• If you are viewing this course as a recorded course after the live webinar, you can use the scroll bar at the bottom of the player window to pause and navigate the course.

• This handout is for reference only. It may not include content identical to the PowerPoint. Any links included in the handout are current at the time of the live webinar, but are subject to change and may not be current at a later date.
Use of Wireless Technology for Children with APD, ADHD, and Language Disorders

Erin C. Schafer, Ph.D.
University of North Texas, Denton, TX

What do typical children need?

• Neuman et al. (2010)

• Typical 6- to 12-year-old children need a +10 to +20 signal-to-noise ratio to get 95% speech recognition
Benefit from remote-microphone technology: no surprise

- FM systems improve hearing & educational performance
- May be surprising: strong evidence to support FM systems in FM in several populations—
  - 1. Auditory Processing Disorder (APD)
  - 2. Autism Spectrum Disorders (ASD) & Attention-Deficit Hyperactivity Disorder (ADHD)
  - 3. Dyslexia
  - 4. Language Disorders

Learning Objectives

- After this course learners will be able to describe research evidence to support the use of hearing assistance technology (HAT) in children with APD, ASD, and ADHD.
- After this course learners will be able to list the steps involved with the fitting and verification of FM systems on children with normal hearing.
- After this course learners will be able to identify behavioral measures and questionnaires that may be helpful for assessing the auditory needs and benefit from HAT in children with APD, ASD, and ADHD.
1. Auditory Processing Disorders (APD)

• Johnston, John, Kreisman, Hall & Crandall (2009)
  – 10 children with APD
  – 13 children in control group
  – Test measures:
    • Speech recognition in quiet & noise: HINT-C
    • Academic Performance: SIFTER & LIFE

1. APD: Speech Recognition

[Graph showing speech recognition in quiet and noise conditions for different groups: control, APD pre-fit, APD post-fit.]
1. APD: Academic Performance--SIFTER

![Graph showing SIFTER mean scores for academic, attention, communication, class participation, and social behavior categories with different conditions: Control, APD Pre-fit, and APD Post-fit.]

2. Autism Spectrum Disorders (ASD):
Auditory Processing Characteristics

- Parent surveys (Tomcheck & Dunn, 2007):
  - 60-80%: distractible, dysfunction in noisy places, unresponsive or poor attention to auditory stimuli
- Auditory filtering on Short Sensory Profile (Ashburner et al., 2008):
  - Most significant predictor of educational performance
- Poorer speech recognition in noise by 2 to 5 dB than peers (Alcantara et al., 2004; Schafer et al., 2013)
- Significantly poorer auditory attention (Corbett & Constantine, 2006)
2. ASD Prevalence

• 1 in 68 children in the US have ASD (CDC, 2010)

• Prevalence increasing:
  – 2000: 1 in 150
  – 2006: 1 in 110
  – 2008: 1 in 88

• 5 times more common in boys than girls
• 80% require special education support

2. ASD: Reasons for auditory deficits

• 1. Abnormal physiological encoding of auditory stimuli in quiet and noise from brainstem to the cortex (Barry et al, 2002; Russo et al., 2009)

P1 correlates to mental, verbal, and receptive language abilities
2. ASD: Reasons for auditory deficits

- Russo et al, 2009

  Similar P1 and N1 Latencies

- 100 gene mutations linked to ASD
- As a result, abnormalities in dendritic spines
2. ASD: Reasons for auditory deficits

- Tang et al., 2014
  - Why do we care?
  - Postmortem temporal lobes: children ASD
  - Increased dendrites in ASD result in increased excitation
  - Likely causes difficulty separating signal from noise

2. Reasons for auditory deficits

- 4. Co-existing disabilities:
2. ASD Studies

- Rance, Saunders, Carew, Johansson, & Tan (2014)
  - 20 children with ASD
  - 20 matched controls
  - Test measures:
    - Speech recognition in noise
    - APHAB
    - Temporal processing
    - Spatial processing

2. ASD: Comparison of Groups
   ASD vs. Controls
2. ASD: Speech Recognition in Noise

A

![Bar chart showing CNC Phoneme Score (%)]

Subject #

B

![Bar chart showing Perceived Difficulty (%)]

Communication, Noise, Reverberation, Aversiveness, Global
2. ASD & ADHD

- Schafer, Mathews, Mehta, Hill, Munoz, Bishop, & Moloney (2012)
  - 11 children with ASD:
    - 7 had ASD: APD (2), anxiety disorder (1), ADHD (2)
    - 4 had ADHD: APD (1), SLI (1)
  - 11 age-matched peers
  - Test measures with and w/o FM systems:
    - Speech recognition in noise
    - Classroom Observations
    - Teacher questionnaires

2. ASD & ADHD: Speech Recognition in Noise

Lower scores are better!

