

What Jane and Carol Know!!!

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Disclosures

- We are receiving honoraria for this talk.
- We write textbooks and have new ones out now, in 2019.



Learning Objectives

- Participants will be able to describe auditory brain development utilizing a practical conversation.
- Participants will be able to discuss necessary and research-based family-focused audiologic and intervention ingredients for a successful LSL outcome.
- Participants will be able to explain the benefits of early school experience for social and language development for children with hearing loss.



We Are So Excited!

- We have had boots on the ground working with children who are deaf or hard of hearing -- for a combined total of about 100 years and the new research is showing that we were right!!
- Technology is critical.
- Technology needs to be set to assure that children are hearing soft speech.
- Technology needs to be worn every waking hour (at least 10 to 12 hours per day).
- Remote microphone systems need to be used at home and in school – in all noisy places.



We Are So Excited!

- Parents need to talk, talk, talk to their kids – have conversations.
- Language has to be rich and complex.
- Read aloud daily, beginning in infancy.
- Sing aloud with children, daily.
- Children who use sign language do not do as well as children who only use spoken language.
- And of course -- BRAIN, BRAIN, BRAIN!!! Hearing occurs in the brain, the ears are just the way in.



Family's Desired Outcome – Parent Choice

- The family's desired outcome guides us – ethically and legally.
- What is your long term goal for your child?
- Where do you want your child to be at age 3, 5, 14, 20?
- What does it take to get there?
- *95% of children with hearing loss are born to hearing and speaking families.*
- This talk is all about what we now know about obtaining a listening and spoken language outcome, if that is the family's choice.



WHY THE BRAIN MATTERS

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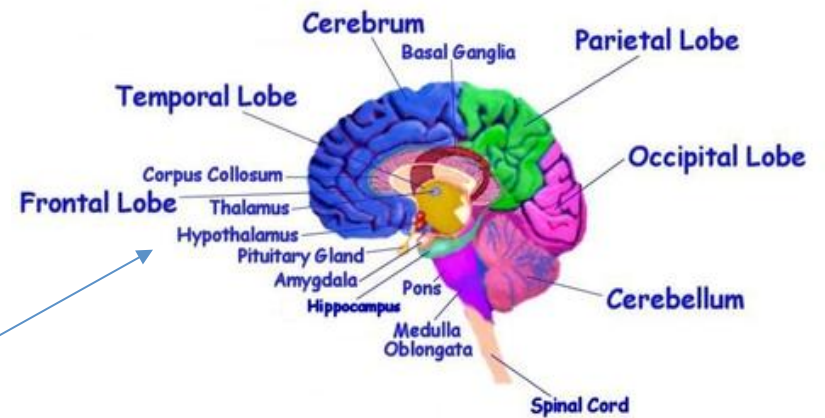


How Does The Auditory Brain Work?

- Important changes have been shown in the higher auditory centers due to hearing loss/deafness.
- The auditory cortex is directly involved in speech perception and language processing in humans (Kral & Sharma, 2012; Kraus, 2018).
- Normal maturation of central auditory pathways is a precondition for the normal development of speech and language skills in children (Kral et al, 2016).



Possible Narrative: The Ear is the “Doorway” to the Brain for Sound -- Spoken Language/Information – Talking – Reading. We hear with the brain – not with the ears!



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.



The Purpose Of Technologies (E.G. Hearing Aids, Cochlear Implants, Wireless Technologies, Cads) Is To Get Sound -- Auditory Language Information -- Through The (Ear) Doorway to the Brain. There is no Other Purpose!



Main “Auditory Brain” Ideas

- 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.**



WHAT THE RESEARCH IS SHOWING

(THANK YOU JACE WOLFE AND HEARING FIRST FOR ORGANIZING THE LATEST RESEARCH)



Technology Now

In the last 20 years, there have been monumental changes in technology.

