Noise Technologies:
What do kids need, and what do they want?

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Shoot for the Moon! Even if you miss, you will land among the stars!

- Norman Vincent Peale
Shooting for the Moon

Wolfe et al., 2015, Unpublished Data

AzBio Sentence Recognition
% Correct

+10 dB SNR  |  +5 dB SNR  |  0 dB SNR

n = 10 Young Adult Normal Hearing Listeners
Houston, we have a problem!

These are adults. Children will have greater difficulty.

AzBio Sentence Recognition
% Correct

Wolfe et al., 2015, AJA
A Noisy World!

The SNR in these environments is typically -5 to +5 dB

- Living Room:
  - 37 dB A (with A.C. = 52 dBA)
- Classroom:
  - 63 dBA
- Dr.’s Waiting Room (4:00 pm):
  - 76 dBA
- Public Transportation:
  - 79 dBA
- Family Restaurant:
  - 84 dBA
- OKC Thunder Basketball:
  - 103 dBA
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
For children with hearing loss, we can shoot for the moon!
Road Map

• Points of Discussion
  – Identifying noise management technologies that allow children to shoot for the moon
  – Results of studies evaluating modern noise management technologies
Noise Management Technologies

• Adaptive Noise Reduction (Adaptive Gain Reduction)
• Directional Microphone Technology
  – Automatic, adaptive directionality (UltraZoom)
  – Binaural beamforming (StereoZoom)
• Changes in gain-frequency response
  – e.g., Phonak Noise frequency response
• Remote Microphone Technology (Roger)
Studies supporting use of Noise Reduction (NR)

• NR use resulted in no change in speech recognition in noise

• No degradation in speech recognition in noise with the use of NR for school-aged children
  – Auriemmo et al. (2009), J American Acad Audiology
  – Pittman (2011a), J Speech Language Hearing Research
  – Pittman & Hiipakka (2013), J American Acad Audiology

• NR may improve novel word learning as well as tolerance of noise
  – Pittman (2011b) J Speech Language Hearing Research

• Shorter verbal response time with use of NR
  – Gustafson et al. (2014) Ear and Hearing

More importantly, noise reduction allows for improvement in noise tolerance, listening ease, comfort, and cognitive load (Bentler, 2005). That’s what kids want!!!!
• Experts are divided as to whether directional technology should be used with young children

• Historically, guidelines have varied in recommendation for use/non-use of directional technology in children

  – American Academy of Audiology Pediatric Amplification Guideline (2013)
  – Australian National Protocol for Paediatric Amplification (King, 2010)
  – Harvey Dillon’s Hearing Aids textbook (Dillon, 2012)
3 Studies looking at Noise Management Features of the Venture Platform and beyond
Automatic Noise Management Technology for Children

- 15 Children
  - Moderate to severe hearing loss
    - Pure Tone Average (Better Ear): 53.9 dB HL
  - Ages 9-14 y.o. (mean = 12 y.o.)

- Compared performance across 3 conditions:
  - Default pediatric program (Real Ear Sound-RES)
  - Automatic, adaptive noise management (AutoSense)
  - Manual noise management (e.g., Speech in Noise)
Automatic Noise Management Technology for Children

• Phonak Audeo V90 hearing aids fitted to DSL v5.0 target
• Children wore hearing aids for 2-4 weeks with default pediatric program

Testing was completed in 3 phases:
• Phase 1
  – Speech recognition in noise across three technology conditions
• Phase 2
  – 4-week real-world trial with journaling to capture technology preference in everyday use
• Phase 3
  – Speech Intelligibility Rating Index (Cox & McDaniel, 1989)-wont review in interest of time.
Automatic Noise Management
Technology for Children

- **AzBio Sentences** *(Spahr et al., 2012)* & **Classroom Noise** *(Schafer & Thibodeau), 2006)*

- **Four Acoustic Situations** *(Pearsons et al., 1977)*
  - **Speech in Noise**
    - Speech: 60 dBA/Noise: 55 dBA
  - **Speech in Loud Noise**
    - Speech: 72 dBA/Noise: 70 dBA
  - **Car**
    - Speech: 55 dBA/Noise: 50 dBA
  - **Quiet**
    - Speech: 60 dBA

- **Three Hearing Aid Programs**
  - RES vs. Manual vs. AutoSense
  - Double blinded – Counter-balanced
Automatic Noise Management Technology for Children

