

Supporting Children's Access to Acoustic and Social Learning Spaces

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Themes

- Hearing is about the Brain -- Review
- What is the Problem? The Science behind Acoustic Accessibility
- Signal-to-Noise Ratio (SNR)
- Personal-Worn RM Systems
- Classroom Audio Distribution Systems (CADS)
- RM use at home
- Executive Functioning and Theory of Mind
- Practical Tips: How to grow a child's brain for talking, reading, learning and making friends

We Must Begin with the Critical Question: What is the Family's Desired Outcome? Family Choice!

- The family's desired outcome guides us – ethically and legally.
- Ask the family, what is your long-term goal for your child, and what does it take to get there?
- How do you want to communicate with your child? What language(s) do you know?
- 95% of children with hearing loss are born to hearing and speaking families.

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- Many families, at home, speak a language other than the community language – so, they are interested in their child speaking several languages.
- The information in this presentation focuses on guiding families who want a listening, spoken language, and literacy outcome for their child.

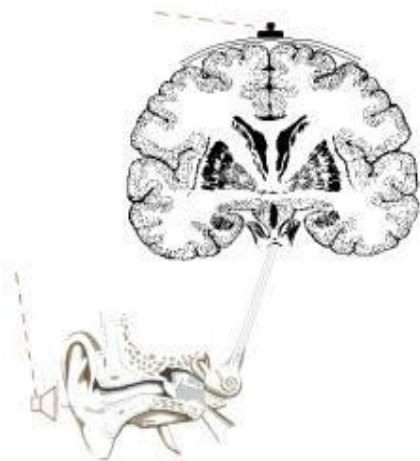
To Begin with: Hearing is about the Brain

We tend to think we hear with our ears, but actually we hear with our brain.

- Ears act like a doorway to help get sound or auditory information to the brain.
- Think about hearing loss as a “doorway” problem.
- The doorway can be blocked a little bit or a lot, depending on the specific hearing loss.
- This means that auditory information, such as conversations, academic instruction, reading aloud, and more, isn’t reaching the child’s brain clearly.
- Modern hearing technologies such as digital hearing aids, cochlear implants, and other assistive listening devices such as remote microphones are designed to break through the blocked doorway to deliver more clear auditory information to a child’s brain - so they can learn to understand the full meaning of sounds, words, and all the language they experience around them.
- **Remember, sound carries information and information becomes knowledge!**

The Purpose of Technologies

- The purpose of technologies (e.g. hearing aids, cochlear implants, remote wireless systems) is to get sound -- auditory language information -- through the obstructed doorway to the brain. There is no other purpose!
- The choice of hearing technology depends on what is happening in the child’s doorway.



Summary: The Hearing and Listening Mechanisms

The Listening Mechanism (Brain): Learns the meaning of the neural events

The Hearing Mechanism (Doorway): Takes in Vibrations

Technology for Babies and Children with Hearing Loss

- **Hearing Aids**
 - Most children will have this type of technology.
- **Bone-anchored Hearing aids**
 - For children with single-sided deafness or conductive hearing loss
 - Worn on a soft band or surgically implanted.
 - abutment or magnet.
- **Cochlear Implants**
 - For severe-profound hearing loss (even moderately-severe)
 - Surgical procedure with internal and external processor.
- **Bimodal**
 - Wearing one CI and one hearing aid



Extrinsic vs Intrinsic Redundancy: A Key Feature of Acoustic Accessibility (James Jerger)

- Extrinsic redundancy refers to the integrity of information from outside the person.....
“**bottom-up**” sensory input – there are many factors that impact the signal that reaches a child’s ear.
- Intrinsic redundancy refers to the cognitive capacity – the internal knowledge and attentional resources of the person..... “**top-down**” processing – there are also many factors that impact how well the listener can “decode” or understand the meaning of the signal.
- There is an inverse relationship between these two concepts that must be considered for children (when the input signal is more challenging, the child has to work even harder to understand).
- Specifically, children do not have the top-down capabilities available to adults.

Tips: Enhance “Bottom-Up” Sensory Input by improving the clarity of the signal reaching the child’s ear

