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Maximizing Outcomes for Children with Auditory Disorders

**PEDIATRIC AUDIOLOGY PROJECT**
Jackson Hole Wyoming
and
**AudiologyOnline**
September 2015

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Auditory Brain Development: Listening for Learning

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Learning Objectives

As a result of this Continuing Education Activity, participants will be able to:

1) Describe auditory brain development as the foundation of listening, language and literacy for all children
2) Explain bottom up and top down processing as influenced by acoustic accessibility
3) Define signal-to-noise ratio (SNR) and discuss technologies that are designed to enhance the SNR

To Begin With: What is Hearing?

• Hearing is a first-order event for the development of spoken communication and literacy skills.
• Anytime the word “hearing” is used, think “auditory brain development” using 1 billion neurons with a quadrillion connections!
• Acoustic accessibility of intelligible speech is essential for brain growth – children speak what and how they hear.
• There are no “earlids” – the brain is available for auditory information 24/7.
• Signal-to-Noise Ratio (SNR) is the key to hearing intelligible speech (spoken information) – speech must be 10 times louder than background sounds. SLM APP
• Our early intervention programs and classrooms must take into consideration the listening capabilities and acoustic access of ALL of our children.
So, What is Hearing Loss? Think about Hearing Loss as a “Doorway” Problem

• The ear is the “doorway to the brain” for sound.

• Hearing loss obstructs that doorway, preventing sound/information from reaching the brain.

• Hearing aids, cochlear implants, FM systems break through the doorway to allow access, stimulation and development of auditory neural pathways with auditory/linguistic information.

The purpose of technologies (e.g. hearing aids, cochlear implants, FM systems) is to get sound/information through the doorway to the brain. There is no other purpose!
What is Sound? (Boothroyd, 2014)

• Sound is an “event”.
• For example, you don’t “hear” Mommy. You hear Mommy in action, such as walking, talking, singing, dancing.
• An event creates vibrations.
• Vibrations are picked up by the “ear doorway” and are sent to the brain as energy for coding, and for perception as information.

What About Hearing vs Listening?

• **Hearing** is acoustic access of information to the brain; it includes improving the signal-to-noise ratio by managing the environment and utilizing hearing technology.

• **Listening** is attending to acoustic events with intentionality – activating the pre-frontal cortex.

• “Hearing” must be made available before “listening” can be taught.

• We must know about the “hearing thing” before we can do the “listening thing”.
Neurological Issues: Listening

- We hear with the brain -- the ears are just a way in! What’s the big deal? (no “earlids”)
- Human beings are rich in auditory brain tissue – But children can’t listen like adults!
- Why? 1) the higher auditory brain centers are not fully developed until a child is about 15 years old, 2) and children cannot perform automatic auditory cognitive closure like adults.
- Therefore, all children need a quieter environment and a louder signal than adults.

Extrinsic vs Intrinsic Redundancy: A Key Concept (James Jerger)

- Extrinsic redundancy refers to the integrity of information from outside the person…..“bottom-up” sensory input.
- Intrinsic redundancy refers to the cognitive capacity -- the internal knowledge and attentional resources of the person…..“top-down” processing.
- There is an inverse relationship between these two concepts that must be considered for each child.
- Specifically, children do not have the top-down capabilities available to adults.
Improve Intelligibility of our Spoken Communication to Enhance “Bottom-Up” Sensory Input

- Most adults, including teachers and parents, speak faster than most children (and many aging persons) can process (often faster than 200 words per minute – way too fast!).
- Use “clear speech”....slow down (aim for 124 words per minute)....pause...use appropriate suprasegmentals to enhance meaning.
- The talker’s use of “clear speech” can improve the listeners speech discrimination by up to 40%.
- Use technology to improve the SNR.
- These are critical ways to enhance extrinsic redundancy.

Top Down Capacity (information in the brain) is Necessary For:

- Auditory/Cognitive Closure – filling in the gaps of missed information – taking a guess – “What do you think I said”, or “What did you hear me say?”
- Casual Listening – paying attention even if the person is not looking at you, and you are engaged in other activities
- Repair of Conversational Breakdowns -- by noting what information was not heard – “Not understanding” and “misunderstanding” are not the same thing.
First display a picture of the “Brain Ear”, and then the more traditional picture of the ear, showing:

Outer (external), Middle and Inner Ear
Mainstream Classrooms Are Auditory-Verbal Environments

“Listening” is the cornerstone of the educational system.

Children spend up to 70% of their school day listening -- to teachers, peers, instructional media/technology, and to their own speech.

Children are the biggest source of noise in the classroom.
If a child cannot clearly hear and attend to spoken instruction, the entire premise of the educational system is undermined.

Teach Acoustic – not Visual -- Similarities of Speech Sounds (Pam Talbot, 2015)

• Creating the child’s auditory-feedback loop by building auditory folders in their brain
• Sound alikes: S,f,th  m,n,ng  b,d,g,j  p,t,k,ch
• Knowing how these sounds “look” on the lips, will not help the child “hear” acoustic confusions when others say them, or when the child says them.
• Teach the child to hear rhyming words, e.g. pick, tick, kick, chick.
• Have the child speak/read into his/her FM mic.

