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Back to Basics: Understanding Hearing Loss for Speech Language Pathologists, Part 1

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Learning Outcomes

As the result of this continuing education activity, participants will be able to:

- Identify types of testing required for a complete audiological evaluation.
- Describe the importance of auditory access for auditory brain development.
- Describe procedures for determining if technology is providing sufficient benefit.
Types of Auditory Problems

- Hearing loss
  - Mild to profound
- Auditory processing disorder
- Auditory attention disorder
- Sound sensitivities

Basic Assumptions

- Hearing is critical for language development
- Even a mild hearing loss can interfere with language development
- It is possible to obtain reliable auditory information on infants and children of any age and any developmental status
- Reliable auditory information is critical to appropriate management
- Early and appropriate technology is the single most important rehabilitative tool available to infants and children with hearing loss
- Appropriate technology is critical for appropriate habilitation and educational placement
Why Is Earlier Identification Critical?

- Infants with hearing loss who are appropriately fit with hearing aids prior to 6 months of age can have speech and language development commensurate with their typically hearing peers.
  - Infants fit at 12 months are 1 SD below their peers
  - Infants fit at 18 months are 2 SD below their peers
  - Infants fit at 24 months are 3 SD below their peers
- Children who wear hearing aids 10 or more hours/day do better than children who wear hearing aids less than 10 hours/day

Yoshinata- Itano

Why Do We Need Excellent Auditory Access?

- Most children with HL are educated in the mainstream
- Facilitate spoken language development
- Facilitate psychosocial development
- Language is best learned through audition
  - Provides the most information
  - Permits incidental learning
  - Provides subtle information not available visually
  - Hearing is an open channel – we cannot close it off

Q1
Families Desired Outcome

- The family’s desired outcome guides us – ethically and legally.
  - What is your long term goal for your child?
  - Where do you want your child to be at age 3, 5, 14, 20?
- What does it take to achieve the families goal?
- 95% of children with hearing loss are born to hearing and speaking families.
- Acoustic accessibility is critical if a child with hearing loss is going to learn to listen and talk.
How Does The Auditory Brain Work

- Hearing loss results in significant changes in the higher auditory centers.
- The auditory cortex is directly involved in speech perception and language processing in humans (Kretzmer et al., 2004).
- Normal maturation of central auditory pathways is a precondition for the normal development of speech and language skills in children (Sharma et al., 2009)

How Much Practice Is Needed To Influence Neural Structure?

- Malcolm Gladwell: 10,000 hours of practice
- Hart and Risley: 46 million words heard by age 4
- Dehaene: 20,000 hours of listening as a basis for reading
- Pittman: Children with hearing loss require three times the exposure to learn new words and concepts due to the reduced acoustic bandwidth caused by the hearing loss
Hart and Risley (1995)

<table>
<thead>
<tr>
<th></th>
<th>PARENTS</th>
<th>CHILDREN</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Professional</td>
<td>Working class</td>
</tr>
<tr>
<td>IQ age 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vocab size</td>
<td>2,179</td>
<td>1,498</td>
</tr>
<tr>
<td>Average Utterances per hour</td>
<td>487</td>
<td>301</td>
</tr>
<tr>
<td>Average Diff Words per Hour</td>
<td>382</td>
<td>251</td>
</tr>
<tr>
<td>Average Words per Hour</td>
<td>2,153</td>
<td>1,251</td>
</tr>
<tr>
<td>Average Words per 14 hour day</td>
<td>30,142</td>
<td>17,514</td>
</tr>
</tbody>
</table>

Acoustic Access

- Sufficient acoustic access is the most important factor affecting children with hearing loss
- Technology is often not programmed well enough to meet the needs of acoustic accessibility
- Auditory environments must be appropriately managed
- Technology must be programmed to provide sufficient auditory access
- If the child is not progressing as expected – and everyone has appropriately high expectations – suspect the technology/acoustic accessibility first.

Hearing Loss and APD is Really About The Brain

- Hearing aids, FM systems and cochlear implants are not about the ears; they are about the brain!
- They are “brain access” tools.
- And, the audiologist is the professional responsible for assuring brain access by managing hearing loss, technology, and acoustic environments.
If A Child Is Not Progressing Well

- Suspect technology first
  - Is the child hearing well enough?
  - Is the child hearing high frequencies
- Is the child wearing technology consistently?
  - If a child is using technology for only 4 hrs/day, it will take 6 years for the child to hear what a typically hearing child hears in one year.
Audiogram

- To quantify hearing loss, we talk about different features from audiogram
- Features give better understanding of specific loss and effects on perception of speech
  - Degree
  - Configuration
  - Type
  - Symmetry
### Audiogram Symbols