- **3 Hearing Aid Programs:**
  1. **Calm:** minimal noise reduction; microphone mode set to Real Ear Sound (RES), which attempts to mimic natural directionality of the ear
  2. **AutoSense OS:** contains an environmental classifier to select the noise management technologies that would optimize hearing performance (e.g., in noisy situations, adaptive directional mode active, and gain attenuation provided by noise reduction (NR) processing).
  3. **Manual directional program:** Condition-specific that was manually selected by the clinician.
     - Speech in Quiet: NR set to weak setting, microphone set to RES
     - Speech in Noise: NR set to weak, microphone set to UltraZoom (adaptive beamformer) – 1st-order Dual Mic
     - Speech in Loud Noise: NR set to moderate, microphone set to StereoZoom, (binaural beamforming) – 3rd-order Binaural Beamformer
Sentence Recognition Results for Automatic Noise Management Technology for Children

Kids are busy!
They don’t want to have to remember to change their program.
They don’t want to draw attention to themselves to change a program!!

They want it to be EASY!

Wolfe et al, (2017) JAAA
Automatic Noise Management Technology for Children

Wolfe et al, (2017) JAAA

• **Design – Test Session 2:**
  - Examined effects of directional technology when the talker is behind the listener (speech at 0 vs. 180° azimuth)
  - Speech intelligibility ratings & journals

• **Session 2 Results:**
  - Speech at 0 better than speech at 180
  - AutoSense better than RES for in the speech at 0 condition
  - RES better than AutoSense in 180 conditions

Performance from behind is not as good, but let’s teach our patients to turn and look at the speaker of interest in these situations. Don’t we want to teach our patients to engage in this way, in most situations, if they can?
• **Participant Journals:**
• Most participants preferred AutoSense (positive ratings) over RES
• Not a single child preferred the pediatric default over AutoSense
New Noise Technology Study
Primary Objectives

- What contribution do various noise management technologies make to speech recognition in noise?
- What is the impact of various microphone modes on the localization abilities of pediatric hearing aid wearers?
- What noise management technologies do children prefer to use in a classroom setting?
• 14 school-age children with moderate to moderately-severe hearing loss fitted with Phonak Sky V-90 hearing aids with occluding earmolds

• Hearing aids fitted to DSL 5.0 targets
  – 55, 65, 75 dB SPL “Standard Speech” signal
  – RESR85
• 5 Hearing Aid Programs (simulated classroom)
  – 1. DSL 5.0 Frequency Response, Omni Mic, NR Off
  – 2. “Noise” Frequency Response, Omni Mic, NR On
  – 3. DSL 5.0 Frequency Response, Adaptive Directionality (UltraZoom), NR Off
  – 4. DSL 5.0 Frequency Response, Real Ear Sound, NR Off
  – 5. “Noise” Frequency Response, Adaptive Directionality (UltraZoom), NR On

• 3 Microphone Modes (localization task)
  – Omnidirectional
  – Phonak Real Ear Sound
  – Adaptive Directional (Phonak UltraZoom)
Assessments

• **Speech Recognition in Noise**
  – AzBio Sentences at 73 dBA
  – Classroom Noise presented at level resulting in score of 30-50% correct in default program \( (\text{DSL freq response, Omni, NR off}) \)
  – Speech from 0° and 180°

• **Localization**
  – “Dog bark” at 70 dBA in classroom noise at 62 dBA

• **MUSHRA Preference Task**
  – Rank-order each program for “Carrot Passage” at 73 dBA at noise level used in speech recognition in noise task
  – Comfort, speech recognition, and overall favorite
  – Speech from 0° and 180°
Simulated Classroom Environment

Distance from each loudspeaker to subject = 4'3"

Speech Recognition in Noise
1. Speech from 0°
2. Speech from 180°
Speech Recognition in Noise – Speech 0°

Hearing Aid Program

Speech in Noise - Front

% Correct

Calm - Omni - NR Off
Noise - Omni - NR On
Calm - DM - NR Off
Calm - RES - NR Off
Noise - DM - NR On
When we teach children to orient to the speaker of interest, their benefits continue to outweigh the decrement when listening to speech from behind.
Assessments

• **Speech Recognition in Noise**
  – AzBio Sentences at 73 dBA
  – Classroom Noise presented at level resulting in score of 30-50% correct in default program (DSL freq response, Omni, NR off)
  – Speech from 0° and 180°

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Localization Task

3 Microphone Modes
1. Omnidirectional
2. Real Ear Sound
3. Adaptive Directional
Localization

![Bar chart showing % Correct for Hearing Aid Microphone Mode.](chart.png)
Assessments

• **Speech Recognition in Noise**
  – AzBio Sentences at 73 dBA
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MUSHRA Task

Which program is most comfortable?