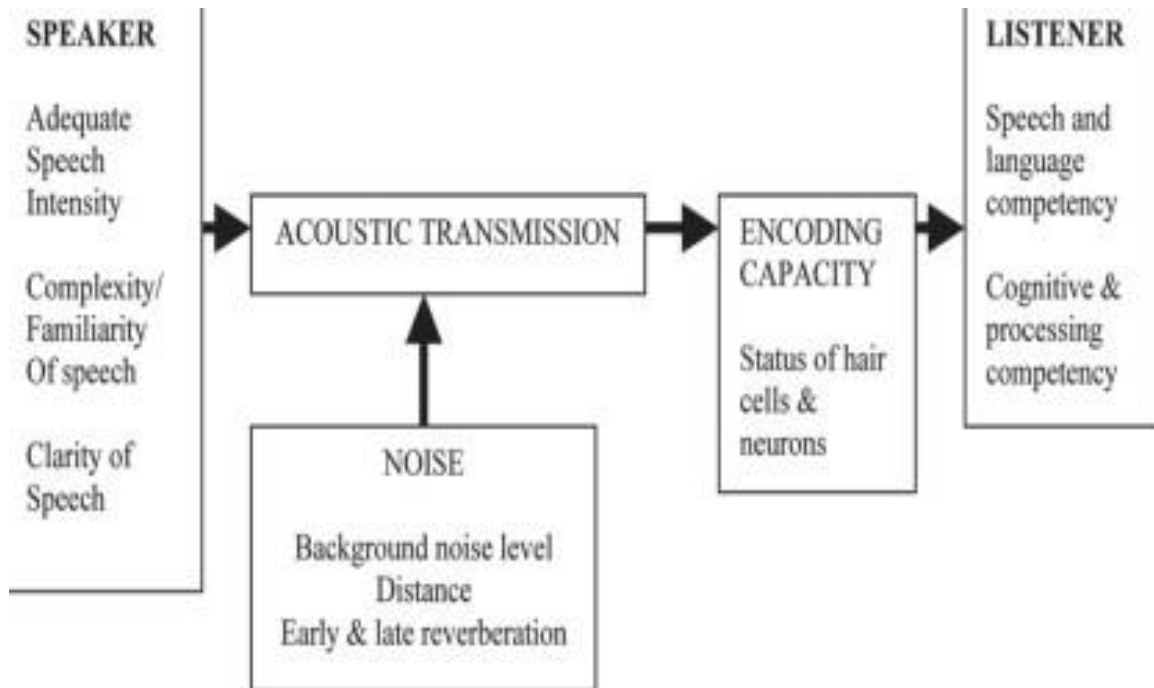
- **Speak slower:** Most adults speak too fast, making it difficult for children (and many aging persons) to understand (often faster than 200 words per minute – that’s way too fast!).
- **Use “clear speech”....**slow down (aim for 124 words per minute, like Mr. Rogers)....pause...use appropriate suprasegmentals to enhance meaning.

- The talker’s use of “clear speech” can improve the listener’s speech **understanding by up to 40%**.
- **Use remote microphone wireless technology (RM)** to improve the signal-to-noise ratio (SNR) – personal worn RM and classroom amplification systems (CADS – sound field).

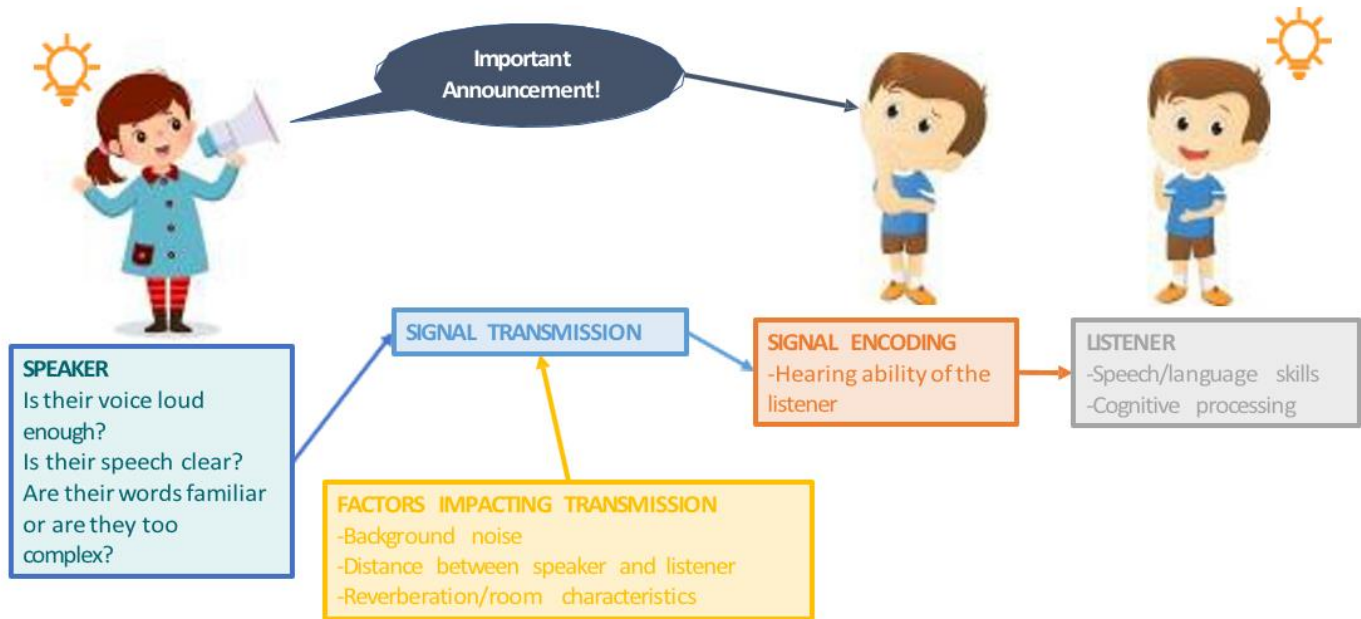
What Is The Problem: The Science Behind Acoustic Accessibility

- Poor/average room acoustics at home and in school can negatively impact the child’s ability to hear speech information - speech audibility.
- Reduced speech audibility can decrease speech perception/word understanding.
- Reduced audibility/understanding will cause children to have to work harder at listening (listening effort) and decrease the cognitive resources they will have available to understand the message (impacting the child’s “top down” processing).
- Lack of clear, easy auditory brain access to auditory information drains a child’s cognitive reserves and weakens their communication and learning.
- For children, the end result will be a high risk of missing information and experiencing a slower pace of learning.

