Functional Assessment of Children with Hearing Loss and Auditory Listening Differences

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UNT Speech and Hearing Center

• Hearing services:
  • Audiol. evaluations
  • Hearing aids
  • Cochlear implant programming
  • Vestibular testing
  • Educational consulting:
    • 2 large school districts

UNT Speech Perception Laboratory

• Mission: Improve communication abilities of children and adults with hearing loss!
  • Assessment:
    • Speech recognition: noise
  • Amplification:
    • FM Systems/DM
    • Hearing Aids
    • Cochlear Implants

Opening Considerations

IDEA 2004 FINAL Regulations Pertaining to Deaf Education and Audiology

ASSISTIVE TECHNOLOGY; PART B 34CFR300.5-6 & C:
34CFR303.12
Assistive technology device means any item, piece of equipment, or product system, whether acquired commercially off the shelf, modified, or customized, that is used to increase, maintain, or improve the functional capabilities of children with disabilities. The term does not include a medical device that is surgically implanted, or the replacement of such device.

Assistive technology service means any service that directly assists a child with a disability in the selection, acquisition, or use of an assistive technology device. This term includes:
(a) The evaluation of the needs of a child with a disability, including a functional evaluation of the child in his/her customary environment.

www.handsandvoices.org
**Evidence-Based Practice + Educational Hearing Services**

Should we develop ongoing evidence-based protocols in the provision of hearing services?

I. Functional evaluation protocol for assessing educ. need for HAT
   a. specific to various populations
   b. supported by up-to-date research evidence

II. Validation of HAT efficacy & effectiveness

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**Determining Educational Need**

- **IDEA:** *an evaluation in the child’s customary environment*
  - 1. Cite acoustics research & measure classroom acoustics
  - 2. Perform classroom observation
  - 3. Measure speech recognition & comprehension
  - 4. Utilize teacher questionnaires
  - 5. Other informal assessments: interviews, academic standing, review file, & trial period
  - 6. Cite research on the population you are assessing
EB Component #1: Cite Literature on Classroom Acoustics

• 1a. Begin with Guidelines:
  • ASHA
    – Acoustics in Educational Settings (2005)
  • ANSI S12.60-2010
    – Acoustical Performance Criteria, Design Requirements and Guidelines for Schools

• Offer guidelines for:
  – 1. Unoccupied noise levels: 35 dBA
  – 2. Reverberation times: .6 to .7 seconds

1a. Noise Criteria Ratings

○ Noise Criteria (NC) Rating
  > Single number to describe noise level based on series of frequency-intensity curves
  > Derived from equal loudness curves consistent with human hearing
  > Suggested ratings given for various facilities (e.g. worship centers, performance halls)

1a. AAA Guideline

1b. What are the acoustics of typical classrooms?
1b. Study One: Classroom Acoustics

  - 32 classrooms selected randomly from 3 school districts
  - Included 12 newer schools in suburban areas, 12 in older in suburban areas, 8 in rural areas
  - Averaged sound level meter measurements at 5 points in each classroom

1b. Unoccupied Noise in Typical Classrooms

- Ranges:
  - 34 to 66 dBA
  - HVAC on

1b. Reverberation in Typical Classrooms

- Ranges:
  - 0.2 to 1.27 sec

1b. Reverberation in Typical Classrooms

- Larger rooms had longer reverberation times
- Rooms with lower ceilings (< 10 ft.) were more likely to meet RT criteria
1b. Effects of Reverberation

- Reverberation masks direct sound energy by reflected energy.
- Reflected signals are temporally delayed and reach child’s ear same time as a direct signal.
- Words may overlap causing alterations to temporal aspects of speech.
- Causes prolongation of spectral energy (no gaps).
- Primarily vowel energy in low-frequency region.
- These low-freq intense vowels then mask consonants (particularly consonants in the final position).

1b. Study Two: Classroom Acoustics

  - 36 classrooms including urban and suburban.
  - 16 were built after 2002: “new”
  - 20 built prior to 1960: “old”
- Averaged 5 head-level sound level meter measurements in each room.
- Determined noise criteria (NC) rating.
- Measured reverb.

