From Ear to Brain: Changing In-Service Conversations about Hearing Loss

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What did we Miss?

• Haven’t we all, at some point, been dismayed to learn that a teacher was not using the remote microphone system!
• What did we miss?
• Are there additional strategies for talking with teachers about hearing loss?
• What about a brain talk?

The Challenge for Audiologists: How do we take our knowledge of Neuroplasticity and Auditory Deprivation, and transform that information into an in-service narrative?

Let’s begin with a Brief Summary of What we Know about the “Auditory Brain”

Sample of References for Brain Research


References for Research about Outcomes

**Kral et al, 2012; 2013; 2015; 2016**

- The results of Dr. Kral’s studies (along with the research of others) suggest that when the brain does not have access to intelligible speech during the early months and years of a child’s life, meaningful auditory input does not coordinate activity between primary and secondary auditory cortex.
- Instead, secondary auditory cortex assists with the processing of other functions such as visual processing.

**Kral et al**

- Additionally, auditory stimulation beyond the critical period of language development finds disordered functional connections/interactions between primary and secondary auditory cortex, further complicating auditory learning.
- The disconnection between primary and secondary cortex has significant functional implications for auditory and spoken language development.

**Kral et al**

- When auditory signals are not efficiently and effectively transmitted from primary to secondary auditory cortex, the secondary cortex cannot distribute spoken language and other meaningful sounds/information to the rest of the brain to create auditory meaning and knowledge...called "downstream degradation."
- Kral uses this connectome model of deafness to explain inter-individual variations in cochlear implant outcomes.

**Ching, et al 2013; Dettman et al, 2016**

The bottom line is, infants/children must have very early brain access to intelligible speech and meaningful auditory information in order to fully develop and connect all auditory areas of the brain for optimization of the child’s spoken language and literacy capacity.

*Hearing is the stepping stone to cognition.*

**So, Where do Audiologists Start?**

**Begin at the beginning**

We need to connect the dots between hearing loss, auditory neural deprivation, brain plasticity, use of hearing technologies and literacy development — and explain this connection to teachers and parents.

*Brain clip.*

**Audiologists Can Begin with the Critical Question: What is the Family’s Desired Outcome?**

- The family’s desired outcome guides us – ethically and legally.
- What is your long term goal for your child?
- How do you want to communicate with your child? What language(s) do you know?
- Where do you want your child to be at age 3, 5, 14, 20? What does it take to get there?
- 95% of children with hearing loss are born to hearing and speaking families.
- 22% of US citizens speak a language other than English at home – they are interested in their child speaking several languages.
**What is Sound? (Boothroyd, 2014)**

- Sound is an “event”.
- For example, you don’t “hear” Mommy. You hear Mommy walking, talking, singing, tapping, dancing.
- An event creates vibrations.
- Vibrations (raw auditory data) are picked up by the “ear doorway” and are sent to the brain as energy for coding, and for perception as information.

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**What is Language?**

- Language is an organized system of communication used to share information.
- It consists of sounds, words and grammar used to express inner thoughts and emotions.
- Language includes facial expressions, gestures, and body movements.
- Language is the platform for the acquisition and sharing of knowledge.

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**But -- How Does Instructional Information Get into the Child’s Brain?**

The nose is the “doorway” to the brain for the sense of smell. But, we smell with the brain, not the nose. “Smelling” occurs in the brain.

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**The Eyes are the Doorway to the Brain for Visual Information.**

But, we see with the brain – not the eyes. “Seeing” occurs in the brain.
The Ear is the “Doorway” to the Brain for Sound – Spoken Language/Information – Talking – Reading. “Hearing” occurs in the brain! The sense organs are portals to the brain for environmental information.

What is Hearing Loss? Think about Hearing Loss as a “Doorway” Problem

- The ear is the “doorway to the brain” for sound.
- Hearing problems of any type and degree obstruct that doorway, preventing sound/auditory information from reaching the brain.
- Hearing aids and cochlear implants break through the doorway to allow access, stimulation and development of auditory neural pathways.

The purpose of technologies (e.g. hearing aids, cochlear implants, RMs, CADS) is to get sound – auditory language information – through the doorway to the brain. There is NO other purpose!

An Audiogram can be described as the way we measure the quantity and quality of the “Doorway” Problem

Well -- What is Hearing?

- Hearing can be defined as “brain perception of auditory information.”
- Hearing is a first-order event for the development of language - spoken communication, literacy skills, and social-emotional connections.
- Anytime the word “hearing” is used, think “auditory brain development” using 1 billion neurons with a quadrillion connections!
- Acoustic accessibility of intelligible spoken language is essential for brain growth.
- There are no “earlids” – the brain is available for auditory information 24/7.
- Signal-to-Noise Ratio (SNR) is the key to hearing intelligible auditory information – speech must be 10 times louder than background sounds. Download SLM APP on iPhones or Tablets.