- Analog hearing aids made soft sounds louder, but they did not have the digital features of acoustic feedback reduction, noise reduction, and speech enhancement.
- Digital hearing aids have significantly better quality, have important acoustic features, and are much stronger than the hearing aids that were available in the 90's.
- Very few cochlear implants were provided 20 years ago, and only in a few clinics.



The 21st Century

- We have new hope and opportunities for children with hearing loss.
- Newborn hearing screening is available in every state in the USA and in many counties.
- Current digital hearing aids are sophisticated and allow for consistent audibility of even soft speech for most children.
- Cochlear implants allow exceptional outcomes for children with severe and profound hearing loss.
- The FDA in the US recommends implanting can begin at 12 months.
- Outside of the US implants are fit as young as 3 months.
- Experienced clinics in the US are fitting implants at 6 months.
- Bilateral cochlear implants are fairly routine.



What Does the Research Say about LSL Outcomes

- As children have brain access to better auditory information, research has shown improvements in outcomes, with some children achieving LSL abilities that match or exceed those of children with normal hearing.
 - Ching, et al, 2018, 2019; Dettmen et al 2016; Eisenberg et al 2004; Geers et all 2003, 2007, 2017
- Earlier research from 2000 to 2010 showed variable results in outcomes.
 - Geers 2003 – only 30% of children did as well as hearing peers
- Recent research is showing much better results.
 - Babies are fit with technology sooner.
 - Technology has improved.
 - Cochlear implants are fit routinely – many binaural.
 - More and more babies are receiving LSL intervention.



Factors that Contributed to Better Spoken Language Outcomes at Age 3 (LOCHI studies Ching et al.)

- Fit with CI before 12 months of age
- Communicating solely through LSL
- Mothers with higher education levels
- Families with higher incomes



Factors that Contributed to Poorer Language Outcomes at 3 years of Age

- Additional disabilities
 - Performance associated with cognitive level
- Lower birth weight
- Greater degrees of HL for children who used hearing aids and not CI



Outcomes at Age 5 Years of Age: We are Learning More

- CI implantation prior to 12 months continues to be associated with higher auditory and language outcomes.
- Children fit with HA's younger than 6 months had better speech, language and auditory outcomes than children who received HA'S later.
- Children who received newborn screening received hearing aids at 3.5 months. Children who did not receive newborn hearing screening did not receive hearing aids until 16.4 months of age.

– **YOUNGER AGE OF HEARING AID FITTING CONFIRMS THE NEED FOR NEWBORN HEARING SCREENING.**



Language Outcomes Improved Between 3 and 5 years of Age

- At age 3 years, most children had language at least 1 standard deviation below normal.
- However, by 5 years of age most children achieved language outcomes that were within 1 SD of normal.
 - This suggests that if we do what it takes, such as the provision of good audiology services and auditory based habilitation, we can close the language gap that has historically existed between children with HL and typically hearing peers.
 - Remember, many of these children were not identified at birth. We expect that children who are identified early and who are in good family-focused listening and spoken language habilitation programs will do even better.



Factors that Affected Improved Outcomes at Age 5

- Communicating through LSL alone resulted in higher language outcomes, when compared to children who used sign language along with LSL.
- Mothers with higher education levels.
- For children with HA's, children with less HL had better results.
- Children with higher nonverbal IQ tended to obtain better language outcomes.
- Additional disabilities resulted in poorer outcomes.
 - Outcomes were consistent with cognitive age.



Optimal Age for Cochlear Implantation

Leigh, J. R. et al 2016

- Children with HL have a 75% likelihood of improvement in word recognition with use of a CI relative to performance with HA -- if hearing loss is greater than 60 dB HL.
- Average language score for the entire group of children with CI was within normal limits.
- Children who received CI after 12 months of age were more likely to experience delays.
- Children with severe to profound HL typically made .33 to .43 years language growth in 1 chronological year prior receiving CI.
- After receiving CI growth went to 1.04 years growth in 1 year.



