Managing Unilateral, Mild, Moderate, & Fluctuating Hearing Losses in Children – Morning Course

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1

Disclosure

I am receiving an honorarium for this presentation.

2

Topics Covered

- Counseling about the Brain-Basis of Hearing Loss
- MMM (Minimal, Mild, Moderate) Hearing Loss
- Fluctuating and Progressive Hearing Loss
- Unilateral Hearing Loss
- Management Issues
- A bit about Vestibular Function

3

What did we Miss?

- Haven't we all, at some point, been dismayed to learn that a child was not wearing their hearing aid, or not using the remote microphone system!
- What did we miss?
- Are there additional strategies for talking with families and teachers about (mild) hearing loss?
- What about a brain talk?

4

We Must Begin Conversations 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.

5

Start with the Brain

6

Brain clip – General Brain Development

7

Sample of references about auditory brain research

- Kral A. (2013). Auditory critical periods: a review from system's perspective. *Neuroscience,* 247: 117–33.
- Kral, A., Kronenberger, W. G., Pisoni, D. B., & O'Donoghue, G. M. (2016). Neurocognitive factors in sensory restoration of early deafness: A connectome model. *The Lancet Neurology*, *15*(6), 610-621.
- Kral, A., Sharma, A. (2012). Developmental neuroplasticity after cochlear implantation. *Trends in Neurosciences*, 35(2): 111-122.
- Kraus, N. (2018). Promoting sound health. *The Hearing Journal, 71*(11). 5.
- Moon, C., Lagercrantz, H., & Kuhl, P. K. (2013) Language experienced *in utero* affects vowel perception after birth: A two-country study. *Acta Pædiatrica, 102,*156-160.

8

Auditory System Complexity (Kraus, 2018)

- The auditory system has more relays connecting the sensory organ to the brain than other sensory systems.
- The auditory system contains some of the longest axonal tracts.
- Axonal tracts directionally link each of the auditory relays between the ear, brainstem, midbrain and cortex.

9

Sound Processing Complexity (Kraus, 2018)

- Sound processing is one of the most computationally demanding tasks the nervous system has to perform.
- The task relies on the exquisite timing of the auditory system, which responds to input more than 1,000 times faster than the photoreceptors in the visual system.
- Humans can hear faster than they can see, taste, smell or feel.

10

The Challenge: Taking knowledge of Neuroplasticity and Auditory Development, and transforming that information into a Counseling Narrative

11

So, how do professionals actually start a counseling narrative about the auditory brain?

Begin at the beginning

Connect the dots between hearing, brain plasticity, technology, listening, talking and literacy development.

12

The Following slides describe a *Counseling Narrative*: Right from the start, explain complex information in a comprehensible fashion – offer the big picture!

Families often do not know what we are talking about…..define terms.

13

What is Sound? (Boothroyd, 2019)

- 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.

14

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 ideas/knowledge you have in your head.
  - Language is the platform for the acquisition and sharing of knowledge.

15

How Does Information Get into the Child's Brain?

Five senses capture different types of raw environmental information and transform that information into neural impulses read by the brain:

- Hearing
- Sight
- Smell
- Taste
- Touch

16

For example, the nose is the "doorway" to the brain for the sense of smell.

But, we smell with the brain!

17

Another example: The eyes are the doorway to the brain for visual information.

But, we see with the brain – not the eyes.

18

The Point: The Ear is the "Doorway" to the Brain for Sound -- Spoken Language/Information – Talking – Reading.

But, the meaning of hearing occurs in the brain!

The sense organs are portals to the brain for environmental information.

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19

So, what is Hearing Loss? Professionals can counsel families to think about hearing loss as a "doorway" problem.

- The ear is the "doorway to the brain" for sound.
- Hearing loss of any type and degree obstructs that doorway a little (hard of hearing), a lot (more hard of hearing) or completely (deaf), preventing sound/auditory information from reaching the brain.
- Hearing aids, cochlear implants, bone anchored devices and remote microphone systems break through the doorway to allow access, stimulation and growth of auditory neural pathways, with auditory information, for development of the child's cognition.

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20

The purpose of technologies (e.g. hearing aids, cochlear implants, RMs, CADS) is to get sound -- auditory language information -- through the obstructed doorway to the brain.

There is NO other purpose!

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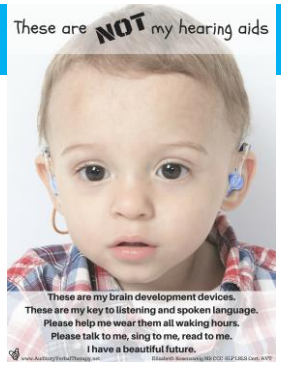
21



Hearing aids must be worn 10-12 hours per day. Eyes open, technology on!