Basic Information Transfer Model -- From Brain to Brain



Fun Model -- Information Transfer From Brain to Brain



Information Transfer: The Point

- Any of these variables can influence the communication pathway between you and the child, and can occur in several combinations.
- The acoustic characteristics of the room mainly determine the clarity and composition of the speech signal received by the listener.
- For children, research has demonstrated that high levels of noise or reverberation can negatively impact not only speech perception, but also children's reading scores, spelling ability, behavior, attention, and concentration.
- This is true for children with normal hearing and these things are even more harmful to children with hearing loss or children who are at risk for literacy and learning problems.

A Child's Ability to Hear Speech Clearly Depends On:

- The level of the talker's voice;
- The level of the listener's hearing;
- The distance between talker and listener;
- The noise in the room;
- And any intervening objects or reflections that interfere with the talker's

And, What about the Acoustic Environment at Home?

- Children with hearing loss have great difficulty hearing in noise.
- Coach parents to turn off unnecessary noise sources....TV, computer...unless they are the focus of the conversation.
- Encourage parents to run the dishwasher, washing machine, vacuum when they will not interfere with communication.

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/noise.

- The more favorable the SNR, the more intelligible the spoken message.
- A positive SNR means the signal is louder than the noise (e.g. +6 dB SNR).
- A negative SNR means the noise is louder than the signal (e.g. -6 dB SNR).

Adults with normal hearing require a SNR of approximately +6 dB in order to hear the spoken message as consistently intelligible.

The desired signal needs to be about twice as loud as background sounds.

Children require a more positive SNR than adults in order to receive intelligible speech -- these children need the SNR to be approximately +15 dB to +20dB -- *the desired signal needs to be about 10 times louder than background sounds – they need extrinsic redundancy to facilitate “bottom-up” input!*

This applies to:

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

Actually, EVERY child is at risk from degraded speech and physical distancing

Additionally, the following populations are at increased risk for decreased learning in poor acoustical settings:

- Young children (less than age 15 due to immature auditory brain development)
- Conductive hearing loss/ear infections
- Sensorineural hearing loss (bilateral and unilateral)
- Language and speech disorders
- Learning disability or dyslexia

- English as a second language
- Auditory processing deficit
- Developmental delays
- Attention deficits

Therefore, children require a better SNR than required by adults because they do not have 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.

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

Sources of Noise



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 – from Karen Anderson

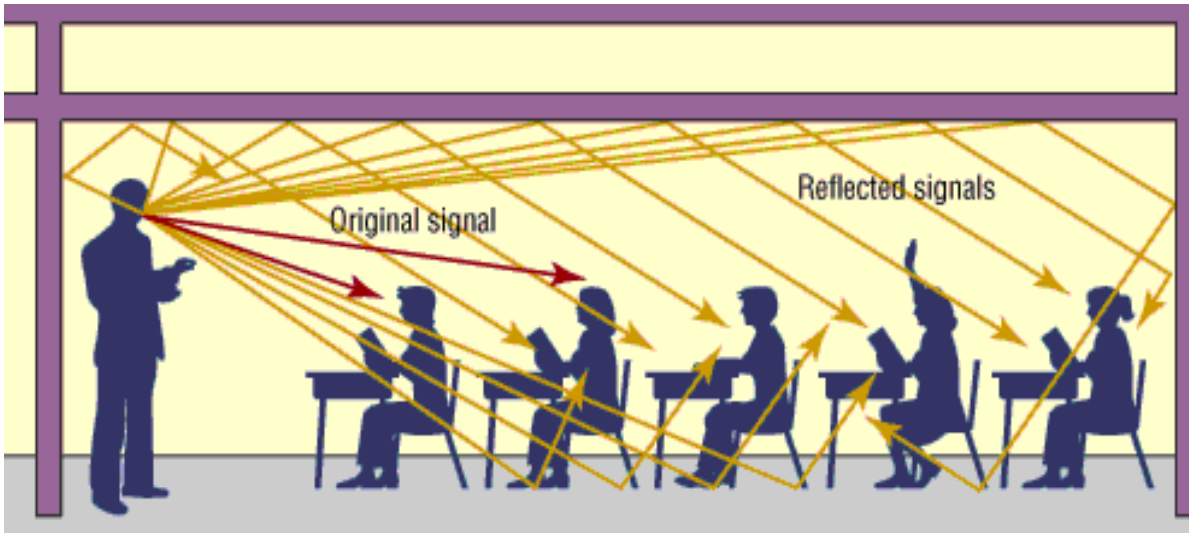
I <u>see</u> some beautiful flowers.	+20
Big dogs can be dangerous.	+15
I like to go to school.	+10
It is lunch time soon.	+5
Walk to the library now.	0
Your brother is not here.	-5

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.

Speech Sounds Smear (Overlap) As RT Increases – from Karen Anderson

I see some beautiful flowers.

Big dogs can be dangerous.

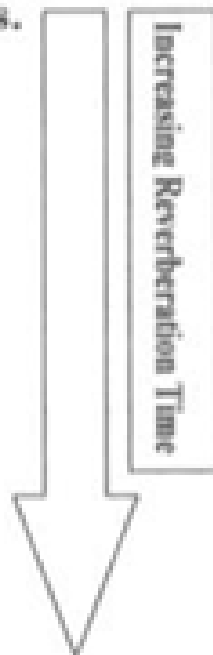
I like to go to school.

It is lunch time soon.

Your brother is not here.

Wild and hairy now.

Is not quite what you wish.