Language Outcomes and Family Factors

Chu et al 2016

- Language abilities are significantly better when using only LSL
 - Receptive language within normal limits
 - Children who used sign language had receptive language abilities that were more than 2 standard deviations below the norm
- Children who received therapy monthly had received CI between 6 and 18 months.
- **Early implantation means families need less therapy.**



Chu Study continued

- Children do better:
 - when families are more attentive and responsive to the child's needs.
 - When they are exposed to robust, language-rich listening environments during first few years
 - Families are the best models for spoken language.
 - Outcomes will be better when families are heavily invested in and engaged with their child's development.
- Clinicians must help families with knowledge and skills to foster development of optimal, listening-rich environments.



Outcomes of Children with Hearing Loss Study

Moeller, Tomblin, Harrison 2015

- A high quality HA fitting is critical.
 - Real ear probe mic measurements are essential.
 - More than half of the children in the study did not have appropriately fit hearing aids – many were “underfit”.
 - Inadequate speech perception was associated with poor hearing aid fitting.
 - Close correlation between appropriate hearing aid fitting and language level.
 - Almost 15 points on a standardized test
 - Children whose scores were in the upper 25% of aided audibility had language levels that exceeded the norms.



OCHL study continued, Language

- Full time HA use resulted in better language outcomes
- Language outcomes were directly related to HA usage
 - Children who used HA's at least 10 hours/day achieved language outcomes that were on par with the mean for children with normal hearing
 - HA's worn at least 10 hrs/day between ages 2-6 years of age had greater rate of language growth
 - Clinician should provide families with strategies to facilitate hearing aid use (tape, pilots caps, cords etc.)
 - Children who received HA's prior to 6 months of age, had better language outcomes than children fit after 12 months of age.



OCHL study – Parent Language

- Parents who used more complex language had children with better language results.
 - Not just “what’s that” or “come here”, “no”, “stop that”
 - “Tell me about your day”, “How do you feel about that?” “Why do you think she did that?”
 - Read, read aloud, daily -- Lots of books. Discuss what is happening, why, what the characters feel about what is happening.



OCHL Study, Hearing in Noise

- For children with HL, word recognition was often good in quiet.
- However, word recognition in noise was significantly poorer for children with HL than for typically hearing peers.
 - Consider noise management settings such as directional microphones -- and use remote microphone systems.



Summary Comments -- OCHL Study

What we CAN control

- Protection against language and literacy delays arises from managing the malleable factors:
 - properly fit hearing aids that maximize audibility
 - Hearing aids 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!



Impact of Sign Language on Spoken Language

Geers et al, 2017

- A child's language is learned from parent language models.
- About 95% of children with HL were born to normal hearing parents.
- The great majority of parents will communicate using LSL and will not be fluent in ASL when their child is born.
- **Question – Are speech recognition, speech production, spoken language and reading skills best developed by focusing exclusively on spoken language, or does early exposure to sign language provide a foundation for learning spoken language?**



GROUP 1	NO SIGN	Parents reported no use of sign language prior to or after cochlear implantation.
GROUP 2	SHORT-TERM SIGN	Parents reported use of sign language prior to cochlear implantation and/or at 12 months post-activation of the cochlear implant, but not at 24 and 36 months post-activation of the cochlear implant.
GROUP 3	LONG-TERM SIGN	Parents reported use of sign language prior to cochlear implantation and/or at 12 months post-activation and also at 24 and 36 months post-activation of the cochlear implant.

Geers et al,
2017



Results

- Children in Group One, who used no sign language, achieved significantly better speech recognition after 3 years of CI use than children who's families used either short or long term sign language.
- Children who's family did not use sign achieved significantly better spoken language skills.
- At late elementary school, children who's families did not use sign language had language skills within normal limits, and children who used sign did not.
- All three groups developed literacy skills that were within normal limits.
 - However, reading abilities of children who's families did not use sign language were significantly better than children whose families did use sign language on a short or long term basis.



WHAT DO CHILDREN WITH HEARING LOSS NEED IN ORDER TO SUCCEED

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What is Success?

