



Auditory Brain Development: The Key to Listening, Language, and Literacy

Carol Flexer, Ph.D., CCC-A; LSLS Cert. AVT
Distinguished Professor Emeritus
Northeast Ohio Au.D. Consortium (NOAC), and
The University of Akron
MSHA – March 22, 2012
www.carolflexer.com



Family's Desired Outcome

- 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 the **context** of service delivery and professional collaboration if the family chooses listening and talking for **today's child** who is deaf or hard of hearing.

www.carolflexer.com



Themes

Because of advances in technology and new research about brain neuroplasticity, the audiologist's role has expanded in pediatric sectors.

Because of advances in technology and new research about brain neuroplasticity the landscape of deafness has changed.

Because of advances in technology and new research about brain neuroplasticity, families, LSLS and audiologists need to be sure they are stimulating auditory brain development

www.carolflexer.com



Session Flow

- Neurological Issues
- Research about early language and pre-literacy development
- Research about later literacy development
- DVD clips that demonstrate several techniques that can be used to facilitate literacy development in our children who are deaf or hard of hearing
- Take-Home suggestions for “growing the brain” for listening, language and literacy
- The developmental model is featured



Intention For This Presentation: Invitation To Listen

- How will the performance of your children improve as a result of what you have learned during this presentation?
- That is, specifically, how will the knowledge that you gain impact the outcomes of the children you serve?

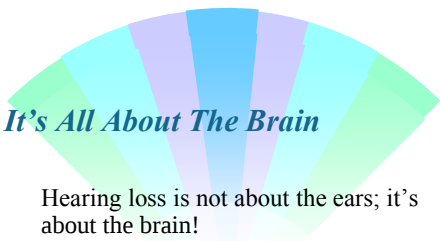
www.carolflexer.com



Main Ideas

- Hearing is a first-order event for the development of spoken communication and literacy skills.
- Anytime the word “hearing” is used, think “**auditory brain development**”!!
- Acoustic accessibility of *intelligible* speech is essential for brain growth – **no “earlids”**.
- Signal-to-Noise Ratio is the key to hearing intelligible speech – speech must be 10 times louder than background sounds. **SLM APP**
- *Our early intervention programs and classrooms must take into consideration the listening capabilities and **acoustic access** of our children.*

www.carolflexer.com



It's All About The Brain

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

Hearing aids, FM systems and cochlear implants are not about the ears; they are about the brain!

They are "Brain Access Tools."

www.carolflexer.com



The World Has Changed For Hearing Loss, Too.

Spoken Communication: Past And Present

1. CD of possible auditory-oral outcomes before early identification, early intervention, and cochlear implant technology
2. DVD of possible auditory-verbal outcomes in this day and age

www.carolflexer.com



New Brain Research

Basic neural research offers increasingly robust information about neural plasticity and about the necessity of accessing and stimulating auditory brain centers early and often.

There is a science behind our practice!



The Big Picture: The World Has Changed!

- ♦ *Who Moved my Cheese?* by Spencer Johnson, M.D. – a book about change
- ♦ We are an Information/Knowledge-based economy that demands high levels of spoken communication and literacy.
- ♦ We are educating children to take charge in the world of 2030, 2040, and 2050....not in the world of 1970 or 1990 or even 2013

www.carolflexer.com



What Does "Deaf" Look Like in 2012?

- ♦ Does 2012 "Deaf" look like 1970 "Deaf"?
- ♦ We have used the same words for decades, but the context and possibilities have changed, dramatically!

www.carolflexer.com



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 (Kretzmer et al, 2004).

Normal maturation of central auditory pathways is a precondition for the normal development of speech and language skills in children (Sharma et. Al, 2009).

www.carolflexer.com

Neuroplasticity – Some Generalizations

We are in a brain plasticity revolution -- much interest and attention.

Experience dependent plasticity: Repeated auditory stimulation leads to stronger neural connections. (Kilgard, 2006) .."time on task"

Sensory experience directly shapes the rewiring that makes learning possible....especially guided neural reorganization. (Merzenich 2010)

The skills and abilities that we develop are a product of our culture -- our exposure, experience and practice.