- Significantly poorer than typical peers
- Same as peers when using FM
2. ASD & ADHD: Speech Recognition in Noise

Lower scores are better!

- Significantly better performance in FM conditions
- No effect of session

---

2. ASD & ADHD: On-Task Behaviors

- Significantly more on-task behaviors with FM during both trial periods
- Both FM conditions significantly better than both no-FM conditions
2. ASD & ADHD: C.H.A.P.S. Results

- Significant improvements in most areas*

2. ASD: Subjective Child Questionnaire

- 8/10 agreed it was easier to put on after practice
- 3/10 had retention issues
- 9/10 thought default volume comfortable
- If had choice of volume, 2 would do softer & 4 louder than default
- 8/10 thought it was comfortable
- All liked using the FM and thought it helped them listen better in class
- 9/10 would like to continue using it
3. Dyslexia

- Hornickel et al. (2012)
  - 38 normal hearing children, ages 8-14 years, with dyslexia
    - 19 used FM system for 1 year
    - 19 wore no device (cntl grp)
  - Test Measures:
    - Reading Ability
      Significant improvement in FM grp; no change for control grp
    - Phonological Awareness
      Significant Improvement; no change for control group
    - Auditory Brainstem Response to Speech (cABR)
      Significant difference relative to control group

---

**Fig. 1.** FM system use increases the consistency of auditory brainstem representation of speech. (A) Responses from dyslexic children before FM system use with the formant transition (7-60 ms) and vowel (60-180 ms) portions of the speech syllables marked. (B) Response consistency, quantified as the correlation between responses collected during the first half of the recording session (light gray) and those collected in the second half of the recording session (dark gray), improved with FM system use during the formant transition for this representative individual. The more consistent response at posttest is reflected by a higher r-value. (C) After FM system use for one school year, children with dyslexia had more consistent speech-evoked brainstem responses, particularly for the response to the formant transition (red triangles, trending at P = 0.030). Significant changes were not seen in response to the vowel portion (black circles). (D) Control children with dyslexia who did not use the FM systems show no change in response consistency in either the formant transition (red triangles) or the vowel (black circles) portions of the response. (E) Response consistency also does not change for typically developing controls in either the formant transition (red triangles) or the vowel (black circles) portions.
4. Language Disorders (LD)

- Will discuss after the following section on fitting procedures
  - Validation of procedures on kids with LD
Fitting HAT on Children with Normal Hearing

• Schafer et al., 2014
• Examined validity of AAA protocol & clearly define procedures for fitting ear-level, open ear, FM-only devices to 26 NH children
  – Meet prescribed targets: DSL
  – Measure RESR
  – We also evaluated REOR to determine potential changes in REUR due to receiver placement
Specific Goals & Fitting Procedures

• 1. Meet DSL targets at 1, 2, 3, & 4 kHz
  – FM mic in the test box; real-ear mic in child’s ear
  – Verifit: select ‘FM’; ‘On-ear’; Speech-std[1]; FM volume adjusted, if necessary
• 2. Do not exceed estimated UCL
  – Same settings, but MPO selected as the stimulus
  – Compared MPO to the estimated UCL on screen
• 3-4. Examine difference between REOR & REUR
  – Transmitter turned off
  – Verifit: ‘Open’ instrument; Speech-std[1] at 65 dB SPL.

DSL Targets vs. Output

- No significant effect of output type
- Significant interaction effect

<table>
<thead>
<tr>
<th>Output vs. Target</th>
<th>Output 2-3 dB lower than target</th>
</tr>
</thead>
</table>

Target Output
MPO vs. UCL

- MPO output significantly lower than estimated UCL

REOR vs. REUR

- Significant difference: = 3 dB
Behavioral Validation:
Speech Recognition in Noise

Behavioral Validation:
Loudness Ratings in Noise
4. Language Disorders & Various Disabilities

Table 1. Overview of Subject Demographics and Frequency Modulation (FM) System Volume