<table>
<thead>
<tr>
<th></th>
<th>Unmasked Air Conduction</th>
<th>Masked Air Conduction</th>
<th>Unmasked Bone Conduction</th>
<th>Masked Bone Conduction</th>
<th>Aided</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right</td>
<td>O</td>
<td>△</td>
<td>&lt;</td>
<td>[</td>
<td>A&lt;sub&gt;R&lt;/sub&gt; CI&lt;sub&gt;R&lt;/sub&gt;</td>
</tr>
<tr>
<td>Left</td>
<td>X</td>
<td>□</td>
<td>&gt;</td>
<td>]</td>
<td>A&lt;sub&gt;L&lt;/sub&gt; CI&lt;sub&gt;L&lt;/sub&gt;</td>
</tr>
<tr>
<td>Not ear specific</td>
<td>SF (Sound field)</td>
<td>^</td>
<td></td>
<td></td>
<td>A&lt;sub&gt;B&lt;/sub&gt; CI&lt;sub&gt;B&lt;/sub&gt;</td>
</tr>
</tbody>
</table>

### Abbreviations

- HL – hearing loss
- HL – hearing level (above 0 dB)
- SL – sensation level (above threshold)
- SPL – sound pressure level
- AC – air conduction
- BC – bone conduction
- - no response
- CHL – conductive hearing loss
- SNHL – sensorineural hearing loss
- Mixed hearing loss
- dB – decibels
- SNR – signal to noise level
- OE – outer ear
- ME – middle ear
- IE – inner ear
Description of Hearing Loss

- Pure tone average
  - 500, 1000 and 2000 Hz
- Description of hearing loss across all frequencies
  - eg – Mild to severe
- Describe air and bone conduction HL

Degree of Hearing Loss

- Intensity level at which a person perceives a sound
- If outside the range of normal, this indicates “degree” or severity of the impairment
- Patient’s threshold responses to pure tones measured in dBHL at each tested frequency (Hz)
- Responses plotted on audiogram
- 0dBHL on top of graph so farther down the graph, the more loss
Can we call it the Speech Bean?
Transducers

- Air conduction
  - Tests the entire auditory system
  - Soundfield, or earphones
- Bone conduction
  - By passes outer and middle ear
  - Tests inner ear directly
  - Bone vibrator places behind on the mastoid

Types Of Hearing Loss

- Conductive
  - Problem in the outer or middle ear
- Sensorineural
  - Sensory – in the cochlea
  - Neural – beyond the cochlear
- Mixed
  - Conductive and sensorineural
Conductive Hearing Loss

- Damage to outer or middle ear
- Otitis Media
- Structural deformities
- Cholesteotoma
- Foreign bodies
Sensorineural Hearing Loss

- Damage to the inner ear
  - Hair cell damage in the cochlea
  - Damage to the VIIIth cranial nerve (e.g. tumor)
  - Auditory dysynchrony – problem in the transmission of the signal

- Causes
  - Congenital
  - Genetic
  - Fever
  - Viral

- Progressive
  - A lot of HL is progressive

---

Sensorineural Hearing Loss

- Damage to the inner ear
- Hair cell damage in the cochlea
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- Causes
- Congenital
- Genetic
- Fever
- Viral

- Progressive
- A lot of HL is progressive

---

![Pure Tone Audiometry Graph](image)
### Degree of Loss: Impact of Untreated HL on Children

<table>
<thead>
<tr>
<th></th>
<th>Slight / Minimal</th>
<th>Mild</th>
<th>Moderate</th>
<th>Moderately-severe</th>
<th>Severe to Profound</th>
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</thead>
<tbody>
<tr>
<td>Hear soft sounds?</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>Vowel articulation?</td>
<td>Most likely unaffected</td>
<td>Most likely unaffected</td>
<td>Most likely affected</td>
<td>Affected</td>
<td>Limited or no develop’t</td>
</tr>
<tr>
<td>Consonant articulation?</td>
<td>May be affected</td>
<td>Most likely affected</td>
<td>Affected</td>
<td>Limited or no develop’t</td>
<td>No develop’t</td>
</tr>
<tr>
<td>Receptive language?</td>
<td>May be affected</td>
<td>Delayed for age</td>
<td>Significantly delayed</td>
<td>Minimal develop’t</td>
<td>No develop’t</td>
</tr>
<tr>
<td>Expressive language?</td>
<td>May be affected</td>
<td>Delayed for age</td>
<td>Significantly delayed</td>
<td>Minimal develop’t</td>
<td>No develop’t</td>
</tr>
<tr>
<td>Processing time?</td>
<td>Slightly increased</td>
<td>Noticeably longer</td>
<td>Awkwardly long</td>
<td>Longer may not help</td>
<td>Long with visual input</td>
</tr>
</tbody>
</table>

### Auditory Processing Disorders

- Normal hearing
- Reduced ability to hear well when the signal is distorted or when there is competing noise
- Identification by an audiologist after conducting an APD evaluation
- Requires team management
- May or may not be associated with
  - Language learning disorder
Sound Sensitivities

- May be a physical or psychological problem
- Measured in a test booth by an audiologist
- Parents, therapists and teachers can contribute to the evaluation by noting if specific sounds or specific situation cause sound sensitivity reactions or if reactions are general.

