If you are viewing this course as a recorded course after the live webinar, you can use the scroll bar at the bottom of the player window to pause and navigate the course.

This handout is for reference only. It may not include content identical to the powerpoint. Any links included in the handout are current at the time of the live webinar, but are subject to change and may not be current at a later date.

The Impact of Unilateral Hearing Loss and Single Sided Deafness for the Pediatric Population: Considerations for Speech-Language Pathologists and Audiologists

Lori Garland, Au.D., CCC/A
lori.garland@cchmc.org
Charlotte Ruder, M.S., CCC-SLP/A
charlotte.ruder@cchmc.org

May 25, 2017

SpeechPathology.com

Cincinnati Children's

Learner Objectives

1. List 3 audiology management options for single sided deafness (SSD).
2. Describe auditory development challenges of children with unilateral hearing loss (UHL), single sided deafness (SSD).
3. Describe potential speech language, educational, social-emotional and behavioral challenges of children with unilateral and single sided deafness (SSD).
4. List speech and language strategies for infants and school age children who have unilateral hearing loss, single sided deafness (SSD).

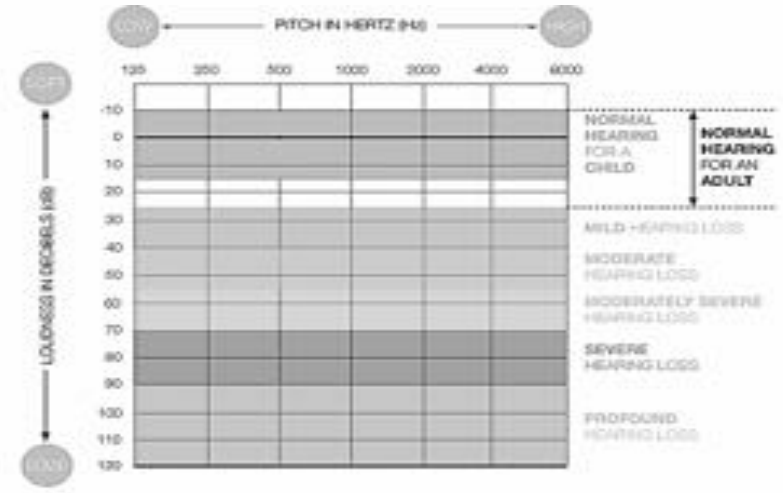
SpeechPathology.com 8 Cincinnati Children's

What does Unilateral Hearing Loss (UHL) or Single Sided Deafness (SSD) look like?

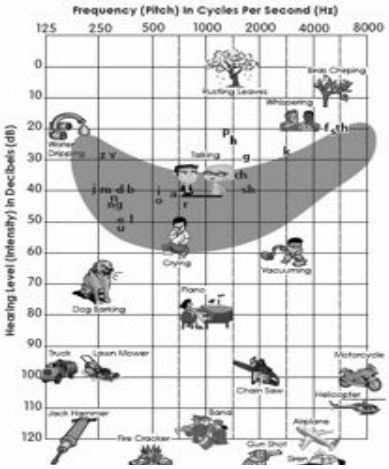
An Invisible Disability

.

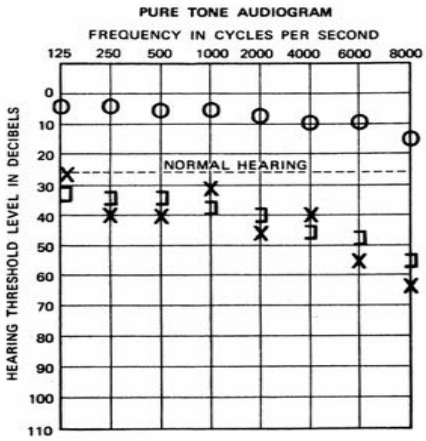
Hearing levels



Pictures of Sounds and Speech



Audiogram for Unilateral Hearing Loss



AUDIOGRAM SYMBOLS

EAR	AIR	BONE
Right	O	⊏
Left	X	⊐

SPEECH AUDIOMETRY

	Right	Left
SRT	5	30
Discrim.	96	50

IMPRESSION:
LEFT SENSORINEURAL HEARING LOSS
NORMAL DISCRIMINATION ON RIGHT
DECREASED DISCRIMINATION ON LEFT

SpeechPathology.com 13 Cincinnati Children's

Definition of Unilateral Hearing Loss (UHL)

Adopted by the July 2005 National Workshop on Mild and Unilateral Hearing Loss (sponsored by CDC and EDHI)

- A calculated and predicted average puretone air conduction threshold at **500 Hz, 1kHz and 2kHz greater than or equal to 20dB HL**