Attention (pre-frontal cortex) plays a major role in activation of the auditory cortex. (Musiek, 2009)

Why Early ID and Amplification/Implantation, before age 2, is Critical for Literacy Development (Robbins, et. al, 2011)

Skills mastered as close as possible to the time that a child is biologically intended to do so, results in developmental synchrony.

Mastery of any developmental skill depends on cumulative practice; the more delayed the age of acquisition of a skill, the farther behind children are in the amount of cumulative practice they have had to perfect that skill. The same concept holds true for cumulative auditory practice.

Developmental practice looks different than remedial practice. Delayed auditory development leads to delayed language skills.

Early use of a hearing aid and/or a cochlear implant can make oral proficiency in more than one language possible for prelingually deaf children....provided we do what it takes.

How Much Practice is Needed to Influence Neural Structure?

Malcolm Gladwell: 10,000 hours of practice

Hart and Risley: 46 million words heard by age 4

Dehaene: 20,000 hours of listening as a basis for reading

Pittman: Children with hearing loss require three times the exposure to learn new words and concepts due to the reduced acoustic bandwidth caused by the hearing loss.

www.carolflexer.com

Pay Attention! (Doidge, 2007) The Brain that Changes Itself

■ “When we want to remember something we have heard, we must hear it clearly because memory can be only as clear as its original signal....muddy in, muddy out.” p. 68

■ Learning new information/tasks/skills requires active attention.

■ “While we can learn with divided attention, divided attention does not lead to abiding changes in your brain maps”. p. 68

■ **Concept of Intrinsic/extrinsic redundancy**

www.carolflexer.com

Therefore, early intervention is not about the child, it is about the family.

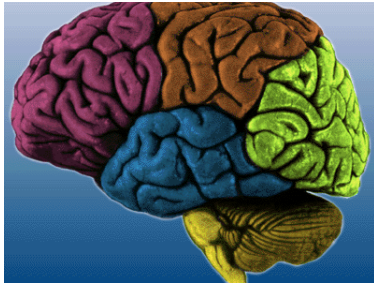
Think of early intervention as “adult education”.

It's All About The Brain

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

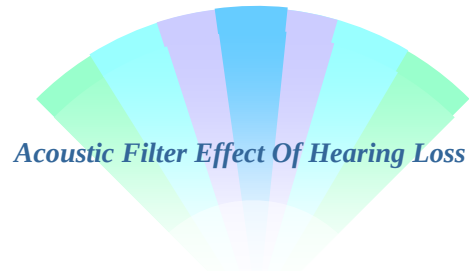
Hearing aids, FM systems and cochlear implants are not about the ears; they are about the brain!

They are “brain access” tools.



THE EAR

www.carolflexer.com



Acoustic Filter Effect Of Hearing Loss

A model for understanding the impact of unmanaged or late-identified hearing loss on literacy and academic development

Understanding the “Acoustic Filter Effect” of hearing loss explains the destructive impact of early, unmanaged hearing loss.

Invisible Acoustic Filter

Spoken Language

Reading and Writing

Academic Competence

Professional flexibility

Independent function, work, and community contributions

www.carolflexer.com

* Hearing is a first-order event for spoken language, reading, and learning !

* Because hearing loss is invisible, the negative results of unmanaged hearing loss of any degree (behavior problems, attention problems, spoken language difficulty, reading, and academic deficiencies) are erroneously believed to stem from causes other than hearing loss.

www.carolflexer.com

- As human beings, we are neurologically programmed to extract patterns from the speech sounds that we hear for the processing of spoken language, reading and academic competencies.

- The auditory centers of the brain are critical to this process-- a fact confirmed by brain mapping and by observations of real-world performance.

www.carolflexer.com

Think of hearing as the **Velcro** to which other skills such as attention, spoken language, reading, and academic competencies are attached.