Barriers – Physiological

- Hearing loss
- Temporary hearing loss (Otitis Media – middle ear infection --occurs in 25% to 30% of students in early grades)
- Lack of language proficiency, including English-as-a-second-language students
- Immature auditory cognitive development (experienced by all children) that leads to deficits in “top-down” processing abilities

Solutions -- Physical

- Stop noise intrusion with exterior walls and floor-to-ceiling interior partitions that reduce sound transmission
- Cut Reverberation Time (RT) with sound-absorbing material -- acoustic ceilings, soft wall materials, carpeting (but beware of high frequency absorption)
- Reduce background noise of air conditioning, computers, instructional equipment, chair scraping

Solutions – Physiological

- Reduce student-generated noise with effective class management techniques
- Provide spoken-voice sound levels that students can readily hear over the background noise – SNR of +15 to +20 decibels
- *Improve extrinsic redundancy*

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!

Remote Microphones Must Be Used By All Children Who are Deaf or Hard of Hearing

Many professionals consider remote microphone systems for a child with hearing loss in a classroom setting, but they're not just for school anymore!

- Even in infancy, RMs can help a child hear you more clearly in any location. They can overcome problems of background noise and distance.
- In this section, we'll explore how you can use remote microphones to increase both the quantity and quality of information that reaches a child's brain – which then becomes their knowledge, skills, and understanding.
- We will discuss why they're important, how they work, and ways to use them in daily life and routines as well as at school, in the community, or during activities, like soccer practice.

Remote Microphones (RM) – An Overview

- In most cases, whether a baby or child uses hearing aids, cochlear implants, or bone conduction devices, additional devices, such as remote microphones (RM), will be recommended.
- To use an RM, the person talking wears a wireless microphone so their voice can reach the child directly.
- The RM is used in addition to the microphone that is already in the child's hearing device.
- The RM system can help a child hear their best in any listening environment.
- In general, remote microphone systems use radio, Bluetooth, or light waves to send sound directly to a receiver that's in or attached to the child's hearing device.
- There are different kinds of remote microphone systems available and a pediatric audiologist can help select what works best for a particular child.

Aren't RMs Only For Use in School and Worn by the Teacher?

- Traditionally, personal RM systems coupled to hearing aids and cochlear implants have been used for school-aged children in the classroom setting, but not used at home, or for babies or very young children.
- But, growing evidence suggests infants and toddlers can also benefit from personal RM systems used outside of school.
- Acoustic accessibility is critical in all of a child's environments for social engagement and academic learning.

Technologies That Use A Remote Microphone

- Personal-worn remote wireless system; provides the best SNR for a child with hearing loss
- Sound-Field system -- FM or Infrared -- also called "Classroom Audio Distribution Systems" are designed for whole group instruction in order to benefit everyone in the room

Personal-Worn RM

- The most effective way to enhance and optimize speech audibility (extrinsic redundancy) for a child with a hearing loss of any type and degree, at home and in the classroom.
- Can improve the SNR up to +15 dB — reduces issues of both distance and noise.

Types of Personal Hearing Assistive Technology (HATs)



Remote Microphones

Personal RM System

- A personal RM system is a two-piece device. One part is built into or connects to a baby's hearing aid or cochlear implant. The second piece is a wireless microphone worn by the talker (often the parent), which sends the sounds of the talker's voice directly into a baby or child's hearing device and then to the child's brain.
- The RM helps a child hear even in noisy environments and when they're not close to the talker, which includes most of the places a child will live and play and learn.
- Many families use the RM device for car travel, grocery shopping, restaurants, daycare and school settings, or anywhere that background noise and distance from the person talking would make listening more difficult. This helps a child's brain hear the full range of speech and language surrounding them.

Remote Microphones – Overview of Types

- One type of personal RM technology has a RM receiver that is built into or integrated into the ear-level hearing-aid or sound processor case.

- Another type is where a small RM receiver “boot” or “audio shoe” is attached directly to the bottom of the ear-level hearing aid or to a cochlear implant sound processor.
- A third type is where the receiver is attached to a streamer, and
- A fourth type is where the receiver attaches to a neck loop worn by the listener that sends the signal to the tele-coil in the hearing device



Remote Microphone Accessory System

- Often, RMs may come as an accessory when a child receives a new hearing device (hearing aid or cochlear implant)
- The RM accessory may provide direct wireless streaming to a receiver that is built into the hearing device (an integrated radio receiver)
- Accessory remote microphone systems typically contain a fixed-gain.
- The strength of the remote microphone remains the same, regardless of the ambient noise level.
- For cochlear implant systems, some accessory remote microphone systems can only be used with a certain manufacturer’s sound processor (i.e. Mini Mic 2+ with Cochlear, PartnerMic with AB, Audiolink with Med El) and the accessory may only connect to a certain type of hearing aid for bimodal users. Check with a pediatric audiologist for more information about the accessory RMs.

Universal Remote Microphone System

Direct wireless streaming to a universal radio receiver that is attached to the hearing aid or cochlear implant sound processor

- Universal remote microphone systems may be used with most cochlear implant sound processors or hearing aids.