1b. Unoccupied Noise (dBA)

- “Old” Range: 34 - 54 dBA
- “New” Range: 31 - 53 dBA

1b. Noise Criteria Ratings

- Only 2 classrooms met the recommended NC Rating.
1b. Reverbberation Times

![Figure 4: Average reverberation times (RT) at 0.5, 1, and 2 kHz in old and new schools. Numbers (1-9) represent the schools and letters (a-d) represent the classrooms.](image)

- "Old" Range: .5 - .6 s
- "New" Range: .4 - .6 s

Most rooms carpeted and had ceiling tiles; absorptive materials were covering almost all wall space.

All met except 1

1b. Studies on Signal-to-Noise Ratio

- Typical occupied classrooms:
  - Sanders (1965) reports average SNRs from 47 classrooms:
    - 17 Kindergarten: -1 dB
    - 12 Elementary: +5
    - 12 High school: -5
  - Arnold & Canning (1999) report typical occupied classrooms as loud as 73 dB
  - With typical conversational speech, this could result in a -18 SNR

1b. Study Three: Occupied Classroom Acoustics

- Cruckley et al. (2011)
- Noise levels vary across & within children’s listening environments

- Dosimeter measurements throughout the day in various children’s listening environments

75% of the day sound levels between 60 to 80 dBA
1b. Occupied Classroom Acoustics

• Cruckley et al. (2011)

Dosimeter measurements

Toddler Room at Daycare

Elementary School

High School
1b. What’s missing from ASHA & ANSI recommendations?

• Issues related to distance from the teacher:
  • Not every seat provides a high-quality speech signal from teacher
  • These effects examined by Leavitt & Flexer (1991)
  • Used Rapid Speech Transmission Index (RASTI) to examine fidelity of speech at various locations in a typical classroom
  • Incorporates perception of sound and speech intelligibility of normal-hearing listeners

Leavitt & Flexer (1991)

– Combines effects of unoccupied noise, reverberation, & SNR
– Less critical speech information as distance increases
– Perfect RASTI transmission = 1.0

Ear & Hearing, 12

1b. Issues Related to Distance

• Crandall & Smaldino (2000)
  • Measured children’s speech perception at various distances from teacher
  • Room with RT of .45 s
  • 6 ft: 89%
  • 12 ft: 55%
  • 24 ft: 36%

Crandall & Smaldino (2000)

1b. OK…so what do I do with this info?

• 1. Use it in your reports!
  • I use citations in my reports (see reference list provided)
    • Yes…I will admit this is dorky, but it seems to get attention, and it is EVIDENCE-BASED PRACTICE
    • Since I started doing this, teachers, parents, administrators, deaf educators, etc. request the articles
    • See sample report in handouts

Ear & Hearing, 12

1b. Issues Related to Distance
1c. Measure Classroom Acoustics

• Anyone can easily assess classroom acoustics with a smartphone and an app!
  • ASHA & ANSI:
    • Unoccupied noise:
      35 dBA
    • Reverberation:
      0.7 seconds
    • Estimate SNR

1c. Measuring Classroom Acoustics

• Ostergren & Smaldino: Journal of Educational Audiology (2012)

Figure 1. AudioTools App from Studio Six Digital.

1c. AudioTools: Studio Six Digital

Figure 2. iPhone with Analog Sound Level Meter App running.

1c. AudioTools: Studio Six Digital

Figure 3. Sound study graph of an unoccupied classroom. This can also be done in an occupied classroom.
1c. AudioTools: Studio Six Digital

.45 seconds

Figure 5. RT60 measures displayed in octave bands.

Determining Educational Need

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EB Component #2:
Perform a Classroom Observation

• Assess the child’s listening behaviors during direct instruction:
  • Where is child seated?
  • Unusual ambient noise in room?
  • On/off-task behavior relative to other children?
  • Independent worker?
  • Need help from other students?
  • Class participation?
  • Student interview: ask about hearing specific teachers

See sample observation form in digital handouts
3. Assessing Speech Recognition in Noise

- Adolescent/Adult tests designed for use in noise:
  - HINT-C: Starkey Pro
  - BKB-SIN: Etymotic ($195)
  - Quick-SIN: Etymotic ($160)

4. Assessing Speech Recognition in Noise

- Pediatric Tests Designed for Use in Noise:
  - BKB-SIN: Ages 6+
  - HINT-C: Ages 5+