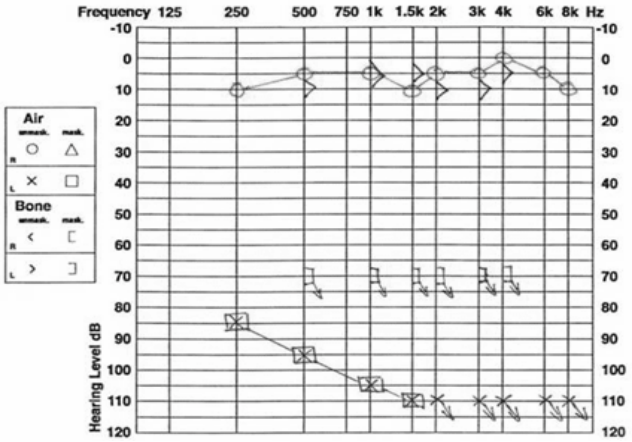
or

- puretone air conduction thresholds greater than **25dB HL at 2 or more frequencies above 2kHz** – with the good ear less than or equal to 15 dB HL

- This definition includes all degrees of hearing loss in the poorer hearing ear – ranging from slight to profound

SpeechPathology.com 14 Cincinnati Children's

Audiogram for Single Sided Deafness



SpeechPathology.com 15 Cincinnati Children's

Definition of Single Sided Deafness

- No established consensus
- Most audiologists consider agree with a definition of one ear with normal hearing and one ear with poor functional word recognition.
  - Due to degree of hearing loss (severe or profound)
  - Auditory neuropathy or poor neural transmission
  - Established that traditional amplification is not effective

SpeechPathology.com 16 Cincinnati Children's

Considerations for UHL vs SSD

- UHL – can often be managed with traditional amplification for hearing loss in the slight to severe range
- SSD – traditional amplification is not an option – often not appropriate for hearing loss with poor word recognition or greater than severe degrees
  - Other management options should be considered

SpeechPathology.com 17 Cincinnati Children's

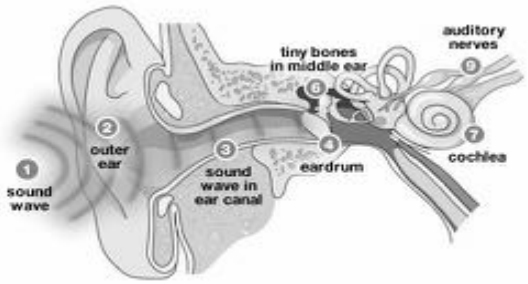
Prevalence Of Unilateral Hearing Loss in Infants and Children

- One of the most common congenital conditions affecting live births
- **Variations in the reporting of prevalence.**
- **Newborns** –1-3 per 1000 are identified through newborn hearing screenings. Many lost to follow up. (Ear Hear 2000, Int'l Journal Pediatric Otorhinolarygnology1994)
- **School-Age –** 30-56 per 1000 for all types of hearing loss (Lieu, et al, 2010)
- 6 in 1000 when all degrees of hearing loss are considered (mild to profound). (http://pedsinreview.aappublications.org/content/35/11/456)
- As children age - prevalence increases - by age **18 years, 17 in 1000 individuals are affected by some degree of permanent hearing loss**. (http://pedsinreview.aappublications.org/content/35/11/456)
- **UHL Increases with age**: 1 in 10 progresses to bilateral (Haffey T, Fowler N, Anne S. Evaluation of unilateral sensorineural hearing loss in the pediatric patient. Int J Pediatr Otorhinolaryngol. 2013;77(6):955–958.)

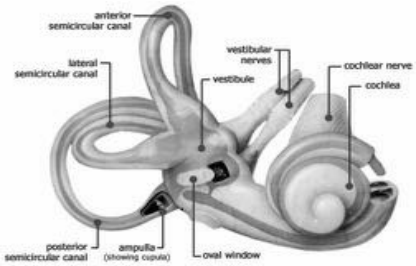
SpeechPathology.com 18 Cincinnati Children's