- The study collected data from 317 children who are hard of hearing, and a comparison group of 117 children with normal hearing.
- The children were recruited from locations surrounding the three collaborating sites and ultimately came from 17 states.
- With a few exceptions, children in the study had permanent, bilateral hearing losses, and all but a few children were fitted with hearing aids.
- The majority of the children, 76 percent, were identified through newborn hearing screenings.

#### Children with mild to severe hearing loss as a group have poorer language development than their hearing peers, and the impact of hearing loss on language increases as the amount of hearing loss increases.

- However, providing children with well-fit hearing aids, early, is associated with better rates of language development.
- Unfortunately, the study showed that more than half of children’s hearing aids were not fitted optimally (they were underfit), limiting the amount of brain access children had to speech information through the hearing aid.

- Good news: many children with hearing loss who receive optimal amplification and early services are able to "catch up" or significantly close the gaps with their hearing peers.


- The cautionary note from the research is that any degree of hearing loss, even mild, can place children at risk. The risk can be minimized with early and aggressive amplification and intervention.
- Other main takeaways include the following:
  - Hearing aid provision in early infancy results in better early language outcomes;
  - Children who were fit later showed delays in language development although this delay diminished with extended, daily, hearing aid use and effective spoken language enrichment;
  - Consistent daily hearing aid use provides some protection against language delay and supports auditory development;
  - The richness of parents’ or caregiver’s talk with the child influences child language outcome.

### It’s All About The Brain

Hearing loss is not about ears; it’s about the brain!

Hearing aids, RM systems and cochlear implants are not about ears; they are about getting auditory information to the brain!

They are “brain access tools”.

### Start a conversation with The Real Ear: Hearing occurs in the Brain

![Frontal Lobe]
This is the doorway to the brain.
Outer (external), Middle and Inner Ear

What Are The Basic Classroom Listening Issues?

The hearing of the child, the acoustic environment, and the speech of the teacher, ALL are Variables - not constants!

As variables, they can and indeed must be managed.

Mainstream and Inclusion Classrooms Are Auditory-Verbal Environments

“Listening” is the cornerstone of the educational system.
Children spend up to 70% of their school day listening.
Children are the biggest source of noise in the classroom.

If a child cannot clearly hear and attend/listen to spoken instruction, the entire premise of the educational system is undermined.
**Hearing vs Listening**

- **Hearing** is acoustic access to the brain for perception of auditory information; 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”.

- The concept of Extrinsic vs. Intrinsic redundancy.

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**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.

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**Improve Intelligibility of our Spoken Communication to Enhance “Bottom-Up” Sensory Input – Speak 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, like Mr. Rogers). 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 remote microphone wireless technology (RM) to improve the SNR.

- These are critical ways to enhance extrinsic redundancy.

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**What are the negative effects of poor classroom acoustics?**

- Misunderstanding verbal instruction
- Missing verbal information
- Fatigue

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**Audibility And Intelligibility Distinctions:**

**The Invisible Classroom Listening Problem**

- There is a critical distinction between speech being heard as **AUDIBLE**

- versus speech being heard as **INTELLIGIBLE**
**AUDIBILITY** means that the speech is “heard” – but not heard clearly enough to distinguish specific speech sounds.

**AUDIBILITY** is carried by vowels – high energy, low frequency speech sounds. The low frequencies of 250 Hz and 500 Hz carry 90% of the power of speech, but only 10% of the intelligibility.

**INTELLIGIBILITY** means that the listener heard clearly enough to identify critical word/sound distinctions.

**INTELLIGIBILITY** is carried by consonants – low energy, high frequency speech sounds. The frequencies of 2000 Hz and 4000 Hz carry 90% of the intelligibility of speech, but only 10% of the power of speech. They are very weak speech sounds.

**Speech Intelligibility Depends On:**

- The level of the talker’s voice;
- The level of the listener’s hearing;
- The distance between talker and listener;
- And any intervening objects or reflections that interfere with the talker’s speech.

**Bottom Line: Educational Audiologists are Pivotal!**

- Until we do our job, no one else can do theirs.
- Acoustic access of auditory information 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 hearing loss (doorway problems) -- worldwide.
- We must have very high expectations for brain access of auditory information as the basis of literacy development.
- Continuity of audiology care is the necessary foundation for the development of a listening and spoken language outcome.
- Audiologists are responsible for the auditory brain conversation.

**General References**