- Language at age level
- Literacy at age level
- Academics at age level
- Social skills at age level



Get Technology Fit and Worn Early

- Children with mild to moderate HL need hearing aids fit by 3-6 months of age – earlier is better!
- Children with severe and profound HL need CI before age 1 year.
 - Language outcomes are decreased by $\frac{1}{2}$ SD (approx. 7.5 points on test of language ability) for every 6 months delay in implantation after 6 months of age.
 - Normal vocabulary will be achieved by over 80% of children who receive a CI before 12 months of age.



What Does It Take To Get There?

- Early identification
- Early, **appropriately fit** technology
 - The better you hear the better you learn
- Technology worn all day
- Auditory-based therapy, involving family
- Family support
- Language-rich environment
- Opportunities to learn
- Educational program willing and able to make the necessary adaptations for maximizing learning



Eyes Open – Ears on

- Children with hearing loss need to wear technology all waking hours to facilitate auditory brain development.
 - If a child wears hearing aids 4 hours a day it will take him 6 years to hear what a typically hearing child hears in one year.
- Families need to understand the necessity of using technology full time.
- The end goal is optimizing listening, spoken language, literacy, academic, and psycho-emotional development.
- Families need to understand the critical need of developing the brain during the first 3 years of life – beginning in infancy.



What Parents Need To Know

- Help families make the link between hearing technology use and auditory brain development
- Offer families tips and strategies to help keep hearing technology on their children
- Talk and Converse with your child
 - Talk about everything that is happening
 - Use high quality language
 - Use open-ended and complex speech
 - Read and sing out loud daily
 - Communicate using listening and spoken language (LSL)
 - A LSL Specialist can best coach and guide families to develop a language-rich environment



Remote Microphones are Key: At Home and in School

- The world is noisy
- It is critical to hear – to receive auditory information -- in noise
- A remote microphone will provide brain access of auditory information so that a child has exposure in all difficult situations



THE ROLE OF THE AUDIOLOGIST IN MANAGING HEARING LOSS

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What Is The Audiologists Job (We are the *Hearing Guardians*)

- Identify and monitor hearing loss
- Fit technology so that it is providing auditory brain access
- **TEST SPEECH PERCEPTION**
 - Be certain that technology is allowing children to hear
 - 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
- Monitor hearing in school
- Monitor speech, language, and literacy development
- Beware of other disabilities and make referrals as needed
- Support children and families