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### What are the negative effects of poor classroom acoustics – for all children?

- Misunderstanding verbal instruction
- Missing verbal information
- Fatigue

### The Science of Acoustic Accessibility: Signal-to-noise Ratio (SNR)

**ALSO CALLED SPEECH-TO-NOISE RATIO**
**SNR** is the relationship between the primary or desired auditory signal to all other unwanted background sounds.

The more favorable the SNR, the more intelligible the spoken message

Everybody hears better in a quiet environment. Quieting the environment is a universal listening condition!

Adults with normal hearing require a SNR of approximately $+6 \, dB$ in order for their brain to hear the spoken message as consistently intelligible.

The desired signal needs to be about *twice as loud* as background sounds.
The following populations require a much more favorable SNR in order for their brain to receive intelligible speech -- these groups need the SNR to be approximately $+15 \text{ dB}$ to $+20\text{dB}$ -- the desired signal needs to be about 10 times louder than background sounds – they need extrinsic redundancy to facilitate “bottom-up” input!

- Typical children.
- Children with any type and degree of hearing problem including ear infections and unilateral hearing loss.

- Children with auditory processing problems.
- Children with learning disabilities.
- Children with attention problems.
- Children with behavior problems.
- Children with developmental disabilities.
- Children with visual disabilities.
- Children whose first language is not the language of the speaker.
Therefore, children require a better SNR then required by adults because they do not the same “top-down” processing capabilities that adults have.

Unfortunately, a typical classroom has an **inconsistent** and poor SNR of about +4 dB.

- A classroom’s SNR can vary minute by minute from about +5 dB to worse than -20dB, depending on teacher and pupil positions and background noise.
Two Ways to Manage, Improve, and Control the SNR

• Positioning: Remain, physically, as close as possible to the desired sound source -- ideally within 6 inches.

• Unfortunately, physical positioning does not work in a classroom environment where teacher and pupils cannot remain in fixed positions.

• Think “Strategic Seating” for the child with hearing loss!

Technologies That Use A Remote Microphone (a Mic placed near the desired sound source...e.g....the teacher’s mouth, or the mouth of a peer)

• Personal-worn FM system; provides the best SNR for a child with hearing loss

• Sound-Field system -- FM or Infrared -- also called “Classroom Audio Distribution Systems - CADS” replicate the sound, through loudspeakers, for everyone in the room

• Spatial hearing – children need to know where to listen
Key Reference from The American Academy of Audiology

- HAT Guidelines – Hearing Assistance Technology

Acoustic Accessibility Requires That Classroom Barriers To Good Listening Must Be Removed.
Barriers -- Physical

- Distracting sound intrusions (horns, airplanes, noisy corridors, band practice)
- Reverberation (speech-masking echoes muddle consonant sounds that define words)
- Background noise (traffic, air conditioning, students) decreases SNR
Background Noise “Masks” Speech

• Energetic Masking reduces audibility of speech sounds because the speech is partially obscured by the noise.
• Informational Masking occurs when the listener cannot distinguish between two streams of meaningful information.
• Most environments include a combination of both causing the listener to expend more effort to piece together a deficient speech signal to obtain its meaning – called “glimpsing”.

Picking Speech Out Of Background Noise – Analogy
http://successforkidswithhearingloss.com/

<table>
<thead>
<tr>
<th>Sentence</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>I see some beautiful flowers.</td>
<td>+20</td>
</tr>
<tr>
<td>Big dogs can be dangerous.</td>
<td>+15</td>
</tr>
<tr>
<td>I like to go to school.</td>
<td>+10</td>
</tr>
<tr>
<td>It is lunch time soon.</td>
<td>+5</td>
</tr>
<tr>
<td>Walk to the library now.</td>
<td>0</td>
</tr>
<tr>
<td>Your brother is not here.</td>
<td>-5</td>
</tr>
</tbody>
</table>

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Reverberation

Sounds reflect off of hard wall, ceiling, and floor surfaces when surfaces do not have sufficient absorption ability.

- Excessive reverberation in the classroom is caused by the type of materials used to build the:
  - wall
  - ceilings
  - floors

- The harder the surfaces, the more likely the sound will bounce off these surfaces resulting in an echo effect that distorts the talker’s voice.

Original/Direct Signals and Reflected Signals

When the talker is distant from the listener, the signal the listener hears may be dominated by reverberation which overwhelms sound energy from the talker. Reverberation causes “overlap” masking.
And, What about the Acoustic Environment at home?

- Children with hearing loss are very compromised by noise.
- Turn off noise unnecessary noise sources....TV, computer...unless they are the focus of the conversation.
- When will dishwasher, washing machine, and vacuum noises not interfere with communication?
References & Resources


References & Resources (cont’d)


Brain, Brain, Brain!!!

The purpose of hearing aids, cochlear implants, personal-worn FM, classroom FM and IR systems, and auditory-based intervention is to access, grow and develop auditory brain centers for language and literacy.