Auditory Attention Disorder

- Child has difficult attending to auditory information but can attend to visual information
  - Child can look at books and play appropriately with toys but has difficult when asked to listen and follow conversation
Factors That Affect Auditory Learning

- Hearing
- Access to auditory information
- Amount of auditory deprivation
  - Hearing loss
  - Middle ear disease
- Good and constant language modeling
- Controlling the auditory environment
  - Noise
  - Distance from the talker

Hearing Screening in Infants

- Newborn hearing screening
  - Otoacoustic Emissions
  - Auditory Brainstem Response screen
- What does it tell you?
  - OAE screen
    - Pass – no worse than mild hearing loss
    - Refer – Fluid? Debris? HL?
  - ABR screen (broad frequency click)
    - Pass – no worse than mild HL at some frequency
    - Refer – hearing loss?
- (key word – screen)
  - Hearing at that moment only
Diagnostic Tests

- ABR
  - Provides information about intactness of auditory pathway
  - Not a direct measure of hearing
- OAE
  - Measures outer haircell function
  - Not a measure of hearing
- Immittance
  - Measures middle ear function
  - Not a measure of hearing
- Behavioral responses
  - Only direct measure of hearing
Behavioral Evaluation

- Direct measure of hearing
- Direct response of hearing measuring responses from the child
- Observation audiometry
  - Birth to 6 months (cognitive age)
  - Response – changes in sucking
- Visual reinforcement audiometry
  - 6 to 36 months (cognitive age)
  - Response – conditioned head turn
- Conditioned play audiometry
  - 30 months to 5-6 years (cognitive age)
  - Response – "listen and drop"
- Standard audiometry
  - > 5-6 years (cognitive age)
  - Response – hand raise or button push
Factors That Effect the Test Results

- Developmental age
- Neurologic status
- Behavioral status
- Middle ear status
What Should We Be Looking For From Testing?

- Ask to see test results – not just the report
- Degree of hearing loss
  - Was the appropriate test used?
    - (BOA, VRA, Play, ABR etc.)
- Speech perception testing
  - Under earphones
  - In soundfield without technology
  - With technology
- Is the child hearing well enough to manage in a classroom?
What Should We Be Looking For From Speech Perception Testing?

- Ask to see test results
- Speech perception testing
  - Under earphones at a comfortably loud level
  - In sound field – no technology
    - Normal and soft conversational levels in quiet
    - Normal conversation level in noise
  - With technology
    - Normal conversation (50 dBHL) (R, L, B, FM)
    - Soft conversation (35 dBHL) (B, FM)
    - Normal conversation in noise (B, FM)
- If speech perception is poor, what can you expect
  - In learning language
  - In the classroom
Types of Speech Perception Tests

- Threshold tests
  - Speech awareness threshold
  - Speech reception threshold
  - Speech discrimination testing

SPEECH THRESHOLD TESTS
Speech Awareness/Detection Threshold

- Softest level at which a person knows speech stimulation is present
- Reported in dB
- Common stimuli
  - Conversational voice
  - Music
  - 6 sound – a, i, u, sh, s, m (Ling)
  - 3 sound – ba, sh, s (Madell)
SPEECH THRESHOLD TESTS

Speech Reception Threshold

- Softest level at which a person can identify speech stimuli.
- Reported in dB
- Common stimuli
  - Standard spondee pictures
  - Standard spondee words
  - Familiar objects or toys
  - Body parts
  - Numbers

Speech Perception

- Tested at suprathreshold levels
- Scored in %
- Under earphones testing usually performed at 40 dBHL
- With technology (R, L, B) testing performed at
  - 50 dBHL (normal conversational level)
  - 35 dBHL (soft conversational level)
  - 50 dBHL+5 SNR (normal conversational level in noise)
Measuring Outcomes Using Speech Perception

- Speech perception measures can
  - Assess unaided performance in typical listening situations
  - Demonstrate benefit with hearing aids or cochlear implants
  - Demonstrate improvement in functioning over time
  - Identify problems that develop over time
    - Reduction in functioning
    - Equipment deterioration or failure
  - Identify perception errors
  - Demonstrate habilitation/rehabilitation needs
  - Assist in selecting the appropriate educational environment

What Does A Child Need To Hear?