<table>
<thead>
<tr>
<th>Test (Abbreviation)</th>
<th>Ages</th>
<th>Test Description</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>BKB-SIN</td>
<td>6-12 years</td>
<td>Adaptive test measures 50% correct responses for sentences in speech shaped noise</td>
<td>High validity, reliability, &amp; sensitivity, computable, may be used with any population, simple administration, scoring &amp; interpretations</td>
<td>May have ceiling/horizonal effect for standard SIN, only affects the standard test, not the children</td>
</tr>
<tr>
<td>Quick-SIN</td>
<td>5 years</td>
<td>Connected Speech Test (CST)</td>
<td>High validity, reliability, &amp; sensitivity, computable, may be used with any population, simple administration, scoring &amp; interpretations</td>
<td>Easy to administer, appropriate for school-aged children, speech shaped noise may not be as challenging as other choices</td>
</tr>
</tbody>
</table>

Schafer, J Ed Aud, 2010
3. Assessing Speech Recognition in Noise

**Pediatric Tests Designed for Use in Noise:**
- PSI: Ages 3+
- LiSN-S:

**Problems:**
- Limited number of tests
- Cannot use standard clinical tests because of vocabulary level and lists not equivalent in noise: WIPi, PBK, NU-CHIPS, NU-6, W-22
- Only test for young children, requires fixed intensities: longer test time, multiple lists, what SNR?, ceiling/floor effects

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### 3. Speech Recognition

#### Stimuli:
- Phrases in Noise Test (PINT):
  - children 3+
- BKB-SIN: children 6 years+ and adults

#### Conditions:
- No FM
- FM 1
- FM 2 (if applicable)

#### Test Environment:
- Soundbooth: speakers at 0 and 180° azimuth, transmitter placed 3 to 6” from signal speaker
- Classroom

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<table>
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</tr>
</thead>
<tbody>
<tr>
<td>PSI</td>
<td>3+</td>
<td>Ages 3+</td>
<td>High validity, reliability, &amp; subjectivity; complete &amp; simple administration, scoring &amp; interpretation</td>
</tr>
<tr>
<td>LiSN-S</td>
<td>3+</td>
<td>Versatile for varying ages &amp; types of noise</td>
<td>Only designed for use with selected JASAP may only present under environmental exposure</td>
</tr>
</tbody>
</table>

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### 3. Speech Recognition: BKB-SIN

- 18 list pairs equated for difficulty
- Each pair has 8-10 sentences and takes approximately 3 minutes to administer and score
- Score based on number of key words repeated correctly, then use formula to calculate SNR loss
- Recorded Split track or Standard CD

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### 3. Speech Recognition: PINT

- Lab Goal: Create or assess reliability and validity of new speech recognition tests:
  - Phrases in Noise Test (PINT)
    - Initial stimuli used in Schafer & Thibodeau, 2006
    - New version: Schafer et al., 2012
    - Available via email: untschaferlab@gmail.com
  - AzBio Sentence Lists in Noise (> 9 years)
    - Sphar & Dorman, Arizona State, $155
    - http://auditorypotential.com/
  - Listening Comprehension Test 2
    - Recorded existing test in background noise
3. Phrases in Noise Test (PINT)

Is it needed?

1. There is no sensitive speech recognition test in noise for young children
   • Current tests are not designed for testing in noise (NU-CHIPS, WIPI, PBK) or they are subject to ceiling effects (PSI)

2. We need a reliable, valid, and portable speech-in-noise test for young children to:
   • Examine those who are at-risk for listening difficulties in the classroom
   • Assess “educational need” for assistive technology
   • Measure the benefit from assistive technology (i.e., FM systems)

Goals of study:

1. Create a reliable and valid test for 3-6 year olds
2. Equipment & set-up for real classrooms or soundbooth
3. Normative data on 3-6 year olds: NH & CIs
4. Assess effects of spatial separation of speech and noise sources

3. PINT: Stimuli

• PINT consists of 12 phrases
   – May be acted out with a doll & objects
   – Sample phrases:
     | Wash his teeth | Comb his hair | Pull his toes |
     | Shave his face | Shave his face | Shave his face |

• Phrases are of equal duration & equal intelligibility in 4-classroom noise
   – Pilot data with 20 adults established that the phrases were equally-intelligible in noise

3. PINT Scoring

• Estimates 50% correct speech-in-noise thresholds (e.g., BKB-SIN)

   Conditions:
   – 1. Speech/noise: same loudspeaker (S0/N0)
   – Speech/noise: separate loudspeakers (S0/N180)

   Threshold = 1.5 dB
3. PINT Equipment/Set-up

1. Attached speaker wire to boom box speakers
2. Placed speakers on desks equidistant to child’s seat (3 feet)
3. Verified output of each speaker using calibration track on CD and radio shack SLM