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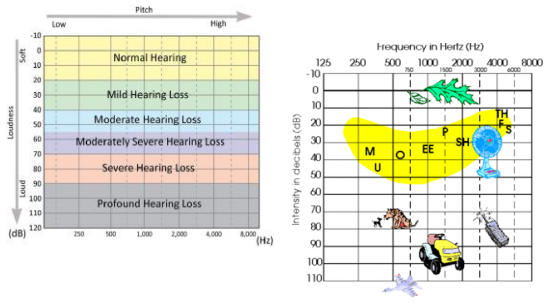
An Audiogram can be described as the way we measure the quantity and quality of the "Doorway" Problem



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23

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.

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24

It's All About The Brain

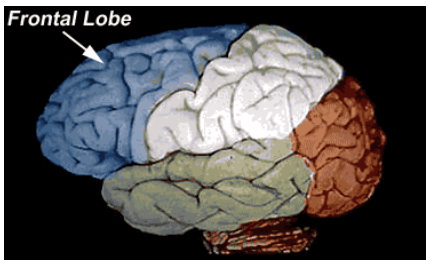
Hearing loss is not about ears; it's about the brain!

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".

25

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



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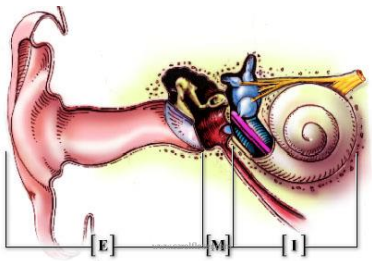
This is the doorway to the brain.

Outer (external), Middle and Inner Ear



27

References for Research about Outcomes

- Ching, T.Y.C., Dillon, H., Leigh, G., & Cupples. L. (2018). Learning from the longitudinal outcomes of children with hearing impairment (LOCHI) study: Summary of 5-year findings and implications. *International Journal of Audiology, 57*(S-2), S-105-S-111.
- Dettman, S.J., Dowell, R.C., Choo, D., Arnott, W., Abrahams, Y. et al. (2016). Long-term communication outcomes for children receiving cochlear implants younger than 12 months: a multicenter study. *Otology & Neurotology*, 37(2): e82-e95.
- Geers, A.E., Mitchell, C.M., Warner-Czyz, A., Wang, N.Y., Eisenberg, L.S., & the CDaCI Investigative Team. (2017). Early sign language exposure and cochlear implantation benefits. *Pediatrics, 140(1)*. e20163489
- McCreery, R.W., Walker, E.A., Spratford, M., Bentler, R., Holte, L., Roush, P., Oleson, J., Van Buren, J., Moeller, M.P. (2015). Longitudinal Predictors of Aided Speech Audibility in Infants and Children, *Ear & Hearing*, 36, pp. 24S-37S.

28

Longitudinal Predictors of Aided Speech Audibility in Infants and Children by McCreery, et al, Ear & Hearing, 2015

- 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 OCHL 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.

29

Longitudinal Predictors of Aided Speech Audibility in Infants and Children by McCreery, et al, Ear & Hearing, 2015

- 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.
- Providing children with well-fit hearing aids is associated with better rates of language development.
- However, 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 and auditory experience through the hearing aid.
- Many children with hearing loss who receive optimal, early services are able to "catch up" or significantly close the gaps with their hearing peers.

30

Longitudinal Predictors of Aided Speech Audibility in Infants and Children by McCreery, et al, Ear & Hearing, 2015

- 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 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 hearing aid use;
  - 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 influence child language outcome.*

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31

Longitudinal Predictors of Aided Speech Audibility in Infants and Children by McCreery, et al, Ear & Hearing, 2015

- Protection against language and literacy delays arises from managing the malleable factors:
  - properly fit hearing aids that maximize audibility
  - used consistently (10 to 12 hours per day – "eyes open, technology on")
  - providing a rich linguistic environment around the child – parent talk can be increased and improved by coaching, beginning in infancy

Hearing aids work…..fit them early and appropriately -- and wear them!

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32

Bottom Line: Infant Auditory Development

How much parents converse with their child is the best predictor of the child's language competence, whether or not the child has a hearing loss.

Parents need to speak the language(s) they know.

Wear hearing technologies 10-12 hours per day.

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33

Ching, et al 2018; , Dettman et al, 2016

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 a stepping stone to cognition.

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34

Audiologists are Pivotal!

- Until Audiologists do their job, no one else can to theirs.
- 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 hearing loss (doorway problems) -- worldwide.
- We must have very high expectations for brain access of auditory information.
- If a child is not progressing as expected, suspect the equipment first.
- Audiologists and SLPs must work collaboratively with other professionals and ***provide evidence of auditory brain access, technology function and language enrichment.***

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35

Mild Hearing Loss
Is Not A Mild Problem

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36

What is the Problem?

Hearing loss of any degree has cumulative effects on a child's development due to auditory neural deprivation and also due to deprivation of auditory experience (McCreery 2020).