- Some universal remote microphone systems contain adaptive-gain:
- The strength of the remote microphone signal increases as the ambient noise level increase
- Most accessory RMs have a fixed gain that does not change
- The universal receiver may be plugged into a variety of different hearing devices.
- Of note, universal RMs are typically 2 to 3 times more expensive than accessory RMs



Remote Microphones (RM) – A Management Issue

- **To Mute or Not to Mute the RM – What about Overhearing?**
- When the primary talker is not speaking to the child wearing the RM receiver, the microphone can be temporarily turned off, or set on “mute”, to avoid having the child listen to information they do not need to hear, or to conversations that may interfere with the child’s current task.
- This information conflict would be especially true in a school setting if the child is working on one project and the teacher is speaking about something else with another child.
- On the other hand, there could be value in purposely letting the child listen in to the back-and-forth exchange between family members and perhaps between the teacher and another student.
- Overhearing conversations of others is a valuable way that typical children develop Theory of Mind (capacity to understand that others are separate individuals with their own thoughts and emotions) and gain an understanding of the emotional exchanges between people.
- The challenge for parents and teachers is to determine how to enable overhearing or “listening-in” to other conversations without compromising the child’s independent work.
- The point is, by always turning off the RM when the child is not the direct recipient of the conversation, we may be limiting the child’s opportunity to learn from overhearing conversations of others.

Remote Microphones of a Different Type: Classroom Audio Distribution System (CADS) – often called Sound Field Systems

Sound Field System – CADS – A Large Area Sound System used in Schools

- A sound field system, also called Classroom Audio Distribution System (CADS), is a device with a set of loudspeakers and a wireless microphone. This device is used to help a child access spoken language instruction in noisy environments.
- The sound field system is typically used in a classroom setting for large group instruction and can benefit every child in the room.
- The wireless microphone is worn by the teacher and the sound of the teacher's voice is transmitted to and then presented from loudspeakers anchored to a wall or a shelf.
- The teacher's voice is amplified and evenly distributed throughout the room so that everyone hears clearly, even if they are seated in the back row.
- There is often a second wireless microphone that the teacher can pass from student to student so that a child has access to the classroom communication of their friends.

Remote Microphones – CADS

There are four basic wireless delivery modes used in CADS:

- FM (radio frequency modulated on the 72-MHz band);
- Digital RM system (on the 2.4GHz band);
- IR (infrared light waves—used for large area classroom systems); and
- Induction loop (magnetic).

Classroom Audio Distribution Systems (CADS)

- A primary value of a CAD is that it can focus students' attention to important auditory information.
- To that end, the effective use of the sound system's microphone can be a powerful teaching tool.
- Teachers need to be trained in how to use the microphone to create a listening attitude in the room; the purpose of the microphone is to quiet and focus the room—to guide the children in “where” to listen—not to excite or distract them.

A teacher may say: “Oh, they can hear me... I have a loud voice”.

Classroom Audio Distribution Systems (CADS)

- To summarize, students hear better in classrooms with CADS than they do in an unamplified classroom. However, the signals the child receives with a CADS are not as complete as the signals they receive when they use a personal RM unit.
- In addition, the equipment, especially the loudspeakers, must be installed appropriately, and teachers must be trained in the rationale and effective use of the microphone and the CADS.

CADS

- Benefit all students in the classroom.
- Does not single out any child who might particularly benefit.
- Provides an improved SNR of from +15 to +20 dB, depending on the noise level in the room.
- Children hear better in a classroom with a CADS than they do in an unamplified classroom
- But, signals are not as complete as those provided by a personal-worn RM unit.
- **Therefore, CADS do NOT replace the need for a personal-worn RM systems for a child with a hearing loss.**
- **They can be used together, and combining the two will require careful management and calibration.**

Key Reference from The American Academy of Audiology (2011)

[HAT Guidelines – Hearing Assistance Technology](#)

Tip: Enhance the Child’s Auditory Feedback Loop – A Key to Developing Literacy

- To read aloud, we need to develop the child’s “Auditory Feedback Loop”.
- The auditory feedback loop is the process of self-monitoring (input) and correcting one’s own speech (output).
- A child must be able to hear his or her own speech clearly to produce clear speech sounds.
- Enhance signal redundancy by improving the SNR of the child’s own speech.



Tip: Enhance the Child's Auditory Feedback Loop – A Key to Developing Literacy – More

- Therefore, place the child's RM microphone close to the child's mouth when the child is reading aloud, and place the RM microphone close to the talker's mouth (parent or teacher) when reading aloud to a child.
- Because speaking and reading are related, speaking into the remote microphone will highlight the child's speech, allowing the child to hear his or her own voice so they can monitor and control their speaking and reading fluency.

Remote Microphones – Additional Types

Assistive Listening Devices – General Information

- Many other devices and accessories are available to connect a child's hearing devices to computers, smart phones, and TVs.
- There are also permanent systems, like induction loop systems and infrared systems that can be used in auditoriums and some school rooms.
- Work with a pediatric audiologist to see what the manufacturer of a particular child's hearing device offers and/or recommends.



How RMs Can Make a Difference at Home

RM Use at Home

- We want the parent's soothing voice and nourishing words to be right next to the baby, even if the parent is across the room, or walking behind the stroller, or sitting in the front seat of the car.
- We want the child to hear everything the parent is saying, even while the child is playing outside or eating in the kitchen.
- These situations are possible when the parent wears a remote microphone.

Use of RM Systems at Home in Early Childhood (Curran et al, JSLHR, 2019)

- Comparisons were made between matched pairs of children with and without RM systems in early childhood.
- Results indicated significantly better communication skills and higher-level language skills for children whose families owned and used RM Systems at home.