3. PINT Results: Normal Hearing

- Good test-retest reliability (each child repeated 2 lists)
- Significant effect of spatial separation (S0/N0 and S0/N180)
- 3-year-old children perform significantly worse in noise than children ages 4-6 years and adults

Schafer et al., 2012, Ear & Hearing

3. PINT Results: Hearing Loss

- No group comparisons because of small samples
- Significant effect of spatial separation (S0/N0 and S0/N180)

3. PINT Results: NH vs. Hearing Loss
3. PINT vs. Teacher S.I.F.T.E.R.

- Significant medium to large correlations for all Preschool S.I.F.T.E.R. areas
- Poorer PINT performance related to poorer teacher ratings

![Graph showing correlation between S.I.F.T.E.R. and PINT performance](image)

\[ R^2 = 0.5595 \]

3. AzBio Sentence Lists

- Used in several CI research studies: Spahr & Dorman, 2004; Gifford et al, 2008; Spahr et al, 2011, 2012
- CD version:
  - 15 lists: Channel 1
  - 10-talker babble: Channel 2
  - Four talkers: 2 male; 2 female

3. AzBio Sentence Lists

- No clear evidence: list equivalency in noise
- Our Method:
  - Assessed equivalency of all 15 lists in noise—
    - 14 adults with normal-hearing sensitivity at 0 SNR and -3 SNR
    - 12 adults and adolescents with CIs +10 SNR

![Graph showing AzBio List Equivalency: NH](image)

**Not equivalent: 1, 6, 7, 12, & 14 different from more than one other list**
3. AzBio List Equivalency: CI

- Not equivalent
- Deleted 1, 6, 7, 12, & 14: now equivalent

Schafer et al., 2012, JAAA

3. Group Comparison

- Significant difference between 0 vs. +10
- Same for -3 vs. +10: 13 dB difference!!!

Schafer et al., 2012, JAAA

3. Listening Comprehension

- Valente et al. (2012)
  - Examined speech recognition & comprehension of NH students for two tasks: discussion and lecture
  - Tested at +5 and +10 SNR and at two reverberation times: .6 and 1.5 seconds
  - Performance compared to adults and to sentence recognition in the same conditions

- Speech recognition ≠ comprehension
- Valente et al., 2012
3. Listening Comprehension

- Significant effect of age
- Significant effect of SNR condition
- Significant effect of RT condition

- What specific areas of comprehension most affected?
- Tested listening comprehension in 6-10 yr olds
  - Listening Comprehension Test 2 (Linguisystems):
    1. main idea
    2. details
    3. reasoning
    4. vocabulary
    5. understanding messages

Compared performance to 95% confidence intervals in quiet from test manual

Schafer et al., 2013 | Educ Audio
3. Listening Comp. Results

- Overall:
  - Children have poorer comp. in background noise
  - Most difficulty: details, reasoning, & unders. messages
  - New research suggests that these findings relate to working memory
  - Although we cannot sell the stimuli, you could do this test live voice with background noise

3. What does this mean??

- 1. Recognition ≠ Comprehension
- 2. We can do better than recognition
- 3. This is critical for determining educational need in children
- 4. Specific areas of comprehension affected by noise:
  - Details, reasoning, vocabulary, understanding messages
  - \( \frac{1}{2} \) are able to identify the main idea, which is similar to recognition

3. Listening Comprehension & Working Memory

- Sullivan, Homira, & Schafer, submitted
  - Examined relationship between two skills in quiet and in noise: 20 NH children
  - Sections of Listening Comprehension Test 2
  - Backward digit recall and listening recall: subsets from the Working Memory Test Battery for Children (WMTB-C)

3. Working Memory
3. Listening Comprehension vs. Working Memory: Quiet

- Auditory Working Memory Total: Quiet
- Listening Comprehension Total: Quiet

\[ r = 0.50 \]

3. Listening Comprehension vs. Working Memory: Noise

- Auditory Working Memory Total: Noise
- Listening Comprehension Total: Noise

\[ r = 0.75 \]
EB Component #4: Teacher & Student Questionnaires

- Almost all of our research includes questionnaires, which correlate to behavioral results
- SIFTER: Screening Instrument for Targeting Educational Risk
- CHAPS: Children's Auditory Performance Scale
- LIFE: Listening Inventory for Education
- www.successforkidswithhearingloss.com