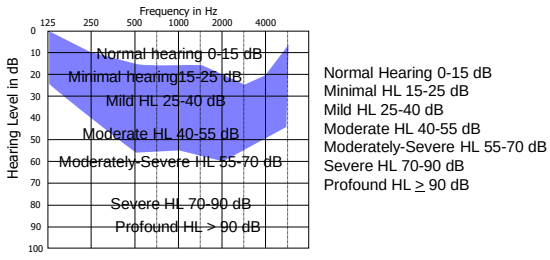
37

Why Does Mild HL Get Missed?

- Newborn screening misses it
  - ABR does not identify mild HL
    - Johnson et al 2005
    - Tested all babies who failed OAE and passed ABR at 9 months
    - 21 of 973 had permanent HL
- School screening misses it
  - Screening may be performed at 25 dB and sometimes louder if the room is noisy
- Children "seem" to be developing speech and language, so learning and behavioral issues often are attributed to something else.
- Language development may appear to be progressing normally through age 2….be sure to test language at age 3!

38

Terminology



Normal Hearing 0-15 dB
Minimal HL 15-25 dB
Mild HL 25-40 dB
Moderate HL 40-55 dB
Moderately-Severe HL 55-70 dB
Severe HL 70-90 dB
Profound HL ≥ 90 dB

39

Key Issues for "Mild" Hearing Losses

- "Normal" hearing for children is 15 dB HL in both ears, at all frequencies and with normal middle ear function.
- Anything less places the child at risk for academic failure.
- Difficulty is with missing soft speech (auditory information) – showing *cumulative,* negative effects on language and cognitive development.
- Problems are distance hearing, overhearing, and listening in noise.
- Under-amplification is a much bigger problem than over-amplification.

40

Why Has Mild HL Been Ignored?

- Moderate to profound hearing loss is recognized as causing problems.
- Children with mild and unilateral hearing loss appear to be developing well in early childhood years.
- Terminology – what is the implication of "mild", "minimal"?
- First study to look at mild hearing loss – Quigley and Tomure, 1969
  - They evaluated children with hearing loss < 26 dB HL
  - Poorer than normal test results on word meaning, paragraph meaning and language

41

Current Research

- Auditory issues
- Educational issues
- Psychoeducational complications
- Significant fatigue (Hornsby et al, 2018)
  - More fatigue than children with cancer, arthritis, diabetes
- Bess et al reported that 1/3 of children with unilateral HL had to repeat a grade by 3rd grade
- Educators have a failure-based model of service provision
  - Wait and see

42

Research on 113 children with mild HL: Walker et al, 2017

- 74% of children with mild HL were identified via Newborn hearing screening (NBHS)
- 26% were identified later due to passing NBHS, or not receiving NBHS
- 94% were fit with HA, but at a later time than those with more HL
- Parents thought HA helped, but many were ambivalent
- Still work to be done on timely fitting and use of HA

43

Etiology

- CMV
  - By age 6 yrs 35% of infants with symptomatic CMV have HL
  - 11% of infants with asymptomatic CMV have HL
- Infections
  - Mumps, Bacterial meningitis (30% unilateral)
- EVA – can be unilateral or bilateral
- ANSD – can be unilateral or bilateral
- Congenital malformations
- Sudden idiopathic hearing loss
- Head trauma
- Noise induced
- Genetics

44

Progression of Minimal HL

- Fitzpatrick et al (2020) found that almost half of the children with mild bilateral hearing loss showed a decrease in hearing in at least one ear.
- Persistent long-term monitoring of children with mild hearing loss is essential.

45

Impact of Auditory Deprivation on Brain Function (Sharma, 2017)

- Neural changes – the brain adapts to the signal
  - More severe brain changes occur with severe and profound HL, but neural changes are present even with minimal HL
- When auditory information to the brain is degraded or diminished, there is activation of the frontal cortex, and that activation causes:
  - effortful listening,
  - an increase in the cognitive load
  - listening fatigue (all degrees of hearing loss experience listening fatigue)
- Early intervention, with any device, is essential
- For any technology fit to a child, listening practice must occur

46

Evaluation

- Screening programs do not target minimal HL
  - Likely to remain a problem in newborn hearing screening programs
  - School screening could do better
    - Screening at 25 dB HL will miss 62% of children with mild HL
    - Test in quiet room at 10 dB HL

47

Clinical Evaluation

- *Every child with educational concerns requires a complete audiological evaluation*
- Behavioral testing
  - Thresholds at 500 to 8000 Hz, R and L
- Physiologic testing
  - ABR will not identify minimal HL
  - OAE – only absent with HL > 30 dB
- Functional testing
  - Speech perception testing in quiet (35 dB HL) and in noise
  - **Use Questionnaires!

48

Fluctuating and Progressive Hearing Losses

49

Fluctuating and Progressive Hearing Losses

- Some conditions are more often associated with progressive hearing losses that also may fluctuate:
  - Enlarged Vestibular Aqueduct
  - Meningitis and other bacterial/viral illnesses (e.g. CMV, Rubella)
  - Certain genetic causes (e.g. Usher, neurofibromatosis)
  - Ototoxicity
  - Neurodegenerative diseases (e.g. Hunter, various neuropathies)

50

What is Enlarged Vestibular Aqueduct (EVA)?