Appropriate
Technology

+

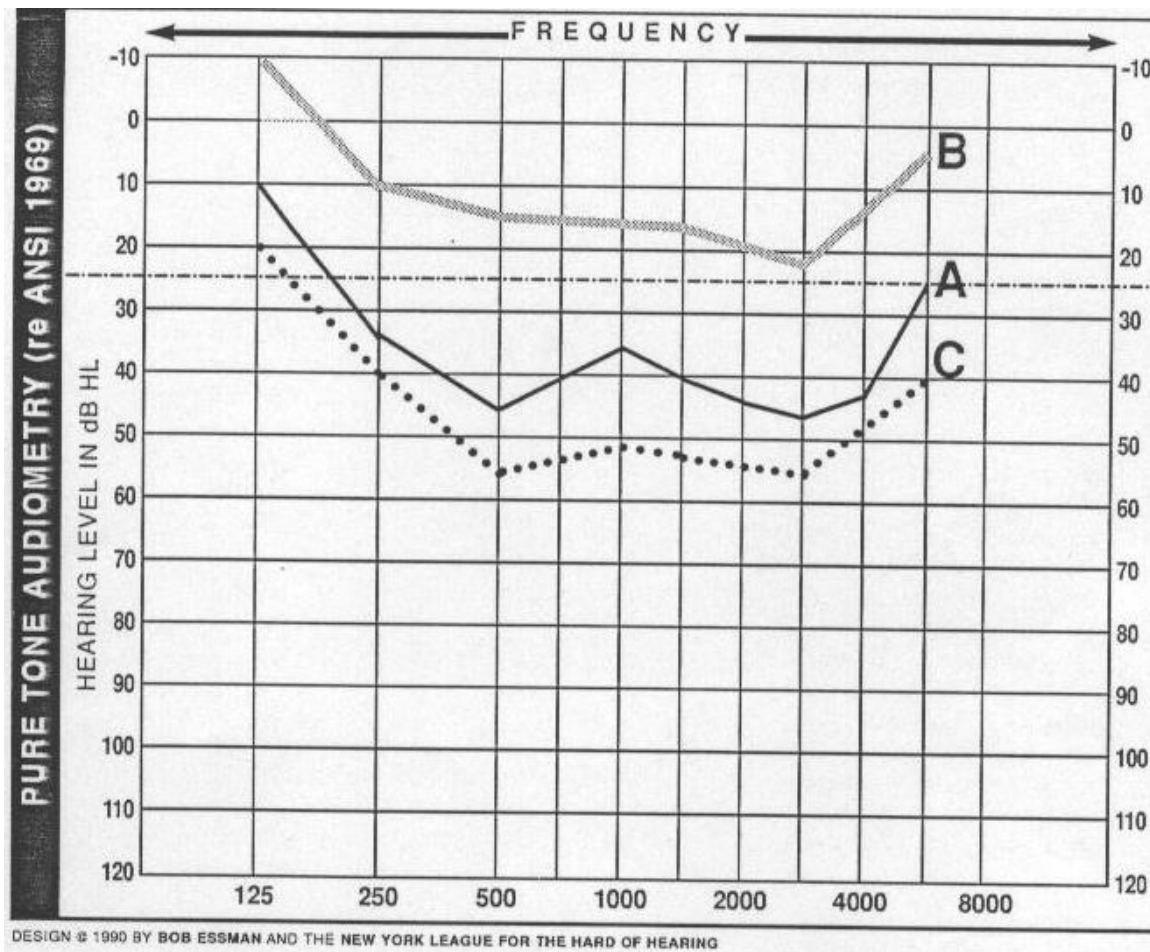
Enriched
Auditory
Exposure

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AUDITORY BRAIN
DEVELOPMENT