Children must *repeatedly hear the details* of phonemes in order to understand the subtle aspects of language. These subtle linguistic aspects are learned all the way through high school.



Summary Thoughts about the Acoustic Filter Effect

- Once we develop the brain's auditory centers, we have set the stage to continually teach the child to listen (auditory attention) and to use audition to learn information -- knowledge.
- **Do not confuse "language" with "knowledge".**
- Beware of being seduced by how "good" this generation of children sound and score on their early language tests (Fairgray, 2010).
- Children with hearing loss must use FM systems have collaborative management to access all of their environments.

www.carolflexer.com



Literacy



"Big Picture" Reading Issues

Almost 70% of U.S children do not read at a proficient level.

85% of children from families in poverty are not proficient readers.

Less than 8% of all 4th grade students are advanced readers.

The Read-Aloud Handbook by Jim Trelease: A must-read for every family!



We have a wide variety of children with cochlear implants and hearing aids in our school and clinic programs. Some of the variables include:

- Those aided/implanted in their first year of life and their brain did not receive any auditory exposure pre-implant.
- Those implanted in the toddler years, but their brain did receive some acoustic exposure (hearing aids) pre-implant.

www.carolflexer.com



More.....

- Those implanted late (after 18 months of age) and their brain has not received acoustic exposure pre-implant.
- Those who receive the implant in infancy, but the CI was not programmed effectively, and/or their early therapy was not auditorally focused.
- Those who are older but they have had a progressive hearing loss....so their brain was developed initially around acoustic sound.

www.carolflexer.com



*So, therapy and educational/literacy goals need to consider all of the above variables, remembering that our goal is to access, expose, stimulate, and enrich auditory brain centers so they can serve as the foundation for listening, speaking, **reading, and the acquisition of knowledge.***

www.carolflexer.com

Foundational Pre-literacy Issues

Early Literacy Development – Janet Werker at UBC, Dev. Psy. 2009

Fetuses hear mostly the low frequency acoustic features of their mother's speech in utero – so the acoustic focus is on rhythmic elements.

At birth, infants listen at multiple levels at the same time.

They learn to distinguish rhythm, phonemes, and phonologic elements all at once.

Therefore, speak in complete sentences/phrases with a great deal of melody.

Infant speech perception acuity predicts their vocabulary.

www.carolflexer.com

Early Literacy Development – Janet Werker at UBC, Dev. Psy. 2009

Infants acquire native languages by listening, and start life being prepared to speak.

At birth, infants prefer their mother's speech, and songs and stories heard before birth, and they can categorize content vs. function words.

In the first 6 months, babies can discriminate many speech sounds, but by the end of the 1st year, there is a functional reorganization to language specific phonemes; infants become language specific listeners between 6 and 12 months of age.

This reorganization improves and tunes the phonetic categories required for their language, and attenuates those distinctions not required.

www.carolflexer.com

Early Literacy Development – Janet Werker at UBC, Dev. Psy. 2009

Infants use their phonetic categories to bootstrap learning new words.

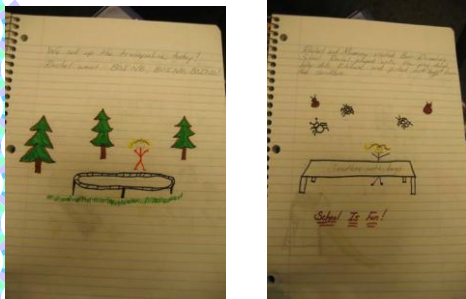
Phonetic distinctions guide new word learning at 17 months.

Listening experience in infancy is critical for adequate language and literacy development.