- Duct between the semicircular canals and cochlea is enlarged (greater than 1.5 mm)
- Change in air pressure, or head injury can cause fluid to be forced into the cochlea and rupture the membrane
- Can cause sudden, profound hearing loss
- May see a drop in speech discrimination before a drop in pure tone thresholds
- EVA is a major cause of fluctuating and progressive sensorineural hearing loss
- Can be spontaneous or can be associated with syndrome (*e.g.,* Pendred)

51

Fluctuating and Progressive Hearing Losses

- We always have to be prepared for a progression in hearing loss, even if progression is not expected.
- We also need to monitor the normal ear in unilateral hearing losses.
- The good news is we have technology for all degrees of hearing loss – we can get through "the doorway".
- Fit CI earlier rather than later – don't wait when a progression is documented because of inconsistent information to the brain.

52

Unilateral Hearing Loss

53

Definitions

- General Definition of Unilateral Hearing Loss **(UHL)** – any degree of hearing loss in one ear, with normal hearing in the other ear.
  - About 25% of all hearing losses are UHL
  - 400,000 school-age children in the US have some degree of UHL.
- Single-Sided Deafness **(SSD):** non-functioning hearing in one ear, and normal hearing in the other ear.
  - About 25% of UHL are SSD.

54

Unilateral Hearing Loss

- 40% of children with HL have structural abnormalities in the cochlea or auditory nerve.
- Children with UHL are more likely to have structural abnormalities than children with bilateral hearing loss.

55

Unilateral Hearing Loss

- Our head is an acoustic feature….a barrier to high frequency sounds
- When we move our head, we are putting our pinnae and head in different acoustic positions to find the sounds.
- Our head is constantly moving to interact with the environment to disambiguate sounds.
- Unilateral listening carries a higher cognitive load and a slower processing speed than bilateral listening.

56

Spatial Hearing and Scene Analysis

- Spatial hearing is not about localization – it is about separating sources of sound into individual components and then cognitively deciding what is important.
- Spatial hearing allows us to address auditory attention; to analyze a scene and separate what one person is saying from what another is saying.
- A distorted scene analysis impedes social cues and can therefore negatively impact social development.

57

Children have a very complex and dynamic environment when compared to adults

Child "cocktail party"

Adult Cocktail party

58

Spatial Hearing and Scene Analysis

- It is easier to localize with our eyes, but hearing is critical to spatial hearing.
- Spatial cues and auditory attention are mediated by executive control of the brain interacting with the peripheral representation of the auditory event.
- **The challenge is:**

"where" to listen!

59

Which Ear? Degree of Hearing Loss?

- Some studies suggest that children with right ear UHL tend to perform more poorly than children with left ear UHL on speech perception-in-noise tests
- Children with severe to profound UHL have more problems than children with mild-moderate UHL – *Degree of UHL Does Matter!*
- Think neural pathways, rather than "ears"; both neural pathways should be stimulated if possible
- Environment effects the child's ability to function as does the child's learned compensatory strategies

60

Unilateral Hearing Loss -- Impact

33% of babies born with unilateral hearing loss (UHL) who did not receive EI services are 2 SD behind peers in speech and language development by age 5 years.

– They perform more poorly than children with bilateral HL who received services (Yoshinaga-Itano, 2017).

61

Unilateral Hearing Loss -- Impact

- Children with unilateral sensorineural hearing loss do benefit from late HA intervention, but not in demanding listening situations.
- Therefore, neural transmission time from the impaired cochlear to the upper brainstem may have an important role in unilaterally aided spatial hearing, warranting early hearing aid intervention (Johansson, et al, 2020).

62

Unilateral Hearing Loss -- Impact

- As a group, children with UHL demonstrate deficits in auditory comprehension compared to age-matched peers with normal hearing in challenging listening environments.
- This highlights the importance of ensuring good SNRs for children with UHL (Griffin et al, 2020).

63

Listening Fatigue

- Children with UHL are at increased risk for Listening-related fatigue.
- Children with UHL are better able to identify listening-related fatigue than their parents, teachers or specialists (Bess et al, 2020).

64

What about Ear Infections (EF)? EF have both medical and audiologic/educational issues

- How can ear infections impact brain development?
- Ear Infections block the doorway to the brain!

65

Conductive Hearing Loss Caused by Ear Infections: Test Hearing

- Even a mild hearing loss can obscure the doorway to the brain.
- Beware of an underlying sensorineural hearing loss.
- "Muddy in, Muddy out".
- Hearing aids and/or RM systems may be required in addition to medical management.