The
Auditory Pathways

How We Hear

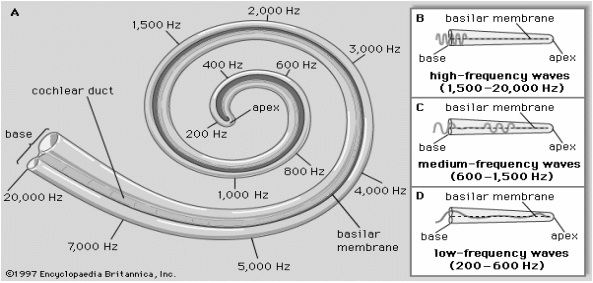


http://www.healthyhearing.com/report/40535-Heart-disease-hearing-loss



http://cochlea.purzuit.com/

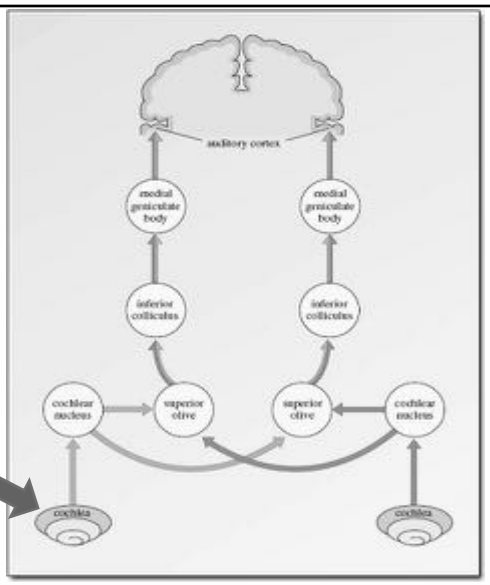
Cochlea



SpeechPathology.com 21 Cincinnati Children's

Auditory Pathways

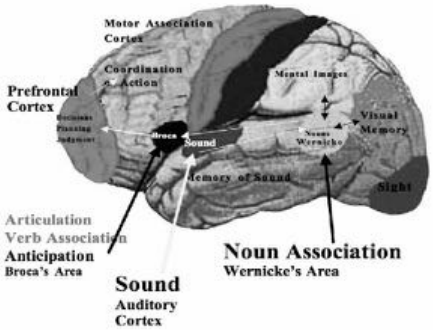
Cochlea



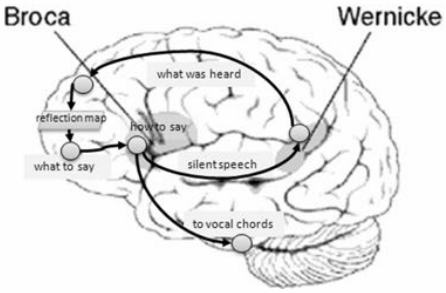
http://www.open.edu/openlearn/ocw/pluginfile.php/67780/mod_oucontent/oucontent/492/2729608a/caa48a7d/sd329_1_027i.jpg

SpeechPathology.com 22 Cincinnati Children's

Where does speech and sound go?



https://wholedude.com/tag/speech-center-of-brain/



https://health-innovations.org/2015/06/25/researchers-map-new-area-of-language-in-the-human-brain/

Hearing is a "Brain Thing"

SpeechPathology.com 23 Cincinnati Children's

Impact of UHL

SpeechPathology.com 24 Cincinnati Children's

Auditory Impact of Unilateral Hearing Loss

1. Loss of **binaural summation**
2. Loss of **squelch effect**
3. Increased negative effects of **noise**
4. Difficulty **with sound localization**
5. **Ease of Listening - Effort**
6. Impact of the **head shadow effect**
7. Difficulty hearing from **a distance**

SpeechPathology.com 25 Cincinnati Children's

What does that mean?

- Difficulty *localizing or finding* the sound source
- Difficulty *hearing in noisy situations*
- Difficulty *hearing from a distance*
- *Turns head* to hear better
- Often *misunderstands* what people say
- Frequently *asks people to repeat* or asks, "What?"

SpeechPathology.com 26 Cincinnati Children's

Social/Emotional/Behavioral Impact

- May be accused of selective hearing due to discrepancies in speech understanding in quiet vs. noise.
- May experiences difficulty understanding in noisy, cooperative learning, or recess situations.
- May misconstrue peer conversations and feel rejected or ridiculed.
- May be more fatigued in classroom due to greater effort needed to listen, if class is noisy or has poor acoustics.
- May appear inattentive, distractible or frustrated. Behavior or social problems are sometimes evident.

SpeechPathology.com 27 Cincinnati Children's

Cortical Plasticity and Reorganization in Pediatric Single-sided Deafness Pre- and Post cochlear Implantation: A Case Study

- **Hypothesis:** To examine changes in cortical development and neuroplasticity in a child with single-sided deafness (SSD) pre and post cochlear implantation (CI).
- **Methods:** High-density 128-channel electroencephalography (EEG) was used to collect cortical auditory evoked potentials (CAEP), cortical visual evoked potentials (CVEP), and cortical somatosensory evoked potentials (CSSEP) in a child with SSD, pre-CI and at subsequent sessions until approximately 3 years post-CI in her right ear which occurred at age 9.86 years
- **Results:**
  - Evidence of delayed auditory cortical response morphology,
  - Auditory cortical development strongly contralateral (to the normal hearing ear)
  - Evidence of increased cognitive load
  - Cross-modal reorganization by the visual and somatosensory modalities.
  - Post-CI developmental trajectory provided clear evidence of age-appropriate development of auditory cortical responses, and decreased cross-modal reorganization, consistent with improved speech perception and sound localization.

Sharma, Anu[*]; Glick, Hannah[*,†]; Campbell, Julia[*,†]; Torres, Jennifer[†]; Dorman, Michael[‡]; Zeitler, Daniel M.[§]Otology & Neurotology: February 2016 - Volume 37 - Issue 2 - p e26–e34doi: 10.1097/MAO.0000000000000904Nashville CI Papers

SpeechPathology.com 28 Cincinnati Children's

Cortical Plasticity and Reorganization in Pediatric Single-sided Deafness Pre- and Post cochlear Implantation: A Case Study

- **Conclusion:** Post-CI, the child demonstrated age-appropriate auditory cortical development and improved speech perception and sound localization suggestive of significant benefits from cochlear implantation. Reversal of somatosensory recruitment was clearly apparent, and only a residual amount of visual cross-modal plasticity remained post implantation. Overall, our results suggest that CI in pediatric SSD patients may benefit from a highly plastic cortex in childhood.
- Sharma, Anu[*]; Glick, Hannah[*,†]; Campbell, Julia[*,†]; Torres, Jennifer[†]; Dorman, Michael[‡]; Zeitler, Daniel M.[§]Otology & Neurotology: February 2016 - Volume 37 - Issue 2 - p e26–e34doi: 10.1097/MAO.0000000000000904Nashville CI Papers

SpeechPathology.com 29 Cincinnati Children's

Benefits of Binaural Input

SpeechPathology.com 30 Cincinnati Children's

#1 Benefit
Sound Localization

- The ability to identify the location of a sound source.
- The constant influx of sound occurs 24/7 and it becomes 3D based on localization cues!