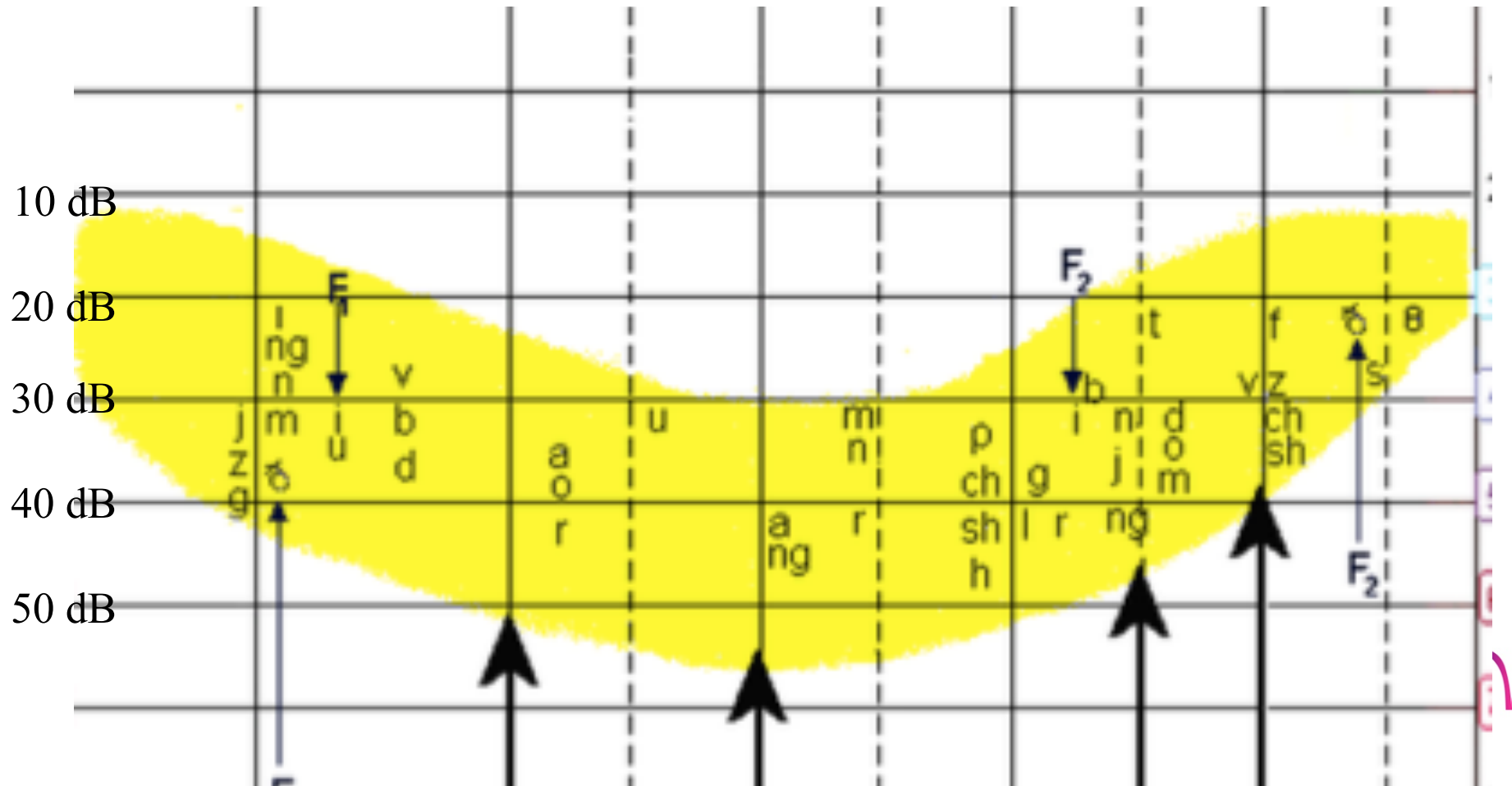
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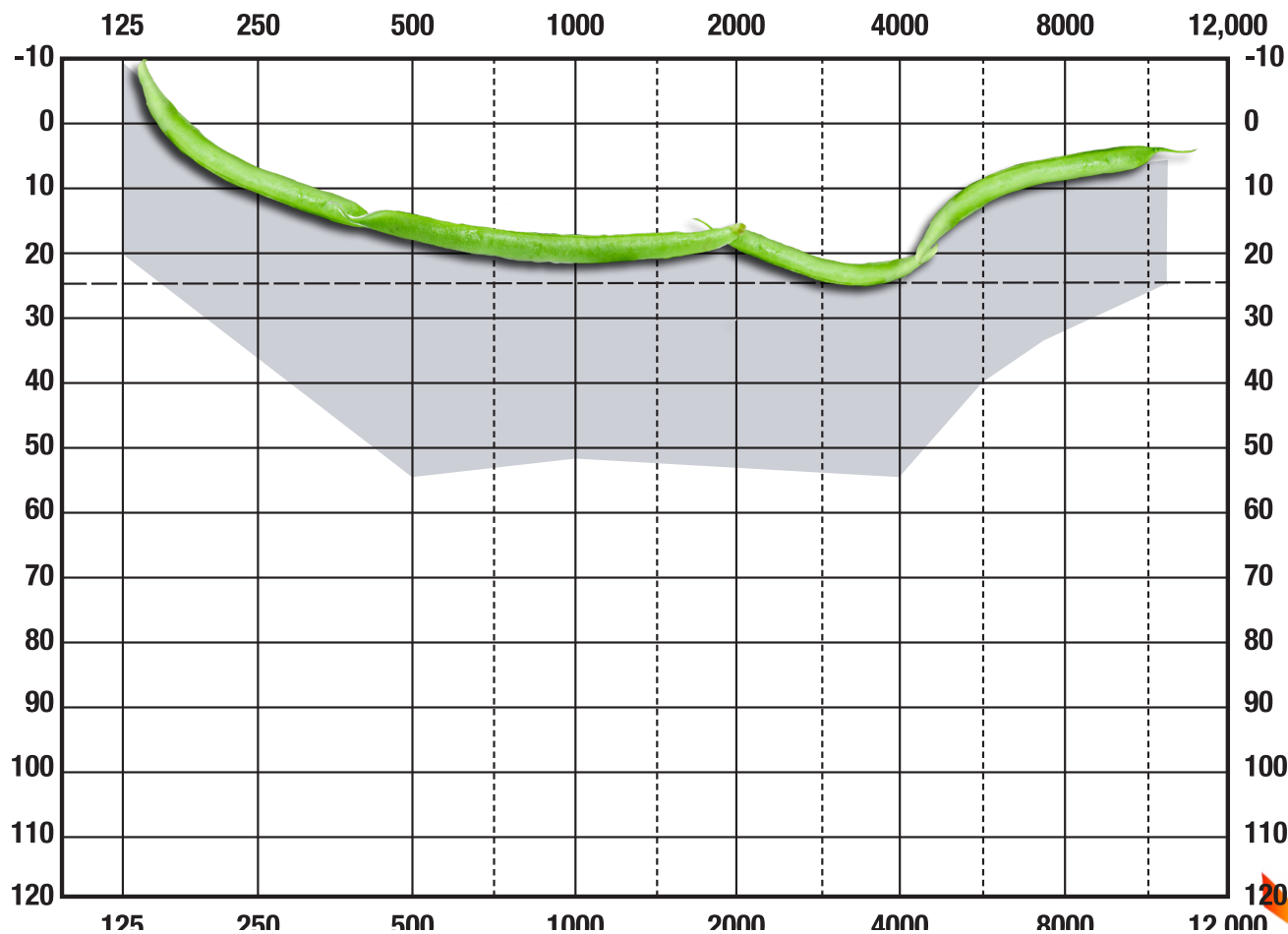
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Speech Banana



