predictor of hearing instrument fit.
Crukley et al., 2011

![Box plot showing mean Leq (dB-A) across different sites: Daycare Toddler (72), Daycare Pre-school (75), Elementary School (62), High School (66).]

![Bar chart showing proportion of time spent per classification: Quiet (10%), Speech Alone (0%), Speech in Noise (90%), Noise Alone (10%). Categories include Daycare, Elementary School, and High School.]
Speech Recognition without Remote Mic HAT

Kids with hearing loss need a +15 dB SNR

+5 dB SNR
What about CI users?

Nucleus 6 Sound Processor  
(CI920)

Cochlear Mini Mic
AzBio Recognition in Quiet

AzBio in Quiet (% Correct)

- **Nucleus 6**: 80.8
- **Nucleus 6/Mini Mic**: 90.9

* *: p < .05
AzBio in Noise

Remember, these are adults. Kids’ results will be poorer.
Why HAT?

• Because most CI users can’t hear in many realistic situations without it

• Because performance improves dramatically with it
  – By as much as 60% points
Hearing Assistance Technology

• For Whom?
Everyone
Imran Mulla, 2013

- LENA Data Logging in Infants/Toddlers
  - Car seat (70 mph): -10 dB SNR
  - Bus: -10 dB SNR
  - Stroller: -8 dB SNR
  - Shopping cart: -6 dB SNR
  - Car seat (30 mph): -5 dB SNR
  - Wind Noise: -3 to -10 dB SNR

**Conservative Take:** Use in situations in the child has no chance to hear without remote mic use.
Carol Flexer: It’s about the brain! It’s hungry. Feed it intelligible speech.

- The Critical Window
- Risley & Hart (1995)
  - 46 million words by 4
- Dehaene (2009)
  - 20,000 hours of listening to support basic literacy development
Digital Systems
Digital Radio Frequency Transmission
Amplitude Shift Keying

Industry, Science, Medical globally license-free 2.4 GHz band

Channel Hopping
Noise Squelch
Hearts for Hearing Experience
Digital Radio Systems

• Multiple studies with Phonak Roger and GN Resound Hearing Aid/Cochlear digital radio remote microphone systems
  – Formally evaluated over 100 adult and pediatric subjects
  – Not one subject has complained of noise/interference from one of these systems
  – Digital “all or nothing”
Remote Microphone HAT

• Optimizing Benefit
Dynamic Digital RF vs. Digital Audio Streaming

Hearing Aids Users (Moderately Severe/Severe Hearing Loss)
Transparency

- Transparency
  - Ensuring that signal from sound processor mic is similar with and without HAT
  - Ensuring sound processor mic and remote mic outputs are equal when inputs to each mic are equal

- CI sound processors
  - Audio Mixing Ratio: 1:1, 50/50
  - Ensure detection thresholds aren’t elevated with remote mic use;
    Adequate recognition of low-level speech

- Hearing aids & CI sound processors
  - American Academy of Audiology Remote Mic Guideline
  - Google it
Remote Mic Use
Remote Mic Orientation

• Take the time...
• Demonstration
  – Tell, show, touch, live, and leave!
• Take the challenge
  – Speech recognition with and without
• Matching tech to needs
  – COSI
  – Budget
• Engage the family
  – Parent Persuasion
  – Give your spiel to the spouse
Breaking off the chains...

Forget the Alamo. Remember the telephone!
T-Mic2 – Monaural vs. DuoPhone

Significant improvement in Quiet & in Noise (RMANOVA)  

n=10
Word Recognition - Noise

% Correct

Nucleus 6

Nucleus 6/Phone Clip+

n=16
Shoot for the Moon!

• THANK YOU FOR YOUR ATTENTION