66

Unilateral Conductive HL Caused by Atresia

- Children with aural atresia (Kesser et al 2013)
  - 65% required resource help
  - 45% had speech-language treatment services
- Infants (Cho Lieu 2004)
  - Average 1st word 12.7 months (WNL)
  - Average age for 2 word utterances 23.5 months (significant delay)
- UHL and Speech Language (Lieu et al, 2010)
  - Significantly poorer language comprehension, oral expression, oral composite scores

67

Osseo-Integrated (Bone Anchored Hearing Aid Device) for Bilateral or Unilateral Conductive Hearing Loss -- Atresia

The osseo device works on a principle of efficient coupling of the sound processor to the underlying bone through:

1) a small connector across the skin, and
2) an implant that directly bonds with the underlying bone – an osseointegrated implant.

68

Management Issues for UHL

- Counseling
  - Families, children, teachers
- Environmental management
  - Measure noise levels and reverberation time
  - Carpeting
  - Sound absorbing cork boards and ceiling tiles
  - Sound reducing pads on chairs and tables

69

Testing Unilateral HL – Hearing Aid

- Evaluate function
  - Speech perception testing in quiet and in noise
  - Speech on the side of the poor ear
  - Noise on the side of the good ear
  - Functional Auditory Assessment Tools: See EAA and Supporting Success for Children with Hearing Loss websites for multiple tools.
  - Mild, moderate, and moderately-severe UHL – fit hearing aid to target – fitting earlier is best
  - More severe UHL – try loaner HA and get functional measures
  - An "aidable" UHL is one that benefits from a hearing aid – get functional measures
  - Use CADS (soundfield RM system) in the classroom – or RM on normal ear

70

Technology Options for UHL

- When to fit hearing aids
  - UHL
    - Determining HL need on poorer ear
      - Binaural listening skills are developed early and cannot be learned later (Litovsky et al 2018)
    - When is an ear "unaidable" (SSD) - test
      - Speech perception
    - BAHA
    - CROS
    - CI – improved localization and QOL
    - Remote microphone use – Personal of sound field

71

CROS Hearing Aid (Contralateral Routing of Signal) for SSD

- Re-routing signal from SSD ear to normal neural pathway – used to be thought ineffective for children -- but today's technology is better --
- The child needs to be at least 8 years old before a CROS fitting is attempted
- Beware of occluding the normal ear – maybe use an open dome earmold
- Parents need a lot of support to manage a CROS fitting and child needs to self-advocate – must look at sound source
- Use parent and teacher questionnaires to evaluate performance
- Use CADS (soundfield RM system) in the classroom

72

Bone Anchored Hearing Aid for SSD

- Goal of the osseo device for SSD is to provide enough force to overcome the negative effects of the head shadow.
- Soft band devices have less force than osseointegrated devices.
- Transcranial attenuation can be 10 dB or more.
- Transcutaneous attenuation (softband) can have an additional attenuation of 10-20 dB – more attenuation occurs in the high frequencies.

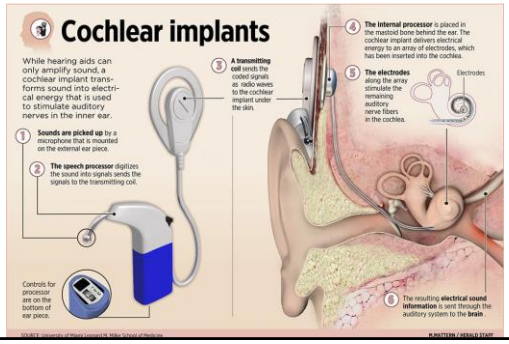
73

Cochlear Implant for SSD

- CI for SSD is being evaluated for children – USA CI candidacy criteria have not been updated since 2009.
- Children with progressive or late onset SSD do much better with CI than older children with congenital hearing loss.
- Fit before 3 years of age.
- CI improves quality of life ... So administer quality of life scales in addition to speech perception testing.

74

Cochlear Implant



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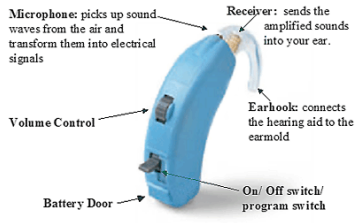
Fitting Hearing Aids for Minimal, Mild, Moderate or UHL – Hearing Aids Work!



76

Fitting Hearing Aids For Children With Mild, Moderate, Unilateral And Fluctuating Hearing Losses

77

McCreery and Walker, AAA 2018

Title: *Using audibility to assess amplification candidacy for children with mild hearing loss*

- 74% ID through newborn hearing screening
- Median age of confirmation of hearing loss – 3 years
- 33% of children with mild hearing loss do not wear hearing aids.
- *Clinical equipoise* about mild hearing loss – some studies show a problem, some studies do not. Wear time typically is not noted.

78

McCreery 2018 continued

Clinical and personal equipoise exists when a clinician has no good basis for a choice between two or more care options or when one is truly uncertain about the overall benefit or harm offered by the treatment to his/her patient.