Curran M, Walker EA, Roush P, & Spratford M. (2019). Using Propensity Score Matching to Address Clinical Questions: The Impact of Remote Microphone Systems on Language Outcomes in Children Who Are Hard of Hearing. *Journal of Speech, Language, and Hearing Research*, 62(3), 564–576.

Remote Microphone Use at Home: Impact on Caregiver Talk (2020)

- Use of remote mic (RM) at home increased the number of words the child was able to hear.
- As many as 5,280 more words per day!!!!
- Use of RM promoted more conversations between caregiver and child and encouraged or reminded caregivers to be a “narrator” to fully expose the child to language throughout their day.
- Caregivers reported having a favorable experience with the RM system.

Thompson E, Benítez-Barrera C, & Tharpe AM. (2020). Home Use of Remote Microphone Systems by Children with Hearing Loss, *The Hearing Journal*, 73(7), 34-36.

Positive Changes Observed in Child Behavior When the RM is Used at Home

- Improved Attention
- Child turns quicker when spoken to
- Improved communication between parent and child
- Improved speech of child
- Increased independence
- Increased confidence in child

Positive Effect of RM Use on Wearing Hearing Aids

- Increased hearing aid use with RM use in general
- Specific situations: when using RM, child is more likely to keep hearing aids on in the car and stroller
- Stopped pulling hearing aids out when RM is used

RM Use at Home Increases Child Safety

- When the child plays outdoors
- When in stores
- When the child's hearing aids are covered, such as when wearing a thick winter hat etc.
- In the car: parents are able to have a conversation with the child without taking their eyes off the road

Challenges to RM Use at Home

- Getting others to use the RM
- Deciding when to mute or unmute the RM
- If the hearing aid cannot be worn, such as when there is an ear infection, the RM cannot be used
- Integrating RM use into daily routines without disruption

Key Points and Summary about RM Use at Home

- Most families use the RM system about 60% to 70% of the baby's or toddler's day; their hearing aids or cochlear implants are worn every waking moment.
- The wearer of the RM transmitter could be the mother, father, grandmother, sibling, playmate, caretaker, and so on.
- Typical RM use situations include the car, stroller, playground, store, dance class, Sunday school, soccer field (baseball, etc.), kitchen, dining room, backyard, and so on.
- A pediatric audiologist will make sure the child's RM system is working properly and that the parent knows how to use it and care for it. A Listening and Spoken Language Specialist/teacher can coach a family about how and when to use the RM system at home and in the community.
- Coach the family to use the RM daily to help grow and integrate the baby's auditory brain by hearing the full range of speech and language surrounding them.
- Children need to learn about their hearing loss and about their devices to boost their self-advocacy skills

On the Team, What Is The Audiologist's Job?

- Diagnose and manage the “doorway”
- Fit technology so that it is providing auditory brain access
- **TEST SPEECH PERCEPTION**
 - Be certain that technology is allowing a child's brain to receive:
 - Normal conversation
 - Soft conversation
 - Why do we need to hear soft speech?
 - 90% of what children learn they learn incidentally (they overhear it)
 - Speech in noise
 - The world is very noisy
- Manage acoustic access in home and school environments
- Monitor speech, language, and literacy development
- Be aware of additional child and family challenges and make referrals as needed
- Support children and families and the team

Therefore, Audiologists are Pivotal Members of the Team!

- Until Audiologists do their job, no one else can do theirs if listening and spoken language are outcomes desired by the family.
- Acoustic access to the brain, including access to incidental (free) information (the way 90% of knowledge is obtained by young children), is the biggest challenge for today's children with doorway problems -- worldwide.
- In this day and age and with newborn hearing screening and current technology, we must have very high expectations for early and ongoing brain access of auditory information.
- If a child is not progressing as expected, suspect the equipment first and the child last.
- **Audiologists must work collaboratively with other professionals and provide evidence of auditory brain access, appropriate technology function and use, and auditory language enrichment.**

Key Points

- All hearing technologies are brain access devices.
- The only purpose of wearing hearing technology, including RMs, is to get auditory information through the doorway to the child's brain for growth of neural connections and knowledge.
- The RM device helps a baby hear the talker even in noisy environments and when they're not close, which includes most of the places a child will live, play, and learn.

- In light of the advantages of RM technology use in home environments, and because babies and children require distance hearing for incidental learning, personal RM systems should be used with hearing aids and cochlear implants soon after the initial fitting.
- Families benefit from coaching about when and how to use personal RMs outside of school environments.

What is Executive Function?

- Medina (2018), writes that Executive Function (EF) is the ability to get something done -- and not punch someone in the nose while doing it.
- EF is a set of neurologically-based skills involving mental control and self-regulation.
- Foundational features of EF include:
 - Response inhibition
 - Cognitive flexibility
 - Working memory

Description of Executive Functions

- Executive Function (EF) is an umbrella concept that includes a collection of interrelated functions that are responsible for purposeful, goal directed, problem-solving behavior.
- Specifically, EFs are a collection of processes that are responsible for guiding, directing, and managing cognitive, emotional and behavioral tasks, especially during novel problem solving.
- EF is the ability to sustain an appropriate problem-solving set for accomplishment of a future goal.
- The EFs pertain not only to cognitive control; they also involve regulatory control of emotional response and behavioral action.