Incorporates classroom acoustics

C. H. A. P. S.
Children’s Auditory Performance Scale

Incorporates

CHILDREN'S AURAL PERFORMANCE SCALE

- NOISE
  - 0
  - 1
  - 2
  - 3
  - 4
  - 5

- SPEECH
  - 0
  - 1
  - 2
  - 3
  - 4
  - 5

- MULTIPLE
  - 0
  - 1
  - 2
  - 3
  - 4
  - 5

- MEMORY
  - 0
  - 1
  - 2
  - 3
  - 4
  - 5

- ATTENTION
  - 0
  - 1
  - 2
  - 3
  - 4
  - 5

TOTAL COMPOSITION SCORE:
PASS RANGE: 0-11
AT-RISK RANGE: 12-19

SCORES: The CHAPS can be scored two ways. Add up the numbers for each condition and place the sum in the Total Composition Score box. Use the CHAPS to establish auditory performance for children in the 3-6 and 7-12 age ranges. The appropriate test is determined based on the child’s age and the CHAPS score. In addition, the average condition score can be plotted on the graph to display performance as compared to the normal range, but the CHAPS manual must be consulted for validity and interpretation information.
Determining Educational Need

- IDEA: an evaluation in the child's customary environment
- 1. Cite acoustics research & measure classroom acoustics
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- 5. Other informal assessments: interviews, academic standing, review file, & trial period
- 6. Cite research on the population you are assessing
EB Component #5: Other Informal Evaluations

- **Parent/Student Interview:**
  - Ask about listening problems in specific classes (e.g., science)
  - Ask student/parent about grades
  - Ask parent about concerns
  - Ask student about hearing different teachers
  - Ask parent about hearing aid use/problems with hearing aids

5. Other Informal Evaluations

- **Review of Sp Ed File:**
  - Audiological evaluations
  - Noted teacher concerns
  - Other evaluations (OT, PT, Autism, Medical, etc.)
  - Review communication assessment from AI evaluation
  - Review speech-language evaluation & goals from SLP
  - Oral/reading comprehension tests given in classroom
  - Neale Analysis of Reading Ability (NARA), Oral and Written Language Scales (OWLS)

- **Academic standing**
  - Should not be a major contributing factor
  - **BIG** difference between academic need and educational need
  - Jake’s story

- **Trial with device**
  - AT Specialist will train school staff on use and maintenance of equipment followed by 6 week trial
  - Pre-post measures:
    - Classroom observation
    - Teacher questionnaires
    - Teacher, parent, student interview
  - Summary report created; Schedule IEP meeting/ARD meeting
EB Component #6: Cite Research

- All children are affected: classroom noise, reverberation, signal-to-noise ratios, and distance from the teacher

<table>
<thead>
<tr>
<th>Data for several populations:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal hearing</td>
</tr>
<tr>
<td>Younger students</td>
</tr>
<tr>
<td>English language learners</td>
</tr>
<tr>
<td>Otitis Media</td>
</tr>
<tr>
<td>Unilateral hearing loss</td>
</tr>
<tr>
<td>Mild or minimal hearing loss</td>
</tr>
</tbody>
</table>

Teachers suffer from significant vocal fatigue!

6. Children with Normal Hearing

- Finitzo-Heiber & Tillman (1978)
  - Examined word recognition of 12 children with normal hearing
  - Tested in noise and reverberation conditions

6. Younger Listeners

  - Speech recognition in noise of 40 children in Kindergarten, 1st, 2nd, and 3rd grades

6. English Language Learners

- Nelson, Kohnert, Sabur, & Shaw (2005)
  - Examined speech recognition of 7 English only speakers and 15 Spanish speakers

Even in a quiet room, scores in the presence of long RTs declined to 80%.

In a typical classroom with +6 SNR and 0.8 RT, scores declined to 60%.
6. Children with OM

- Gravel & Wallace (1992)
  - Speech recognition using adaptive stimuli: 13 children with OM- and 10 children with OM+

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6. Children with Unilateral Loss

- Bess, Tharpe, & Gibler (1986)
  - Speech perception of 25 children with mild to severe unilateral hearing loss; 25 with normal hearing

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6. Children with Mild/Minimal SNHL

- Alarming number of children, many not be identified
  - Niskar et al. (1998) [JAMA 279(14)]
    - 14.9% of 6166 children, ages 6 to 19, had low-frequency or high-frequency hearing loss of 16-dB HL or greater
  - Bess, Dodd-Murphy, & Parker (1998)
    - 11.3% of 1218 3rd through 9th grade students had hearing loss > 20 dB HL