79

McCreery 2018 continued

- Full time hearing aid users had better vocabulary skills than non-users
- Full and part-time hearing aid users had better morphosyntactic skills than non-users.
- Cumulative auditory experience affects structural aspects of language development.
- But, no significant differences in articulation skills were noted between users and non-users of hearing aids.

80

McCreery 2018 continued

- So, do not rely solely on audiological outcome measures to determine benefits from hearing aids.
- Testing speech discrimination at soft levels (35 dB HL), can help.
- In dB HL, a child's thresholds will appear to get worse over time as ear canal grows.
- We need a standard that incorporates how hearing loss affects audibility, and how do ear canal acoustics change over time.

81

McCreery 2018 -- Recommendations

- Children with unaided Speech Intelligibility Index (SII) < 80 should be considered candidates for amplification.
- Enter audiogram into Verifit.
- Observe unaided SII value for average speech.
- Consider other language values beyond vocabulary.
- Extend this procedure to unilateral hearing losses.

82

McCreery 2018 Recommendations

- Families should be coached to anticipate how the child may miss conversational nuances and subtle social details in noisy situations.
- Families should determine ways to inform the child of information that might have been missed.

83

Fitting a Hearing aid: Real-Ear Measurements – A Necessary First Step for *Verification* of the Hearing Aid Fitting

84

Validation: What Does The Technology Need To Be Doing To Meet The Needs Of Acoustic Accessibility?

- The child needs to hear throughout the frequency range
  - 6000 and 8000 Hz really do matter
  - Missing high frequencies results in missing grammatical markers for pluralization, possessives, and missing non-salient morphemes (morphemes that are not stressed during conversation, such as prepositions)
- The child needs to hear at a soft enough level
  - Soft speech is about 30-35 dB HL.
  - If a child cannot hear soft speech, she will:
    - Not hear peers in the classroom or on the playground
    - not "overhear" conversation and will have limited incidental learning
    - have reduced language and literacy skills
  - Moeller (2011) reported in her research that 40% of children fit with hearing aids were underfit.
- Aided/implant thresholds at 15-20 dB HL is the goal

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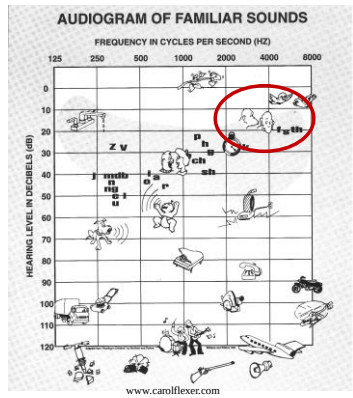

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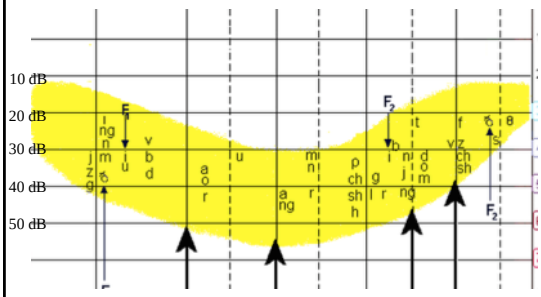
The Old Speech Banana



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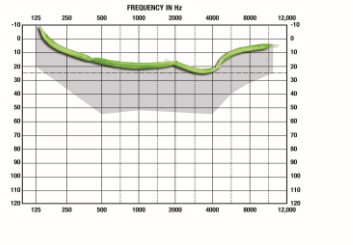
The New Speech String Bean! (Jane Madell,2016)



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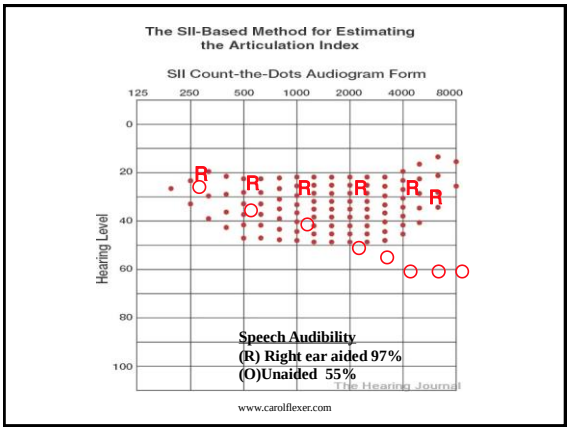

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Speech Perception Testing: What Auditory Information is Getting to the Brain?

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90

What Can we Learn from Speech Perception Tests?

- Identify performance issues that can affect learning
- Determine candidacy for technology
  - Obtaining hearing aids
  - Moving from hearing aids to CI's
  - Changing hearing aid or cochlear implant settings
- Assess the child's performance with technology
- Monitor changes in the child's performance over time
- Identify problems that develop over time
  - Reduction in functioning
  - Equipment problems/failure
  - Specific phoneme perception errors
- Demonstrate habilitation/rehabilitation needs and outcomes
- Assist in selecting appropriate educational environment and technology

91

Speech Perception Testing

- Diagnostic testing
  - What can the child hear if speech is loud enough to overcome the HL (e.g. 40 dB SL)?
- Functional testing –Critical for Validation of technology fittings
  - How the child functions in daily living situations with technology – each ear:
    - Typical conversational level (50 dB HL)
    - Soft conversational level (35 dB HL)
    - Competing noise (50 dB HL + 5 SNR)

92

What is "Good" Speech Perception?