- Children with typical hearing understand 90-100% in quiet and in noise

- Excellent 90-100%
- Good 80-89%
- Fair 70-79%
- Poor < 70%
When Should Speech Perception Be Measured By The Audiologist?

- When hearing loss is identified
- At re-evaluations
- When selecting technology
- When changing technology settings
  - Hearing aids
  - Cochlear implants
  - FM systems

If we do not test, we will not know
- What the person hears
- More important – what the person does not hear
- If there has been a change in perception
- If there is something you can do to improve auditory functioning
Selecting Test Materials

- Linguistically appropriate
  - Not too easy or too hard
- Appropriate level of complexity
- Single vs multiple tests
  - One test does not give all the info

Speech Perception Test Stimuli

- Single words
  - Limited clues
  - Response will likely be limited to familiar words
  - Word vs phoneme scoring
- Nonsense syllables
  - Even fewer cues
  - Responses provide best indication of what is heard
- Sentences
  - Can use knowledge of the language to fill in blanks
  - May provide an unrealistically high score
Factors Which May Affect Speech Perception

- Degree of hearing loss
- Length of hearing loss
  - Length of profound hearing loss
- Experience with technology
- Demands on using audition
  - Educational setting
  - Family demands
- Language level
- Etiology of hearing loss
- Appropriateness of
  - Hearing aid settings
  - MAPping strategy, rate, etc.
- Experience of audiology and/or implant team

Suggested Protocol

- Monosyllabic words
  - Normal conversation 50 dBHL (R, L, B)
  - Soft conversation 35 dBHL (B)
  - Normal conversation 50 dB+5 SNR (B)
<table>
<thead>
<tr>
<th></th>
<th>Right</th>
<th>Left</th>
<th>Binaural</th>
<th>Binaural + FM</th>
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</thead>
<tbody>
<tr>
<td>WORDS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50 dB HL Words</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phonemes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>35 dB HL Words</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Phonemes</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>50 dB HL +5 S/N words</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phonemes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SENTENCES</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quiet 50 dB</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quiet 35 dB</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Noise 50 dB+5S/N</td>
<td></td>
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</table>

MONITORING TECHNOLOGY
Goals of Technology

- Reduce sensory deprivation
- Maximize use of residual hearing
- Provide input sufficient for auditory learning
- Lay foundation for auditory academic learning
- Facilitate socialization
- Facilitate information access/extended learning/incidental learning
- Safety
- Comfort

Never Assume!!

- Technology needs to be tested if we want to know how a child is performing
The Real Goal of Testing

- Is the child hearing speech at a soft enough level
  - Can she hear the teacher/parent/primary talker?
  - Can she hear conversation around her?
  - Can she use hearing for incidental learning?
- Is speech clear enough?
  - Distortion
  - Noise
  - Reverberation

What Needs To Be Tested With Technology?

- Real ear testing
- Aided threshold testing – Right and Left
- Speech perception testing
  - Normal conversation 50 dBHL (R, L, B)
  - Soft conversation 35 dBHL (B)
  - Normal conversation 50 dB+5 SNR (B)
The Audiologists Role

- Accurate identification of degree and type of hearing loss
- Evaluation and selection of technology
- Modify technology as needed
- Evaluate auditory progress
- Monitor classroom functioning
- Identify other disabilities and refer as needed
- Work cooperatively with other team members
- Collect information from SLP’s and teachers about auditory and language function
- Provide support to children and families

The Speech-Language Pathologists Role

- Monitor language and literacy development
- Monitor auditory development
- Communicate with audiologist about auditory skills and need for change of technology settings
- Work with other professionals including teachers and other therapists
- Provide support for the child and the family
The Role of the Listening and Spoken Language Specialist

- Monitor auditory development
- Develop a therapy program using a normal auditory development sequence
- Work with audiologist to determine when perception is indicates a need for a change of technology or technology settings.
- Educate others working with the child about hearing loss and the effect on academics and literacy

What can we do to change what a child hears?

- Make sure technology is worn full time
  - Change hearing aid settings
    - Limit of high frequencies with hearing aids
    - What do high frequencies tell us?
    - Receiver limitations
  - Change hearing aids
  - Cochlear implants
    - What do they provide?
    - Determining candidacy
- Auditory based language therapy
When A Hearing Aid Is Not Enough

- Hearing aids cannot provide enough gain to hear normal and soft conversational speech
- Child not making sufficient auditory gains
- Consider cochlear implant