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6. Children with Minimal SNHL

- Children mild/ minimal SNHL:
  - Crandell, Smaldino, & Flexer (1995)
  - Compared speech perception of normal-hearing to children with minimal degrees of SNHL

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In Book: Sound-field FM Amplification Theory and Practical Applications
6. Children with Mild-Mod SNHL

- Finitzo-Heiber & Tillman (1978)
  - Word recognition: 12 normal-hearing children vs. 12 with hearing impairment
  - Tested in noise and reverberation conditions

Scores decrease as noise and reverberation increase, significantly worse performance than NH children in previous slide

In a typical classroom with -6 SNR and 0.8 RT, scores declined to 50%

6. Children with Cochlear Implants

- Schafer & Thibodeau (2004)
  - 10 normal-hearing adults; 8 with CIs
  - Speech recognition significantly poorer for CI group

Similar decrement noted for children between quiet and noise conditions (Davies et al., 2001; Schafer & Thibodeau, 2003, 2006)

6. Children with ASD & ADHD

Lower scores are better!

- Significantly poorer than typical peers
- Same as peers when using FM

Schafer et al., 2012, J Comm Dis

6. Teachers

- Roy et al. (2004)
  - Prevalence of teachers who had voice disorders
  - During lifetime, teachers had significantly more voice disorders versus non-teachers
  - More likely to consult physician or SLP
  - Woman higher prevalence than men

Figure 3: Lifetime prevalence of voice disorder according to teacher status and age. A voice disorder was defined as any time the voice did not work, perform, or sound as it normally should, or that it interferes with communication.
Determining Educational Need

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Summary ....Yay!!

• Classroom acoustics does not have to be boring.
• OK...maybe the guidelines are boring, but...assessing acoustics with an app is FUN!
• Observing children in their customary environment is INTERESTING!
• Assessing speech recognition and comprehension in noise out in a child’s classroom is pretty EXCITING!
• Teacher questionnaires are super NEAT!
• Other assessments are extremely HELPFUL!
• Don’t be afraid to use research on populations!

What do you do once you find educational need?

1. Classroom modifications
2. Behavioral management
3. Amplification & Wireless Tech

1. Classroom Modifications

http://www.allnoisecontrol.com/
Lower ceilings are better, install ceiling tiles, baffles, banners

Using carpet and rugs, or adding tennis balls or rubber tips to legs of chairs, desks, and tables

Drapes, panels, corkboard, or acoustical fabrics on windows and walls
2. Behavior Management: Occupied Noise Management Techniques

Non-verbal cues to get attention:
1. Light switch or hand signals to gain attention
2. Hands up, mouths closed
3. Noise Thermometer
4. Monkey Meter
5. Chatter Tracker
6. Talk Light: $750
7. Yacker Tracker: $40–$100

2. Calmness Counter

3. Occupied Noise Management Techniques

• Get the entire school involved to reduce noise in hallways:
  • Line leader reviews hallway rules before leaving classroom
  • Line leader carries a quiet sign in the halls
  • Whole school implements a quiet hand signal

3. Amplification: Personal Devices for Children Hearing Aids & Cochlear Implants

UNIVERSAL
- Phonak MLxi
- Oticon Amigo R2

DEDICATED
- Phonak ML 12i
- Oticon Amigo R7

NECKLOOP
- Phonak MyLink+
- Oticon Arc
- Phonak ML14i for Nucleus 5
3. Amplification: Personal Devices
Normal Hearing

- Oticon Amigo Star
- Phonak Dynamic
- Soundfield

Phonak iSense Micro

If you have questions...

- Email:
  - utschafertab@gmail.com
  - Erin.Schafer@unt.edu

I'm just going to ask you a few questions so I can transfer you to the right department. They will ask you the exact same questions and be of no help.
Helpful References!
Erin C. Schafer, Ph.D.