Our ears never rest!

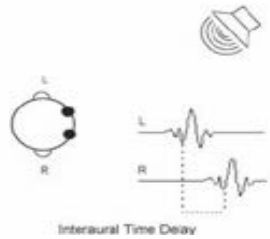
Factors Impacting Localization

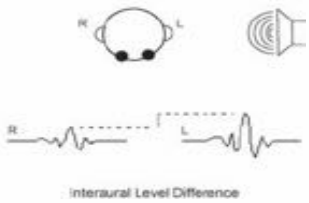
Interaural Timing Difference(LTD

- Sound pressure will reach the ears at different **times** depending on the location in space

Interaural Level Differences (LLD)

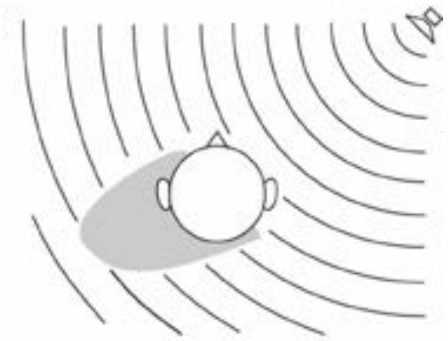
- Sound pressure **level** will be louder in one ear than the other depending direction and intensity of the sounds





https://www.researchgate.net/figure/257764036_fig1_Figure-1-Interaural-time-delay-and-level-difference-example-The-sound-source-is-closer

Head Shadow Effect



https://www.researchgate.net/profile/Liang_Sun6/publication/276473132/figure/fig1/AS:302616455204864@1449160793211/Figure-12-Interaural-Time-Difference-ITD-and-Interaural-Level-Difference-ILD.png

SpeechPathology.com 33 Cincinnati Children's

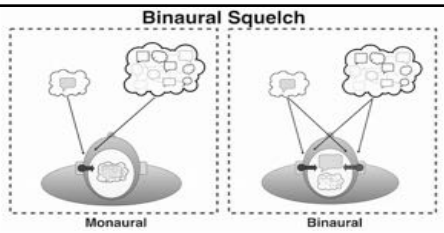
Binaural Summation

- "two ears are better than one"
- the input from both ears together results in 3-6dB additional gain

http://www.audiology.org/news/binaural-loudness-summation

SpeechPathology.com 34 Cincinnati Children's

Squelch Effect



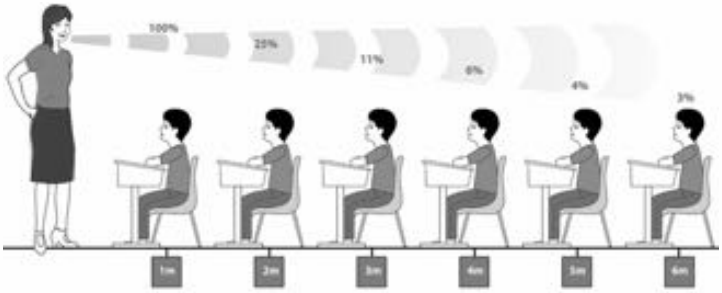
- Two normal hearing ears use the brain to suppress sound/noise on one side while attending to a priority signal near the other ear
- Our brains help separate out what we pay attention to in the world.

http://hearinghealthmatters.org/waynesworld/files/2015/03/Binaural-Squelch-2.jpg

Ability to Handle Noise!

- Noise is everywhere and a challenge for EVERYONE!
- Noise has a negative impact by masking the primary signal or speaker
- Two ears are better equipped to locate ***(localize)*** the primary sound source and use the ***squelch effect*** to manage the noise

Distance from speaker



http://www.certestechnologies.com/wp-content/uploads/2016/10/classroom-hearing-1.jpg

SpeechPathology.com 37 Cincinnati Children's

What else affects the sounds we hear?

Our Bodies

Our Environment

SpeechPathology.com 38 Cincinnati Children's

Our Body and Brain

- Ears – pinna and shape
- Head – Head transfer function
- Shoulders – reflect sounds
- Vision – confirms location
- Health – ear infections
- Body movement – constantly
- Brain – cognition and processing

SpeechPathology.com 39 Cincinnati Children's

Our Environment

Space Size

- Large vs small
- Open vs closed walls

Set-up

- Empty/full
- Surfaces – hard vs absorbent
  - Reverberation/Echo
- Distance from speaker/sound source
- Other competing sound sources
  - Noise
- What's in the environment?