Can We Call It The Speech String Bean?



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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 (e.g. morphemes that are not stressed during conversation –e.g. 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 playground
 - Will not “overhear” conversation and will have limited incidental learning
 - Will have reduced language and literacy skills
 - Moeller (2011) reported that in her research 40% of children fit with hearing aids were underfit.



Suggested Scoring

Madell et al 2010

- Excellent 90-100%
 - Good 80-89%
 - Fair 70-79%
 - Poor < 70%
-
- Be honest.
 - 70% is not good speech perception



Supporting Families

- We all need support.
- We need to be part of a group -- consider “circles of support.”
- Circles are critical to building happiness and trust.
- We all are members of many groups:
 - Nuclear family
 - Extended family
 - Neighbors
 - Professions
 - School
 - People with similar concerns
 - Hearing loss



Circles for Families With Hearing Loss

- Children who use listening and spoken language need their own support groups.
 - They do not fit in with children who sign.
 - If language is good, they will fit in with typically hearing children.
 - Even if they have a circle of friends who are typically hearing, they will benefit from having a circle of children with hearing loss who understand their concerns.
- Parents need a circle of other parents of children with hearing loss.
- Siblings need support from other children who have siblings with hearing loss.
- We can help by figuring out ways to organize circles of support.





THANK YOU FOR LISTENING



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NOW ASK JANE AND CAROL ANYTHING

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General References

- Cole, E., & Flexer, C. (2016). *Children with Hearing Loss: Developing Listening and Talking, Birth to Six, 3rd 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.



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.



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., Strube, M.J., Tobey, E.A., Pisoni, D.B., & Moog, J.S. (2011). Epilogue: factors contributing to long-term outcomes of cochlear implantation in early childhood. *Ear & Hearing*, 32(1 Suppl.), 84S–92S.
- 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.



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