Most
2nd
3rd
4th
Least
A  B  C  D  E
“Noise” Frequency Response with Ultra Zoom was preferred over all other settings with hearing performance and comfort!

When we account for preference and teach children to orient to the speaker of interest, they will likely experience satisfaction with hearing performance and comfort.
But, that’s not all....

What about a truly typical classroom situation in today’s settings?
Acoustics of a child’s school day
New Study with Phonak Sky Venture
Noise Management Technology for Children

Evaluation of Roger + Adaptive Directional
Automatic Noise Management Technology for Children

• Wolfe et al., in press

• Participants:
  – 15 children, ages 8-17 years old
  – Mild to severe hearing loss
  – Previous users of digital behind-the-ear hearing aids

• Methods
  – Evaluated speech recognition across different conditions with Roger+Omni and Roger+Adaptive Directional
Automatic Noise Management Technology for Children

- **Phonak Quest**
  - 2 A/D Converters
  - A/D Converter 1: Front Mic
  - A/D Converter 2: Back Mic or DAI
  - Requires a switch to omnidirectional mode when Roger is activated

- **Phonak Venture**
  - 3 A/D Converters
  - A/D Converter 1: Front Mic
  - A/D Converter 2: Back Mic
  - A/D Converter 3: DAI
  - Allows for directional use when Roger is activated
Automatic Noise Management Technology for Children

Talker: Teacher – Remote Mic

Speech: 70 dBA
Noise: 70 dBA
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Talker: Peer – Front

Speech: 65 dBA

Noise: 65 dBA
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Talker: Peer – Behind

Quiet

Speech: 65 dBA
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- Teacher (Roger inspiro)/0 dB SNR
- Peer Talker (front)/0 dB SNR
- Peer Talker (behind)/Quiet

Graph showing comparison between Roger+Omni and Roger+Adaptive Directional.
AutoSense Sky OS results in improved comfort for children using the Autosense designed for children!!!
Takeaway: These added benefits result in improved hearing AND comfort!
How can I optimize hearing performance in small groups with more than one talker?
Roger Select
Roger Multitalker Network
• Multi-talker babble (noise) from 4 corner speakers

• AzBio sentences (targets) were randomly presented from 0, 90, and 270 degrees simulating a group of 4 near-field individuals engaged in conversation around a table
  – Small group at school
  – Café
Roger Multitalker Network

- Multi-talker babble (noise) from 4 corner speakers
- AzBio sentences (targets) were randomly presented from 0, 90, and 270 degrees simulating a group of 4 near-field individuals engaged in conversation around a table
  - Small group at school
  - Café
Roger Select and Multitalker Network

Roger Select improves performance with multiple talkers
Roger MTN optimizes performance with multiple talkers

All Roger solutions provide improved speech understanding in noise. Additional microphones as used in a multi-talker network will provide the best outcomes. Something to consider for an active classroom!
Take Home Points

• Our studies have found that children prefer the use of Phonak noise management technologies relative to the noise-management-technology-disabled condition and potentially understand speech better in noise with the use of these noise management technologies
  – Teaching children to orient to the speaker of interest, is another way to further support these benefits.

• Children need remote microphone technology with adaptive gain changes and beamforming to have great hearing performance in real world listening situations

• Adaptive noise management technology should be used in conjunction with adaptive digital remote microphone technology to optimize performance across a variety of real world listening situations
  – Addition of multi-talker networks will further improve speech understanding in group settings.
Protocol for Selecting Settings

• Noise reduction should be activated at fitting for all children.
• Adaptive Directionality should be considered around 18-24 months of age.
  – Counsel that a child may not hear as well from behind.
    • Teach child to orient to speaker
  – Work with parents and AVT/SLP to get feedback about how the child is doing with these additions.
Shoot for the Moon!

• THANK YOU FOR YOUR ATTENTION