Center on the Developing Child: Harvard University

[Enhancing and Practicing Executive Function Skills with Children from Infancy to Adolescence – clip about Executive Function](#)

Neurological Issues for EF

- The developmental route of EFs follows the prolonged course of neurological development, chiefly with respect to the pre-frontal regions of the brain.
- The neurological nature of the frontal lobes is their dense synaptic connectivity with other cortical and subcortical regions of the brain.
- The prefrontal system is highly and reciprocally interconnected through bidirectional connections with the limbic (motivational) system, the reticular activating system (arousal), the posterior

association cortex (perceptual/cognitive processes,) and the motor regions (action) of the frontal lobes.

Developmental Stages of Executive Function

- At birth, babies have inhibitory control, e.g. they have to inhibit inappropriate mouth behaviors in order to nurse....red flag if this was a problem.
- From 3 to 24 months -- the beginning of non-verbal working memory.
- Verbal working memory develops from 2-13 years.
- Emotional modulation goes from 3 years -- ???
- Plan/organize/monitor -- 3 to 32 years.
- Because of their complex, higher order nature, the maturation and development of EF is prolonged.

Theory Of Mind (ToM)

“The capacity to infer other people’s mental states, and to use this information to predict behavior, is a central cognitive ability that emerges early in human development” (Peters and Senghas, 2009).

Definition and Description of ToM; An Aspect of Social Cognitive Development – Emotional Understanding

- A "Theory of Mind" (often abbreviated in ToM) is a specific cognitive ability to understand others as intentional agents.
- It also means one must be able to maintain, simultaneously, different representations of the world.
- ToM appears to be an innate cognitive potential in humans, but one requiring social/linguistic and other experience over many years to bring it successfully to adult fruition.
- It has been commonplace in philosophy to see ToM as intrinsically dependent upon our linguistic abilities.
- As each child’s ToM matures, he or she is able to gauge others' beliefs, desires, perspectives, and intentions, and perhaps predict their behavior.

Definition and Description of ToM -- More

- Having a ToM allows children to understand many nuanced and layered aspects of human social life such as surprises, jokes, teasing, secrets, tricks, deceit, manipulation, cheating, negotiation, collaboration, exaggeration, mistakes and lies.

- As children age and gain more social and language skills, a ToM forms the basis for inference, perspective taking, social reasoning, social navigation, and empathy.
- A ToM is critical for academic development, especially in collaborative educational environments.

What are Mirror Neurons?

The Science: Mirror Neurons

- A mirror neuron is a neuron that fires when a person acts, and also when the person observes the same action performed by another.
- Mirror neurons are thought to be in the pre-frontal cortex and inferior parietal cortex and are important for language development and for growth of Theory of Mind skills.
- **Talking activates mirror neurons – texting does not.**

We can't help copying others, especially if we are emotionally in-tune!

ToM and Children

- A workable ToM doesn't develop before the age of 4 years; by that age, a child should be able to distinguish between what is so and what people believe is so.
- One of the most important milestones in theory of mind development is gaining the ability to attribute false belief: that is, to recognize that others can have beliefs about the world that are wrong.
- A new model of sex differences in the mind suggests females, on average, show a stronger drive to empathize; empathy is broader than 'theory of mind' because it not only involves identifying the mental states of the other person, but also responding to these mental states with an appropriate emotion.

Theory Of Mind And Children With Hearing Loss

- The language skills in children with hearing loss are directly related to their Theory of Mind skills, however, it isn't general language skills but rather specific vocabulary skills.
- That is, if a child can understand sentences such as, "He thought his cake was in the cupboard," he is more likely to understand and predict behavior premised on a false belief.
- One important way that children gain an understanding of other's thoughts is by attending to the back and forth viewpoint exchange of family members; therefore, the child must be able to track multi-talker conversations – a skill that demands the maximum possible auditory brain access to soft speech at a distance – **in the same language as those in the environment.**

Theory Of Mind And Children With Hearing Loss

- Overhearing “self-talk” (of parents, or others in the environment) such as “where are those car keys,” or “I forgot the agent’s name”, assist the child in understanding others have a state of mind that is different from the child’s.
- Siblings in the home promote the development of ToM because there tends to be more discussions of mental states that lead to differences in behaviors – **provided those discussions are available to the child who is deaf or hard of hearing – and in the same language.**

Summary Comments: ToM

- Language, not just social experience, is required for development of an understanding of false-belief.
- Nevertheless, social experiences and language likely function together to build a mature ToM.
- The child needs to use/produce as well as hear mental-state verbs (e.g. think, know), which leads to a meta-awareness of those internal processes that can affect human action.

Examples of Mental-State Words and Phrases for Desire, Emotion, Modulation of Assertion, Thinking and Knowing

- What if...?
- I wonder...
- If I were..
- What do you think?
- One time..
- When I was....
- Would you believe??
- You won’t believe...
- How do you think she feels?
- Bet you can’t guess...
- What could happen next?
- What do you see?
- Why did she....?
- Remember....
- Want
- This reminds me
- Like
- Possibly

- Disappointed
- Could be

Use Causal Explanatory Talk

- Because.....
- Ask, “How do you know?”
- Seeing is knowing
- Hearing is knowing
- Smelling is knowing

Summary Comments: ToM

- To compete academically, children need to be able to know and have the confidence to express their feelings in presenting arguments.
- Children require knowledge about the subtle social rules for communication-- and these rules are learned incidentally --by participating in conversations and by overhearing the conversations of others.
- ***Lack of social competence impedes academic progress.***
- ***Language and speech delays impede social relationships.***

Practical Tips for Audiologists and Parents: How To “Grow” an Infant/Child’s Brain for Speaking, Listening, Reading, Learning and Making Friends

Calculating the Time Children Spend at Home vs. at School, From Birth to Age 18

- Assume that a child sleeps 8 hours/day
- 24 hours/day - 8 hours sleeping = 16 waking hours/day
- 365 days/year x 18 years = 6,570 days
- 6,570 days x 16 waking hours/day = 105,120 waking hours by age 18
- Average 6 hours per day at school.
- Average 180 school days/year
- 180 school days/year x 6 hours/school day = 1,080 hours per school year.
- 1,080 hours/school year x 13 school years (1 year kindergarten + 12 years through H.S.) = 14,040 school hours
- 14,040 school hours / 105,120 waking hours = .13356 or ...