SpeechPathology.com 40 Cincinnati Children's

Amplification Options
UHL vs SSD

SpeechPathology.com 41 Cincinnati Children's

Amplification options for UHL

- Traditional Hearing Aids
- Remote microphone systems (former technology called FM systems)
- Soundfield systems

SpeechPathology.com 42 Cincinnati Children's

Amplification options for SSD

- Bone Conduction Devices – softband or surgically implanted
  - Bone anchored hearing aids using a **surgically implanted post**
  - Bone anchored hearing aids using **surgically implanted magnets**
- Contralateral Routing of Signal (CROS)
- Remote microphone systems
- Cochlear Implants
  - Currently not approved for infants or children with SSD
  - Only option that actually delivers sound to impaired ear
  - May be considered when cochlea is completely formed and auditory nerve is intact
  - ENT is involved in determination for CI candidacy
  - Have been used in "off label" in some cases (e.g. meningitis)

SpeechPathology.com 43 Cincinnati Children's

Amplification Challenges for SSD

- Does not restore binaural integration
- Cannot restore localization
- Cannot restore hearing in noise skills
  - noise management is available in newer devices
- Possibility of introducing negative noise to better ear

Singling Out Single Sided Deafness ppt. Wollet (2013)

SpeechPathology.com 44 Cincinnati Children's

Bone conduction devices

- How they work:
  - Sound is picked up by the bone conduction device and transferred through the bone in the skull to the good cochlea

SpeechPathology.com 45 Cincinnati Children's

Bone conduction devices

- Wearing options
  - Surgically implanted abutment or magnet – only available for children over 5 years.
  - Softband (non-surgical)

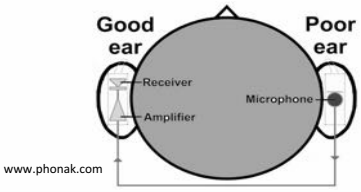
Baha – Cochlear Corp.

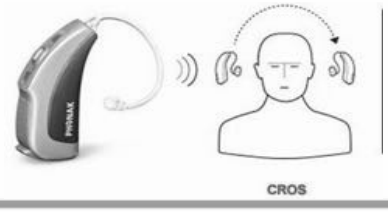
Ponto – Oticon Medical

SpeechPathology.com 46 Cincinnati Children's

Contralateral routing of signal (CROS)

- Air conduction hearing aid on user's good ear receives sound from a wireless transmitter on deaf side
- The audio signal from the un-aidable ear is sent wirelessly, in real time, from the transmitter to the receiver hearing instrument in the better ear.
- Remote microphone technology is compatible with HA (CROS inactive if remote mic is active).





SpeechPathology.com 47 Cincinnati Children's

Wireless Remote microphone systems

- Air conduction system that transmits the speaker's voice wirelessly through a microphone to a receiver on the listener's ear (personal soundfield system)
- Primarily for school use
- The speaker's (i.e. teacher) voice is sent wirelessly, in real time, from the transmitter to the receiver in the better ear.

SpeechPathology.com 48 Cincinnati Children's

Educational accommodations and services

- Preschool/Teacher in-service is beneficial.
- Students will benefit from a personal or sound-field FM system in the classroom, especially in the younger grades.
- Look and Listen
  - Use visual cues combined with auditory information.
- Check Comprehension
  - Periodically ask questions to confirm the student is following and understanding discussion.
- Rephrase and Restate
  - Due to possibility of reduced receptive vocabulary and language impairment.
- Pre-teach New Topics and Vocabulary
  - Provide vocabulary and new subject matter in advance of classroom discussion. Familiarity will allow the child to focus on learning rather then figuring out new words.
- List Key Vocabulary
  - List vocabulary in visible location prior to discussion of new material.

Singling Out Single Sided Deafness ppt. Wollet (2013)

SpeechPathology.com 49 Cincinnati Children's

Tips for classroom teachers

- Multi-sensory Learning
  - An emphasis on visual aids allows child to associate and learn new information with various means of filling in missing information.
- Individual Instruction
  - Identifies gaps in language and comprehension
- Provide Verbal Instructions in Writing
  - Children with hearing loss may struggle with understanding and recalling multiple step directions. Assignments and announcements should be given in writing.
  - Use closed captioning
- Encourage Participation
  - Reading aloud, class discussion, storytelling and creative dramatics
- Develop Literacy Skills
  - Reading can supplement missed classroom information.
  - Children with hearing loss should be read to every day.

Singling Out Single Sided Deafness ppt. Wollet (2013)

SpeechPathology.com 50 Cincinnati Children's

Tips for classroom teachers

- Monitor non-Verbal Communication
  - Children with hearing loss may fatigue more quickly than normal hearing peers
    - Reduced attention, misbehavior or withdrawal
- Team with Parents
  - Share child's successes and challenges with parents regularly and brainstorm possible interventions
- S-P-E-E-C-H
  - **S**tate topic to be discussed.
  - **P**ace your conversation at a moderate speed and use occasional pauses to allow for comprehension and processing.
  - **E**nunciate clearly, without exaggerated lip movements
  - **E**nthusiastically communicate, using body language and natural gestures
  - **C**heck Comprehension before changing topics
- Monitor Amplification
  - Check that hearing aids and FM systems are working appropriately

Singling Out Single Sided Deafness ppt. Wollet (2013)

SpeechPathology.com 51 Cincinnati Children's

Speech Language, Social, Behavioral, IEPs, Academic, Cognitive, Cortical Consequences

SpeechPathology.com 52 Cincinnati Children's

Infant Speech Perception

Infant Speech Perception

- Infants come for the womb with a preference for speech
- Early on preference for mom's voice
- Three filters direct an infants attention to speech
- *Initial bias
- *Developmental level
- *Task demands

- Werker, J., Currin, S. (2005). PRIMIR: A developmental framework of speech processing. Language, Learning and Development. 1 (2) 197-234.