- Speech Perception Qualifiers – Madell et al, 2011
  - Describing performance
    - Excellent 90-100%
    - Good 80-89%
    - Fair 70-79%
    - Poor < 70%
- Children with hearing loss need to hear as well as children with normal hearing, to learn.
- We need to describe performance accurately.

93

Speech Test Protocols by Age

	0-6 months	6-12 months	12-18 months	18-24 months	24-36 months	3-5 yrs	6-8 yrs	8+ yrs
SAT	X	X	X	X				
SRT			X	X	X	X	X	X
ESP		X	X	X				
PINT						X	X	
NU Chips				X	X	X		
WIPI						X	X	
PBK						X	X	
NU 6/ CNC							X	X
HINT							X	X
Baby Bio's							X	X
AZ Bio's								X

94

Summary

- **Suspect equipment first - and the child last!**
- Look for evidence to demonstrate equipment function
- Equipment has to be functioning
- Child has to use it (10-12 hours per day)
- Enriched auditory language stimulation must occur all day, every day with parent involvement in order to grow the child's brain with knowledge
- Beware of the subtle *cumulative effects* of missing information due to distance and noise
- All of the child's environments must be acoustically accessible in order to **attain and sustain listening**, spoken language, and psycho-social outcomes

95

A bit About Vestibular Function/Balance

96

Key Ideas about Vestibular Function

- While we could survive without vision or hearing, as some species do, it would be impossible to survive without the ability to resist the pull of gravity or safely navigate within our environment.
- The primary function of the inner ear is balance, not hearing.

97

More Key Ideas

- All newborns and infants with identified congenital or acquired sensorineural hearing loss should be considered at risk for co-morbidity of vestibular dysfunction.
- Do not assume children with "one good ear" are immune from bilateral vestibular labyrinthine dysfunction.
- An infant's balance function may be evaluated as early as three months of age.
- Evaluation protocols include motor milestones.

98

More Key Points

- The majority of equilibrium problems that occur in infants and children, manifest as delayed gross motor and balance problems, not as vertigo or dizziness.
- In fact, delayed maturational motor milestones may be the earliest signs of a vestibular dysfunction.
- Muscle tone is another important aspect of an infant/child vestibular evaluation because it is closely associated with the integrity of the vestibular system.
- It's likely that 90% of children with congenital SNHL hearing loss have vestibular abnormalities.

99

Equilibrium

- Equilibrium is a complex integration of the vestibular system, vision, somatosensory-proprioception and the central nervous system.
- The vestibular system is the primary sensory modality contributing approximately two-thirds of the critical data about where we are in space including our sense of motion, speed and direction.
- It is an internal reference, whereas vision and somatosensory are external reference systems, telling the brain about the status of the outside world.

100

Resources

101

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.

102

103

BabyBeats

Search for 'Advanced Bionics' in the iTunes® or the Google Play™ store.

Look for the BabyBeats app and download. This App is free!

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104

Supporting Success for Children with Hearing Loss – Karen Anderson

- http://successforkidswithhearingloss.com/
- Teacher Tools is designed to support all aspects of instruction by addressing underlying skills and word knowledge that support all curriculum content. There are articles related to current topics and trends, sections on developing instructional skills, student self-advocacy, self-concept and a forum for discussion of current issues and concerns. A Teacher Tools membership includes materials such as worksheets and activities appropriate for all school age levels and an extensive information resource library.

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105

General References

- Cole, E., & Flexer, C. (2020). *Children with Hearing Loss: Developing Listening and Talking, Birth to Six, 4th ed.* San Diego: Plural Publishing.
- Madell, J., Flexer, C., Wolfe, J., & Schafer, E.C. (2019). *Pediatric Audiology: Diagnosis, Technology, and Management, 3rd ed.* New York: Thieme Medical Publishers.
- Madell, J., Flexer, C., Wolfe, J., & Schafer, E.C. (2019). *Pediatric Audiology Casebook, 2nd ed.* New York: Thieme Medical Publishers.
- Merzenich, M.M. (2010, April). *Brain plasticity-based therapeutics in an audiology practice*. Learning Lab presented at the American Academy of Audiology National Conference, San Diego.
- Robertson, L. (2014). *Literacy and Deafness: Listening and Spoken Language.* San Diego: Plural Publishing.