Phonetic categories > phonological processes > lexical-semantic use > reading and higher order language use.

www.carolflexer.com

Early Literacy Beginnings: The Experience Book

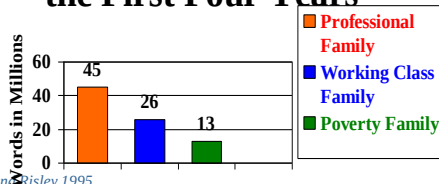


www.carolflexer.com

Key Study By Hart And Risley Showing How Much Auditory Stimulation Is Needed

Meaningful Differences in the Everyday Experience of Young American Children

Cumulative Words Addressed to a Child in the First Four Years



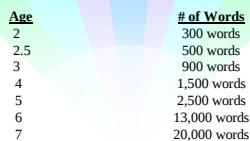
Hart and Risley 1995

www.carolflexer.com

Vocabulary is one of the biggest predictors of kindergarten success...therefore, early intervention is not about the child, it is about the family learning about vocabulary development.

www.carolflexer.com

Number of Words Understood by Typically Developing Children



Numbers of Spoken English and Sign Language (ASL) Words

- The Second Edition of the 20-volume *Oxford English Dictionary* contains full entries for **171,476 words** in current use.
- Random House Webster's Unabridged Sign Language Dictionary (2008) by Elaine Costello, Ph.D. identifies **5,600 up-to-date signs** with full torso illustrations.

www.carolflexer.com

Intervention Models

In today's context, we all must use a combination of models.

Ecological model – Typical social-linguistic models with high expectations.

Instructional intensity --- practice, practice, practice.

Families must be involved if sufficient instructional intensity is to be obtained.

www.carolflexer.com

Research about Later Literacy Development

www.carolflexer.com

Neurocircuitry Related to Reading— Maria Mody, 2007

- Reading is probably the most complex task humans perform using the most parts of the brain.
- Speech is biologically programmed using specific parts of the brain; children learn to speak naturally.
- Reading is not natural; it requires explicit instruction and practice in the code. We are not “hard-wired” for reading; we need to create the wiring.
- The brain has not evolved to have “built-in” specialized regions for reading; we need to create the regions.
- Therefore, reading is an exercise in plasticity.

www.carolflexer.com

Neurocircuitry Related to Reading

- Literacy retrains and re-wires all aspects of language.
- To read, the child’s brain has to connect phonology (the key) with semantics and orthography; multimodal integration. A good reader never bypasses phonology.
- Skilled readers can read words fast; approximately 150-200 msec.
- Poor readers are slow, labored & error prone, taking about 2000 msec to code a single word.
- Poor readers have a slower Reaction Time (RT) for both phonological and semantic processing.

www.carolflexer.com

Neurocircuitry Related to Reading (Mody, 2007; Pugh, 2005)

- Becoming expert in a skill means that the brain has developed specialized portions.
- Expert readers have clear activity in the temporoparietal region of the brain whereas poor readers have diffuse brain activity, including diffuse activity in the right hemisphere.
- Primary portions of the brain are in the left hemisphere; frontal, temporoparietal (key for fast processing) and occipitotemporal

www.carolflexer.com

Brain Issues (Tallal, 2005)

- The underlying cognitive building blocks for learning are:
- Memory
- Attention
- Processing
- Sequencing
- *These skills are critical for Executive Functioning.*

www.carolflexer.com

Research has identified 5 areas that need to be addressed to enhance literacy:

- *Phonemic Awareness*
- *Phonics (Decoding)*
- *Reading Fluency (automaticity in recognizing words),*
- *Vocabulary (word meaning)*
- *Comprehension (background knowledge, prediction, imagery, asking questions, compare and contrast, metacognitive awareness)*

www.carolflexer.com

Reading Fluency: A Key to Developing Literacy

- To read aloud, we need to develop the child’s “Auditory Feedback Loop”
- Need to enhance signal redundancy by improving the S/N of the child’s speech
- Therefore, place the child’s FM microphone close to the child’s mouth
- Practice, practice, practice... repeated readings of performance material.

www.carolflexer.com



Why do Some Children Stall at Third or Fourth Grade Reading Levels?

- Some kinds of knowledge may be missing:
 - **Insufficient time-on-task**
 - Complex sentence structures
 - Vocabulary and conceptual knowledge
 - Story structures and informational structures
 - Cause and effect
 - Main idea
 - Chronological seriation
 - Enumeration and categorization
 - Strategic memory

www.carolflexer.com



How Do Children Learn Sophistications of Spoken Language?