Infant Perceptual Biases
controls access to speech

- Perceptions sensitive to structure of vocal space
- Peripheral Vowels F1-F2: /i/, /a/, /u/ strong perceptual bias = perceptual salience, similar across languages Polke, L., Bohn, O. (2011). Natural Referent Vowel (NRV) framework: An emerging view of early phonetic development. pure.au.dk/portal/files/71808786/Polka. J of Phonetics.
- Supersegmental biases: speaker voice, affect, stress Werker, J., Currin, S. (2005). PRIMIR: A developmental framework of speech processing. Language, Learning and Development. 1 (2) 197-234.
- Phonetic biases, less peripheral /a/-/u/ easier than /u/-/a/ Polke, L & Bohn,O. (2003). Asymmetries in Vowel Perception. Speech Communication – 41-221-223.

SpeechPathology.com 55 Cincinnati Children's

Background noise in natural environments: infants

- Impedes access to relevant speech patterns. In NOISE infants can:
- Detect phonemic difference (Nozza, R., Miller, S. Infant Speech-sound discrimination in noise. J. Acoustic Society of America. 87(1):339-50. February, 2011
- Detect Mother's voice (Baker, B., Newman, R. Listen to your mother! The role of talker familiarity in infant streaming. Cognition, B 45-B53. 2004
- Segment words from fluent speech (Newman, R., Jusczyk, P. The Cocktail part effect in infants. Perception & Psychophysics. August 1996, Volume 58, Issue 8, pp 1145–1156)
- Recognize name (Newman, R. The Cocktail Effect revisited. Listening to one's own voice in noise. Dev Psychology: 41, 352-362. 2005)
- Infants require substantially higher speech to noise ratio: to learn speech, language, new information (Nozza 2011, Kuhl 2014)

SpeechPathology.com 56 Cincinnati Children's

Background **noise** in natural environments: infants

- Infants require substantially higher signal to noise ratios to accomplish the above tasks than adults (10x)
- Noise blocks access to relevant auditory information, reduces attention from speech or critical parts of speech signal
- (Nozza, R., Miller, S. Infant Speech-sound discrimination in noise. J. Acoustic Society of America. 87(1):339-50. February, 2011

SpeechPathology.com 57 Cincinnati Children's

Infant speech processing with **Distraction**

- COMPARED:
- Infants discrimination of /bu-gu/ using habilitation procedure.
- Infants discrimination of pared CV syllable & high frequency distracter (bird-cricket songs) with no frequency overlap. Could hear both
- Infants 6-8 mos performed significantly better in quiet than group in distracter condition (Polka, L., Rvachew, S., Molnar, M. Speech Perception by 6- to 8-Month-Olds in the Presence of Distracting Sounds. Infancy. Sep/Oct2008, Vol. 13 Issue 5, p421-439. 19p. 1)

SpeechPathology.com 58 Cincinnati Children's

Infant speech processing with **Distraction**

- CONCLUSION:
- It is a substantial cognitive challenge for infants 6 to 8 mos to perceive auditory phonetic patterns in noise
- Auditory-visual speech stimulus may provide critical support that makes speech perception in noise possible for infants (Hollich, G., Newman, R. Jusczyk, Infants' Use of Synchronized Vicual Information to Separate Streams of speech. Child Language Development. 76, 1-16 May, 2005) onlinelibrary.wiley.com/doi/10.1111/j.1467-8624.2005.00866.x/abstract.
- Sensory impact of noise will not change, but with maturity infants increase ability to attend to speech signal over the noise (Polka, L., Rvachew, S., Molnar, M. Speech Perception by 6- to 8-Month-Olds in the Presence of Distracting Sounds. Infancy. Sep/Oct2008, Vol. 13 Issue 5, p421-439. 19p. 1

SpeechPathology.com 59 Cincinnati Children's

Speech and Language Development in NH

- Kuhl's research demonstrated that babies watching speaker's mouth combined with auditory input helps develop articulation skills (Kuhl, P., Ramariz, Rey., Bosseler, A., Lin, J., & Imada, T. Infants' brain responses to speech suggest Analysis by Synthesis. vol. 111 no. 31. 2014 11238 11245, doi:10.1073/pnas.1410963111
- Infants who discriminate CV sets from their native language at 7 mos of age demonstrate better language outcomes at 12, 18, 24 mos of age on a battery of language measures Kuhl, P., et-al. Early Speech Perception and Later Language Development. isites.harvard.edu/fs/docs/icb.topic724278.files/03-24/Kuhl-et-al.-2005.pdf

SpeechPathology.com 60 Cincinnati Children's

Otitis Media – Speech Perception

Infants: Blinded study which measured discrimination of bu/gu

Results: found 3 groups

- Infants with OM on day of testing
- Infants with hx of OM but normal tymps day of testing
- Infants with normal tymps and no hx of OM