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106

General References

- Dehaene, S. (2009). *Reading in the brain: The science and evolution of a human invention.* New York: Penguin Group.
- Doidge, N. (2007). *The BRAIN that changes itself*. London, England: Penguin Books, Ltd.
- Hart, B., & Risley, T.R. (1999). *The social world of children learning to talk.* Baltimore: Brookes.
- Kilgard, M.R. (2006). Cortical plasticity and rehabilitation. *Progressive Brain Research, 157,* 111-122.
- Musiek, F.E. (2009). The human auditory cortex: Interesting anatomical and clinical perspectives. *Audiology Today, 21*(4), 26-37.

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107

Sample of References for Brain Research

- Kral A. (2013). Auditory critical periods: a review from system's perspective. *Neuroscience,* 247: 117–33.
- Kral, A., Kronenberger, W. G., Pisoni, D. B., & O'Donoghue, G. M. (2016). Neurocognitive factors in sensory restoration of early deafness: A connectome model. *The Lancet Neurology*, *15*(6), 610-621.
- Kral, A., Lenarz, T. (2015). How the brain learns to listen: deafness and the bionic ear. *E-Neuroform*, 6(1):21-28.
- Kral, A., Sharma, A. (2012). Developmental neuroplasticity after cochlear implantation. *Trends in Neurosciences*, 35(2): 111-122.
- Moon, C., Lagercrantz, H., & Kuhl, P. K. (2013) Language experienced *in utero* affects vowel perception after birth: A two-country study. *Acta Pædiatrica, 102,*156-160.

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108

References for Research about Outcomes

- Ching, T.Y.C., Dillon, H., Leigh, G., & Cupples. L. (2018). Learning from the longitudinal outcomes of children with hearing impairment (LOCHI) study: Summary of 5-year findings and implications. *International Journal of Audiology, 57*(S-2), S-105-S-111.
- Dettman, S.J., Dowell, R.C., Choo, D., Arnott, W., Abrahams, Y. et al. (2016). Long-term communication outcomes for children receiving cochlear implants younger than 12 months: a multicenter study. *Otology & Neurotology*, 37(2): e82-e95.
- McCreery, R.W., Walker, E.A., Spratford, M., Bentler, R., Holte, L., Roush, P., Oleson, J., Van Buren, J., Moeller, M.P. (2015). Longitudinal Predictors of Aided Speech Audibility in Infants and Children, *Ear & Hearing*, 36, pp. 24S-37S.

109

Sample of References about Mild/Moderate and Unilateral Hearing Losses

- Bess, F.H., Davis, H., Camarata, S., & Hornsby, B.W.Y. (2020). Listening-related fatigue in children with unilateral hearing loss. *Language-Speech, and Hearing Services in Schools, 51*(1), 84-97.
- Fitzpatrick, E.M., Nassrallah, F., Vos, B., Whittingham, J., & Fitzpatrick, J. (2020). Progressive hearing loss in children with mild bilateral hearing loss. *Language-Speech, and Hearing Services in Schools, 51*(1), 5-16.
- Griffin, A.M., Poissant, S.F., & Freyma, R.L. (2020). Auditory comprehension in school-aged children with normal hearing and with unilateral hearing loss. *Language-Speech, and Hearing Services in Schools, 51*(1), 29-41.
- Johansson, M., Asp, F., & Berninger, E. (2020). Children with congenital unilateral sensorineural hearing loss: Effects of late hearing aid amplification – A pilot study. *Ear and Hearing, 41*(1), 55-66.
- McCreery, R.W., Walker, E.A., Stiles, D.J., Spratford, M., & Lewis, D.E. (2020). Audibility-based hearing aid fitting criteria for children with mild bilateral hearing loss. *Language-Speech, and Hearing Services in Schools, 51*(1), 55-67.

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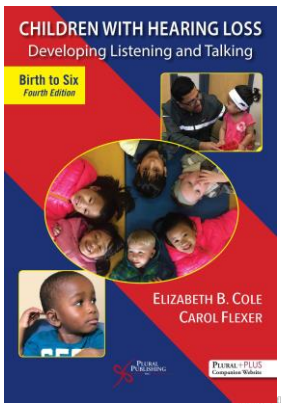

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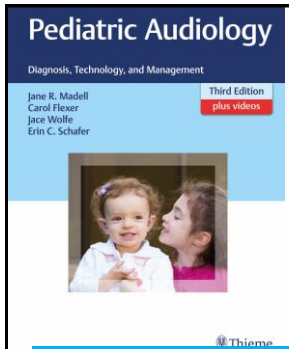

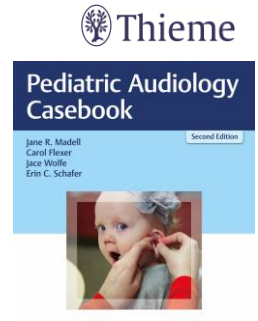

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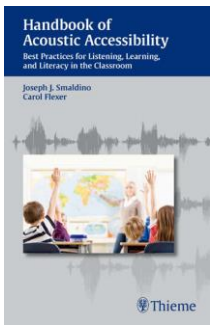

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