<table>
<thead>
<tr>
<th>Subject #</th>
<th>Age</th>
<th>Disorder</th>
<th>FM Volume: Right</th>
<th>FM Volume: Left</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8; 10</td>
<td>APD</td>
<td>-2</td>
<td>-2</td>
</tr>
<tr>
<td>2</td>
<td>10; 7</td>
<td>APD</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>3</td>
<td>8; 0</td>
<td>Listening problems</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>4</td>
<td>11; 11</td>
<td>ADHD, LD</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>5</td>
<td>9; 6</td>
<td>ASD, SLI</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>6</td>
<td>9; 3</td>
<td>ASD, APD, SLI</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
<td>10; 5</td>
<td>ASD, APD, SLI</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>8</td>
<td>9; 5</td>
<td>ASD, ID, ADHD, SLI</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>9</td>
<td>8; 11</td>
<td>SLI</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>6; 4</td>
<td>SLI, APD, ADHD</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>11</td>
<td>10; 2</td>
<td>SLI</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>12</td>
<td>11; 3</td>
<td>SLI</td>
<td>6</td>
<td>6</td>
</tr>
</tbody>
</table>

4. LD & Other Disabilities

- **Test Measures:**
  - Same procedure as the previous fitting study
  - Same speech recognition measures
  - Listening Comprehension Test 2 (recorded in noise)
  - Trial period: child, parent, & teacher questionnaires
    - Participant and parent C.H.I.L.D. and participant and teacher L.I.F.E.-R
4. LD: Fitting Results

DSL output was met or slightly exceeded (3 dB) for all 24 ears

4. LD: Speech Recognition Results
n=10

We recommend bilateral FM/DM!

All loudness ratings “Comfortable or “Loud, but OK”
4. LD: Listening Comprehension  
\( n=8 \)

![Bar chart showing listening test scores for different subtests (Main Idea, Details, Reasoning, Vocabulary, Understanding Messages) for unaided and FM conditions.]

4. LD: Participant C.H.I.L.D.  
\( n=7 \)

![Bar chart showing subject C.H.I.L.D. ratings for different listening conditions (Quiet, Noise, Distance, Social, Media) at baseline and with FM.]

**CONTINUE**
4. LD: Parent C.H.I.L.D. (n=10)

![Bar chart showing Parent C.H.I.L.D. Rating for different listening conditions. The chart indicates that all conditions are better with FM.

Summary

- 1. Strong evidence that several disordered populations need HAT:
  - 1. APD
  - 2. ASD & ADHD
  - 4. Dyslexia
  - 5. Language Disorders

- 2. Fit using real ear & DSL targets
  - Not always possible....
Questions?

Thank you for listening!

Erin.Schafer@unt.edu

How to obtain for kids

• Private pay

• Letter of medical necessity/insurance coverage

• School: IDEA
  – May have to show educational need with an assistive technology evaluation/functional evaluation
Determining Educational Need...

a whole other talk

• 1. Assess classroom acoustics using an app to see if it meets ASHA/ANSI criteria (AudioTools)
   – Measure unoccupied noise, occupied noise, estimated SNR, RT
• 2. Perform classroom observation:
   – Seating, on/off task behaviors, participation, noise
• 3. Speech recognition in noise: BKB-SIN & PINT
• 4. Student & teacher interviews and questionnaires
• 5. Review of special education file or previous testing
• 6. Cite literature showing benefit of HAT

Future directions

• Data collection in progress:
  o Low- and high-functioning children with ASD in public-school using remote-mic technology
    ▪ Speech recognition, comprehension, ANL, subjective questionnaires
    ▪ ANL scores with no device: 11, 15, 19 dB
    ▪ ANL no device: 0 dB; ANL with device: -10 dB
Parent Email #1:

I've just finished using the devices for the first time today, and my daughter and I just had a 3-minute conversation about cocoa. She made eye-contact consistently while we talked back-and-forth, and she responded quickly as I've never seen her do before. Afterwards, we continued with our conversation some more.

Usually, a conversation with her requires a lot of work with repeated requests, questions, etc. (as many as ten times) to get her to respond, and keeping her engaged in having an ongoing conversation with her is taxing. However, the conversation that I had with her just now was super easy. Because of that, I'm so amazed and excited!!

Parent Email #2:

They are doing so well with them. The teachers are giving some great feedback.

We actually tried them Sunday when we went grocery shopping at Target, and it literally brought me to tears cause it's the first time in years we've all been able to go and they listened. I would talk to them and remind them how we behave while we were in there, and having my voice talk them throughout, they actually helped put things in the cart.