Polka L.., Rvachew, S., The impact of otitis media with effusion n infant phonetic perception *Infancy*. 8: 101-117. 2005

SpeechPathology.com 61 Cincinnati Children's

Otitis Media – Speech Perception

Obtained Hx and Tympanometry after testing:

Results:

- Best discrimination by infants with normal hearing on the day of testing and no Hx of OM
- Intermediate level: discrimination by infants w normal tymps on the day of testing & Hx of OM
- Poorest Discrimination by infants with OM on the day of testing

- Conclusion
- 1. OM negatively impacts phonemic perception after fluid is gone
- 2. Impact not due just to audibility-OM affects infant **attention** to speech over time

Polka L.., Rvachew, S., The impact of otitis media with effusion n infant phonetic perception *Infancy*. 8: 101-117. 2005

SpeechPathology.com 62 Cincinnati Children's

Speech and Language Development in children with Unilateral Hearing Loss

SpeechPathology.com 63 Cincinnati Children's

UHL effects on young children's language

- Limited research on language in young children who have UHL
- First words are usually on time 12.5 mos
- First Two word combinations are delayed by about 5 months to approximately 18 months
- Study: children in preschool had delayed language compared to NH peers (lieu 2010)
- Age of first word of children w UHL was not delayed (12.7mos), but onset of 2 word combinations was delayed (23.5 mos) by parent recall (Kiese-Himmel, C. Unilateral sensorineural hearing impairment in childhood: analysis of 31 consecutive cases. Int J Audiol, 41(1): 57-63, 202, [4b]
- 30% birth to 3 yrs with UHL demonstrated delays in communication/language, 2000-02 Colorado follow-up (Brown 2008)

SpeechPathology.com 64 Cincinnati Children's

UHL in Preschoolers

Speech Language Preschool

- MacArthur-Bates Communication Development Inventory administered to 11 children in this group in age range appropriate for this instrument. Mean @ 27th %Ptile expressive;

  15th %Ptile receptive; 17% group below 10thPtile on receptive
- 15 (15-62mos) 33% below age on language sample analysis: delays in syntactic development

- Yoshinga-Itano, C & Thomson, V. The work of the Village: creating a new world for children with hearing loss and their families. Int J of Audio, 47 Suppl 1:S14-22, 20008, [5]

Speech Language Preschool

(Yoshinaga-Itano 2008)

- Of 15 children (no other disabilities) in study: 27% demonstrated significant delays in language development, 7% borderline delays
- 47% of children had abnormal tympanograms, fluid, and/or tubes during study
- 50% Rt, 50% L, all had severe to profound UHL, all identified by 2 mos of age, used oral communication, parents educ, mid SES
- (Yoshinga-Itano, C & Thomson, V. The work of the Village: creating a new world for children with hearing loss and their families. Int J of Audio, 47 Suppl 1:S14-22, 20008, [5]

SpeechPathology.com 67 Cincinnati Children's

Speech Language Preschool

- Borg found that 4- and 5-year old children with UHL had delayed language development compared with their peers with NH. (Borg E, Risberg A, McAllister B, et al. Language development in hearing-impaired children. Establishment of a reference material for a 'Language test for hearing-impaired children', LATHIC. Int J Pediatr Otorhinolaryngol. 2002; 65(1):15–26. [PubMed: 12127218]
- Loss of binaural summation can interfere with incidental learning as background noise interferes with overheard speech. Effort locating sound may interfere with child's comprehension. **(Lieu, J. Unilateral hearing loss in children: speech-language and school performance. HHC Access. B-ENT. 2013; Suppl 21: 107-115**

SpeechPathology.com 68 Cincinnati Children's

School Age Language, Cognition, Academics, Social and Behavioral Issues

SpeechPathology.com 69 Cincinnati Children's

School Age Language Research

- Lieu compared 6-12 yr old children with UHL to their siblings on measure of language, academics achievement, and cognition: N 109 UHL, 96 NH sibs
- UHL children demonstrated poorer language and verbal IQ scores (OWLS, Weshler IQ and Achievement Tests)
- Had IEP's 3 times more often than NH siblings and required speech therapy 2 times as often
- Often academic issues did not improved over time.
- ((Lieu, J., Unilateral hearing loss in children: speech-language and school performance. HHS Public Access. *B-ENT*. 2013 ; Suppl 21107–115.

SpeechPathology.com 70 Cincinnati Children's

School Age Language Research (Lieu, J., Unilateral hearing loss in children: speech-language and school performance. HHS Public Access. *B-ENT*. 2013 ; Suppl 21)

- Lieu followed 46 UHL children longitudinally for 3 yrs:
- 75% had severe-profound HL
- UHL used 1st 2 word phrases later and had more head trauma than NH siblings
- 30 of 46 never tried an FM, 18 never tried HA and only 4 had tried a CROS
- Verbal IQ, Oral Expression increased significantly, was related to those with higher initial IQ's and having IEP.
- Academic delays continued in UHL but not in NH sibs