Typical Classroom Acoustics


Recommended Classroom Acoustics & Measuring Acoustics


Effects of Noise on Younger Listeners


Effects of Noise: Normal Hearing Listeners

Effects of Noise: English Language Learners

Effects of Noise: Hearing Loss and Hearing Aids

Effects of Noise: Unilateral Hearing Loss


**Effects of Noise: Cochlear Implants**


**Effects of Noise: Otitis Media**


**Other Effects:**

**Listening Comprehension**


**Working Memory**


Listening Effort (see pubmed.com for more studies on this):


**Processing Time:**


**Teacher Vocal Fatigue**


**Remote-Microphone Technology Guidelines**

**FM System Research: Young Children**


**FM/DM System Research: Normal Hearing**


**FM System Research: English Language Learners**


**FM System Research: Auditory Processing Disorder, Autism Spectrum Disorders, ANSD, ADHD, & Other Needs**


Friederichs, E. & Friederichs, P. (2005). Electrophysiologic and psycho-acoustic findings following one-year


**FM/DM System Research: Minimal and Mild Hearing Loss**


**FM System Research: Unilateral Hearing Loss**


**FM System & Digital Transmission Research: Moderate to Profound Hearing Loss and Hearing Aids**


FM System/Digital Transmission Research: Cochlear Implants


Observation of Attending Behaviors

Student: ______________________________________ DOB: _______ Grade: _______
Parent(s) Name(s): ___________________________ Hm Phone: _______________________
School: ___________________________ Teacher: ___________________________
Observed By: ___________________________ Date: _________________

Current amplification in use: RE _____________________________________________________
                          LE _____________________________________________________
Is he/she a consistent user?       Y    N
Amplification compatible with telecoil and DAI? RE __________________________________________
                          LE __________________________________________
Are other FM systems used at school?   Y    N
     If yes, please list systems and channels in use: _________________________________________
     ___________________________________________________________________________________
Will the student be changing classes? Y    N      If yes, how many? _____________________
Classroom acoustics measurements: _______________________________________________________
                          ___________________________________________________________________________
Many unusual ambient noise in the classroom? ____________________________________________
                          ___________________________________________________________________________
Where is the student seated in room?_____________________________________________________
                          ___________________________________________________________________________
Does he/she follow along with the lesson independently? _________________________________
                          ___________________________________________________________________________
Does he/she look to other students to follow activities? ________________________________
                          ___________________________________________________________________________
Does he/she do well with transitions? _________________________________________________
                          ___________________________________________________________________________
**Target Student**

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<th>Time:</th>
<th>Off Task</th>
<th>Repetition</th>
<th>Redirection</th>
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Comments:

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**Peer**

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Comments:

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**Parent Interview**

Parent Preference for FM: ________________________________

How does the student feel about using hearing aids/CI?

__________________________________________________________________________________

__________________________________________________________________________________

__________________________________________________________________________________

Additional Comments:
Student Interview

Student Preference for FM: ____________________________________________________

Additional Comments:
* Developmental questionnaire/checklist
~Good for validation of hearing assistance technology (HAT)

- **Auditory Behavior in Everyday Life (ABEL)**

- **Children’s Auditory Processing Scale (CHAPS)**
  [https://successforkidswithhearingloss.com/tests](https://successforkidswithhearingloss.com/tests)

- **Children’s Abbreviated Profile of Hearing Aid Performance (CA-PHAP)**

- **Parent’s Abbreviated Profile of Hearing Aid Performance (PA-PHAP)**

- **Children’s Home Inventory of Listening Difficulties (CHILD)**

- **The Children’s Outcome Worksheets (COW)**
  Available from Oticon:

- **Developmental Index of Audition and Listening (DIAL)**

- **Early Listening Function (ELF)**

- **Functional Auditory Performance Indicators (FAPI)**

- **The Functional Listening Evaluation (FLE)**

- **Pediatric Hearing Demand, Ability, and Need Profile (HDAN)**
*Infant-Toddler Meaningful Auditory Integration Scale (IT-MAIS)

*Meaningful Auditory Integration Scale (MAIS)*

*Parents’ Evaluation of Aural/oral performance of Children (PEACH)*

*Teachers’ Evaluation of Aural/oral performance of Children (TEACH)*

*Screening Instrument For Targeting Educational Risk (SIFTER)*

*Screening Instrument for Targeting Educational Risk in Preschool Children (age 3-Kindergarten) [Preschool SIFTER]*

*Screening Instrument For Targeting Educational Risk in Secondary Students (Secondary SIFTER)*

Listening Inventory For Education An Efficacy Tool Student Appraisal of Listening Difficulty (Student LIFE)

Listening Inventory For Education An Efficacy Tool Teacher Appraisal of Listening Difficulty (Teacher LIFE)
Reason for Evaluation
Joe was referred for a FM system evaluation at the request of his mother. She was concerned that he was not receiving adequate benefit from his current FM system, a desktop soundfield system.