- Immersion with good speech-language models
- Hearing language repetitively from significant others in a natural setting...Practice!
- Hearing language in a meaningful context
- Being read to -- above their own reading level

www.carolflexer.com



Surprising, Unfortunate Findings...

- Only **20%** of parents read to their children daily
- In **both** poverty and university-level families, **fathers read to children 15%** of time while **mothers read 76%** of time

www.carolflexer.com



Implications for Parents, Teachers, and LSLS working with Children with Hearing Loss

- Talk constantly with the child -- --
.....**Conversations**
- Create experiences and talk about them
- Use complex language, explain it, and link it to the experiences
- Read aloud with the child on a daily basis, using books that are at least slightly beyond where the child is linguistically

www.carolflexer.com



More.....

- Use synonyms and antonyms and point them out (compare and contrast)
- Show curiosity: ask questions and show the child how to find answers
- Play word games and board games
- Sing, dance, and play instruments
- Organize information

www.carolflexer.com



Introduce Music – Early and Often!

- Sing, sing!(McKonkey-Robbins & Barton-Tune-Ups!)
- The earlier you start the better!
- Start without background music- lots of rhythm and intonational contours
- Try some basic common songs- “Where is Thumbkin, Twinkle Twinkle, If You’re Happy and You Know it, Itsy Bitsy Spider (Tune-Ups & Hear & Listen, Talk & Sing!)
- Auditory first and then pair the song with motions and objects or pictures so there is an association – can later use for identification between songs (you sing- they start the motion or pick the object)
- Play with basic musical instruments– highlight the concepts of loud/quiet, fast/slow, high/low

www.carolflexer.com



Teens with Implants:

Do better than peers with hearing aids, but less well than hearing peers

There appear to be increasing difficulties in adolescence...

Why are later reading skills such a challenge?

Reading demands skills...such as extensive world knowledge, complex vocabulary.... But also subtle language skills: of making inferences, and the pragmatic skills of language... where there is increasing evidence of difficulty...

Have we stopped vocabulary enrichment and information redundancy too soon?

www.carolflexer.com

Literacy Development in Children with Hearing Loss – Once We Provide Auditory Brain Access.....

Engage all 5 critical areas actively and thoughtfully from infancy on; “generalized auditory training” will be insufficient.

The five areas necessary to build literacy are: phonemic awareness, phonics, reading fluency, vocabulary and comprehension.

Then, Practice, Practice, Practice – Rhythm, Rhyme, and Repetition!



Tips for Reading Aloud...

- Read aloud to your child—it’s never too early to begin and never too late to start
- Continue to read aloud after your child learns to read alone—best to read to child slightly above their own reading level
- Read aloud every day, even several times a day
- Establish a regular time to read

www.carolflexer.com



Tips for Reading Aloud...

- Show enthusiasm about what you are reading
- Choose a story, poem, news story to grab the child’s interest
- Cut the session short if interest lags
- **Use an FM and pass the FM mic back and forth**
- Link the story to life and other books
- Ask the child to predict the outcome through the reading of the story

www.carolflexer.com



Tips for Reading Aloud...

- Start with picture books, build to storybooks and novels
- Vary the length and subject matter of your readings
- Go on a “book walk” prior to reading the book
 - point out the title, author, illustrator
 - talk about front/back of book
 - discuss illustration on cover
 - predict what the story will be about

www.carolflexer.com



Acoustic Access To The Brain

- This is the biggest problem—worldwide, for all degrees of hearing loss.
- Technology often is not programmed to today’s possibilities.
- **Evidence must be obtained**, daily, about technology function.
- **If the child is not progressing as expected – and have very high expectations – suspect the technology first.**