Just 13.36% of waking hours by age 18 are spent in school!

PARENT ENGAGEMENT MATTERS!!!!

Adapted from “Nine Truths about Parent Engagement” (Wherry, 2014)

Work in Harmony with Our Organic Design

Human beings are designed to have social relationships -- if we do what it takes!

Thoughts about Audition and ToM

- Caregivers may need training/coaching to be sensitive to the infant’s/toddler’s emotional state and emotional communications.
- Psycho-social development is not an isolated domain but is interwoven with language and cognition.
- ToM developed during the preschool years provides a conceptual foundation for metacognitive thinking processes that will be a major focus in the school years.
- We need to be aware of emotional readiness for school.

Make our Speech Easier to Understand by Enhancing Sensory Input – Talk Slower!

- Most adults 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, including remote microphones, to improve the SNR.

How Can We Help Children to Learn Theory of Mind Skills?

- Inferring how others feel is based on underlying skills such as perception of facial expressions, perception of emotion in the vocal expressions of others, knowing the emotion words, and reasoning about emotion.
- Social access to group learning demands auditory brain access!
- Distance hearing, multiple microphones, acoustic accessibility, strong language base and an experience base are necessary to allow auditory cognitive closure.

How Can We Help Children Learn Theory of Mind Skills?

- Pretend play and role-playing allow children to escape from the reality of objects and roles; to do this, children may need to create separate cognitive representations for what is real and what is imaginary.
- Talking about past events also has been found to be related to Theory of Mind skills in children, probably because children need to discuss decontextualized events.
- **Talk about what you are “thinking”, not only about what you are “doing”.**
- **Overhearing or “overseeing” capabilities are critical!**

Children’s Literature And ToM

- Children's literature may be especially useful for ToM development in children who are deaf or hard of hearing.
- By reading to children, parents expose children to alternate views of the world.
- In experiencing stories, children can become cognizant of other people's thoughts, perceptions, and motivations.

Implications for Parents, Teachers, Auditory Therapists and Early Interventionists working with Children who are Deaf or Hard of Hearing

- Talk constantly with the child about what the child is **thinking** as well as about what the child is doing
.....Conversations
- Create experiences and talk about them
- Use complex language, explain it, and link it to the experiences
- Singing can advance emotional expression.
- Read aloud with the child on a daily basis, using books that are at least slightly beyond where the child is linguistically
- **Have the child tell the story back to you**

Tip: Have the Family make Experience Books at home, paper or apps – one page every day -- a wonderful conversational tool!



To Coach Parents: How To Grow Auditory Brain Centers - Always explain the “Brain Why”

- Above all, **love, play, and have fun** with your child!
- Once your child receives a hearing aid or cochlear implant, make sure he/she **wears it every waking moment (at least 10-12 hours/day – eyes open, technology on)**. The auditory brain centers need consistent access to clear, complete sound in order to develop.
- **Use a remote microphone (RM) System at home and in school.**
- **Check** your child’s technology regularly. Equipment malfunctions, often. Without auditory brain access, talk to the floor.

Minimize background noise. Turn off the T.V.

- Sing to your child! Fill their days with all kinds of music and songs; promotes interhemispheric transfer. And, “bounce”.
- **Speak slowly, clearly** and in full sentences with correct grammar and with lots of melody. Stay close!
- Focus your child on **listening**. Call attention to sounds around the room. Point to your ear. Use listening words such as “you heard that”, and “you were listening”.

- **Emphasize sound** before vision for auditory enrichment.

Read, Read, Read aloud every day. Try for 10 books per day.

We should be reading chapter books to our children by age 4.

- Name objects in the environment as you encounter them in daily routines.
- Talk about and describe how things sound, look, and feel.
- Compare how objects or actions are similar and different in size, shape, smell, color, or texture.
- Talk about where objects are located. You will use many prepositions such as in, on, under, behind, beside, next to, between. Prepositions are the bridge between concrete and abstract thinking, and should be known by age 4.
- Describe sequences. Talk about the steps involved in activities as you are doing the activity. Sequencing is necessary for organization.

Hearing First

<https://hearingfirst.org/>

- This website offers many ideas for the advancement of listening, talking and pre-literacy skills. Their suggestions are helpful and appropriate for all children, not only for children with hearing loss.
- There is a Parent Section and a Professional Section

Resources

Cheryl DeConde Johnson's website contains various tools for classroom listening assessments

www.adevantage.com/resources

The Importance of Good Classroom Acoustics: <https://edaud.org/pdf/classroom-acoustics.pdf>

Hearing First www.hearingfirst.org

Success for Kids with Hearing Loss – Karen Anderson www.successforkidswithhearingloss

Pediatric and Educational Audiology Textbooks:

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