Background Information
Joe is a six-year old Kindergartner at Alder Elementary. Previous testing shows that he has a bilateral profound hearing loss. Joe uses an Advanced Bionics HiResolution 90K implant with Auria Sound Processor on his right ear and a digital hearing aid in his left ear. When using his implant, he has excellent word-recognition performance in quiet conditions in the sound booth. No speech recognition testing was conducted in a noise condition.

Existing Evidence
Typical school classrooms do not provide adequate acoustics that meet guidelines recommended by the American National Standards Institute (2010) or the American Speech-Language-Hearing Association (2005) for appropriate levels of unoccupied noise, reverberation, and signal-to-noise ratios (Arnold & Canning, 1999; Knecht et al., 2002). Furthermore, previous research shows that children with cochlear implants experience significant decreases in speech recognition in noise relative to performance in a quiet listening condition; however, personal frequency modulation (FM) systems that are directly coupled to the cochlear implant significantly improve speech recognition performance in noisy test conditions (Schafer & Thibodeau, 2003, 2006). Also according to previous research, personal FM systems provide significantly better speech recognition performance for individuals with cochlear implants than soundfield systems, which consist of wall-mounted or desktop loudspeakers (Schafer & Kleineck, 2009).

Informal and Formal Evaluation Results
The functional evaluation to determine the need for the FM system consisted of formal and informal evaluations including speech recognition in noise testing, a teacher questionnaire, a classroom observation of listening behaviors, a parent interview, and a review of current academic performance and educational challenges.

Joe’s speech-recognition performance in noise was evaluated in his classroom with the Phrases in Noise Test (PINT), which measures a 50% correct speech-in-noise threshold for simple, closed-set phrases in classroom noise. During testing, the signal speaker (phrases) was presented directly in front of him while the background noise (classroom noise) was presented directly behind him. Lower scores on this test indicate better performance or the ability to function in a more adverse listening environment. Joe was tested in three conditions: (1) cochlear implant alone, (2) desktop soundfield system, and (3) electrically-coupled personal FM receivers that directly connect to his cochlear implant and hearing aid. Scores for the three conditions were (95% critical difference level=3.2 dB):

1. Cochlear implant alone: +10.5 dB
2. Desktop soundfield system: +1.5 dB
3. Electrically-coupled personal FM system: -9.0 dB

The cochlear-implant alone condition results suggested that Joe requires the phrases to be at least 10.5 dB more intense than the background noise to hear the speech only half of the time. Both the desktop and electrically-coupled FM system significantly improved his ability to hear the closed-set, simple phrases; however, the electrically-coupled system provides significantly greater gains in speech recognition in noise. Given the substantially more difficult, open-set listening tasks expected of children in a real classroom environment, this simple speech-in-noise test substantially underestimates the
difficulties he will face in a real listening situation. As a result, Joe should use the device that provides the greatest benefit.

The teacher questionnaire used for the evaluation was the Screening Instrument for Targeting Educational Risk (SIFTER). Results from both of his general education teachers indicated that he is at risk in the areas of attention, communication, and class participation when compared to his peers with normal hearing. The questionnaire results were validated by the classroom observation conducted by the audiologist. During the observation during center time, the classroom was particularly noisy with occupied noise levels ranging from 67 to 88 dBA across eight measurements throughout his classroom. These noise levels would make it difficult, if not impossible, to achieve the +15 signal-to-noise ratio recommended by the American Speech-Language-Hearing Association (2005) for children with hearing loss, even when the desktop system is in use. Furthermore, it was not feasible for Joe to carry around his desktop system to each center; therefore, he did not use it during center time and other similar periods throughout the day. As a result, during any given school day, it was only used during circle time, snack time, and music. Given the noisy conditions, Joe had substantial difficulty following directions and he relied on peers during transitions. Joe's mother was concerned that he was not hearing well at school with the desktop soundfield FM system. He was performing well in the classroom in terms of academic performance, but his expressive and receptive language levels were delayed relative to normal-hearing peers.

Recommendation
Given the results of the formal and informal evaluations, an electrically-coupled personal FM system is recommended for Joe. This recommendation is further supported by peer-reviewed literature cited above on FM systems for children and adults with cochlear implants. It is also recommended that Joe should be preferentially seated in the classroom away from noise producing equipment. The electrically-coupled system will need to be fit and regularly monitored by a licensed educational audiologist.

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References