www.carolflexer.com

Real-Ear Measurements – A Necessary First Step for Hearing Aid Fitting

www.carolflexer.com

Evidence from the Audiologist: Speech Perception Test Presentation Levels

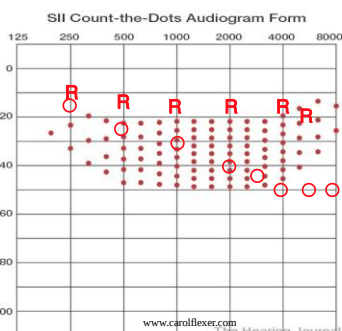
- 60 dBHL may give optimal speech perception because it is loud.
 - It is not indicative of daily listening situations
- In daily living people need to hear at:
 - Normal conversational levels (50 dBHL)
 - Soft conversational levels (35 dBHL)
- And in competing noise
 - Normal conversation (50 dBHL+5 SNR)
 - Using realistic noise (4 taker babble)

www.carolflexer.com

Figure 5-4
Count the Dots
Audiogram
showing the
comparison of
speech audibility
between the right
ear aided (97%),
and unaided
(55%) conditions

O = unaided right ear
thresholds obtained
with insert earphones
R = Right ear aided
sound field thresholds

The SII-Based Method for Estimating
the Articulation Index



www.carolflexer.com

The Hearing Journal

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 hearing soft speech – showing negative effects on language and cognitive development.
- Problems are distance hearing, listening in noise.
- Under-amplification is a much bigger problem than over-amplification.

www.carolflexer.com

How To “Grow” Your Baby/Child’s Brain

Information for families of children with hearing problems of any type and degree, including auditory processing difficulties

For Parents: How To Grow Auditory Brain Centers

- 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 hour (at least 12 hours/day)**. The auditory brain centers need consistent access to clear, complete sound in order to develop.
- **Check** your child’s technology regularly. Equipment malfunctions, often. Without auditory access, talk to the floor.

www.carolflexer.com

For Parents: How To Grow Auditory Brain Centers

- **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 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.

For Parents: How To Grow Auditory Brain Centers

- **Read, Read, Read aloud** every day. Try for 10 books per day. “Write” notes.
- 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.
- **Use an FM.**

www.carolflexer.com

For Parents: How To Grow Auditory Brain Centers

- 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.
- **Describe sequences.** Talk about the steps involved in activities as you are doing the activity. Sequencing is necessary for organization.

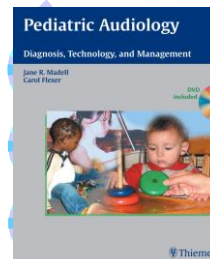
www.carolflexer.com

General References

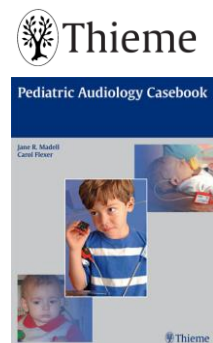
- Cole, E., & Flexer, C. (2011). *Children with Hearing Loss: Developing Listening and Talking, Birth to Six, 2nd ed.* San Diego: Plural Publishing.
- Madell, J., & Flexer, C. (2008). *Pediatric Audiology: Diagnosis, Technology, and Management.* New York: Thieme Medical Publishers.
- Madell, J., & Flexer, C. (2011). *Pediatric Audiology Casebook* 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. (2009). *Literacy and Deafness: Listening and Spoken Language.* San Diego: Plural Publishing.

General References

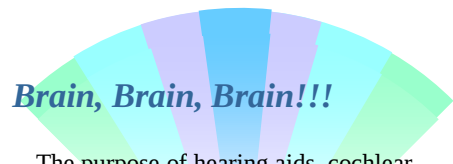
- Dehaene, S. (2009). *Reading in the brain: The science and evolution of a human invention.* New York: Penguin Group.
- Doidge, N. (2007). *The BRAIN that changes itself.* London, England: Penguin Books, Ltd.
- Hart, B., & Risley, T.R. (1999). *The social world of children learning to talk.* Baltimore: 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.



Thieme Medical Publishers, Inc.
Order toll-free: 1-800-782-3488
Fax: 1-212-947-0108
www.thieme.com



www.carolflexer.com



Brain, Brain, Brain!!

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