SpeechPathology.com 71 Cincinnati Children's

School Age Research

- UHL have high rates of grade failure (22–35%) and NH (3%) and others had educational support (12–41%). (Lieu JE. Speech-language and educational consequences of unilateral hearing loss in children. Arch Otolaryngol Head Neck Surg. 2004; 130(5):524–530. [PubMed: 15148171])
- Many states do **not recognize UHL as a qualifying disability for HI services**. The children who exhibit problems qualify as SpLg impaired, Behavioral or Learning disabled. (National Center for Hearing Assessment and Management. [Accessed May 4, 2009}. EDHI/UNHS Mandates. Summary Table 2008. Available at: http://www.infanthearing.orglegislative/summary/index.html
- 55% of children with UHL receive special services in school (McKay, S., Knightly, C., Marsh, R., Amann, C. & Gravel, J. (2007, December). *Perceived listening difficulties of children with unilateral hearing loss*. Poster session presented at the A Sound Foundation for Early Amplification conference, Chicago, Il)

SpeechPathology.com 72 Cincinnati Children's

Academics and Behavior Challenges

- In Lieu's 2014 study: UHL children were also compared to NH siblings on Child Behavior Check List (parent) Questionnaire (CBCL). UHL kids had more difficulty with school competency, attention and ADHD types problems than NH siblings.
- Brain connections and processing are different in kids with UHL. Some studies suggests that UHL affects phonological processing. (Tibbetts K, Ead B, Umansky A, et al. Interregional brain interactions in children with unilateral hearing loss. Otolaryngol Head Neck Surg. 2011; 144(4):602–611. [PubMed: 21493243])
- Lieu believes that working memory may also be slowed ((Lieu, J., Unilateral hearing loss in children: speech-language and school performance. HHS Public Access. *B-ENT*. 2013 ; Suppl 21)

SpeechPathology.com 73 Cincinnati Children's

Older children: Academics and Behavior Challenges

- Unfortunately, even after focused interventions such as discussed above, children with UHL often continue to have academic difficulties as they grow older
- Adolescents with UHL (20) demonstrated worse overall and expressive language scores than controls (NH 13), (98 vs. 114, P=0.001; 100 vs. 114, P=0.006) and had significantly lower full scale (98 vs. 112, P=0.017), verbal (101 vs. 113, P=0.032), and performance IQ (95 vs. 107, P=0.037)
- None wore HA's at the time of study, 25% had trial with FM and various UHL listening devices, 2 occasionally wore HA's

- Fischer, C., Lieu, J. Unilateral Hearing Loss is Associated with a Negative Effect on Language Scores in Adiolescents. Int J Fediatr Otorihniolaryngol. 2014 Oct: 78(10): 1611-1617. Published online 2014 12. Doi: 10.1016/j.ijport.201407.005

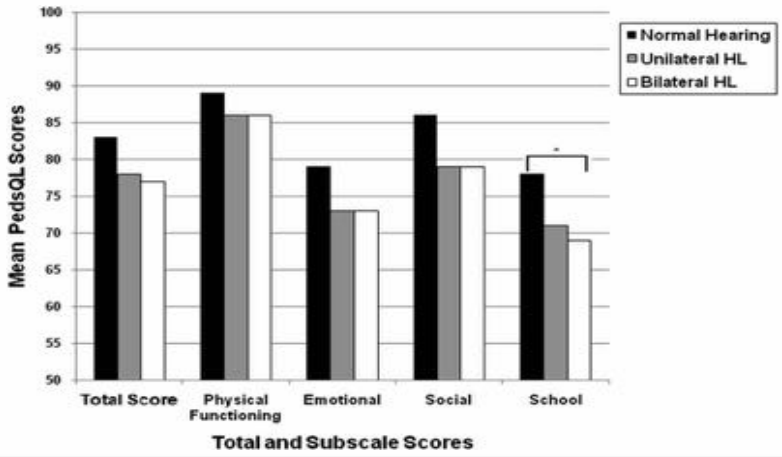
SpeechPathology.com 74 Cincinnati Children's

Academic and Behavior Challenges Hear QOL and Peds QOL

- Participants included 35 children with unilateral HL, 45 with bilateral HL, and 35 siblings with normal hearing
- Children ages 7 -12 with UHL completed the questionnaire about quality of life Peds QOL on situations about interactions with family and friends
- Results demonstrated 5/7 area evaluated were the same for UHL and BHL children on subscales of Physical Environment, Emotional, Social, School, Environments, but not on subscales of Activities and Feelings.
- Both UHL and BHL children were significantly different from those with NH (Umansky, A., Jeffe, D., Lieu, J.: The HEAR-QL: Quality of Life Questionnaire for Children with Hearing Loss. J Am Acad Audiol. 2011 Nov-Dec; 22(10): 644–653. doi: 10.3766/jaaa.22.10.

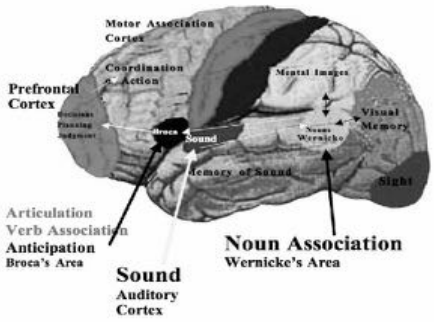
SpeechPathology.com 75 Cincinnati Children's

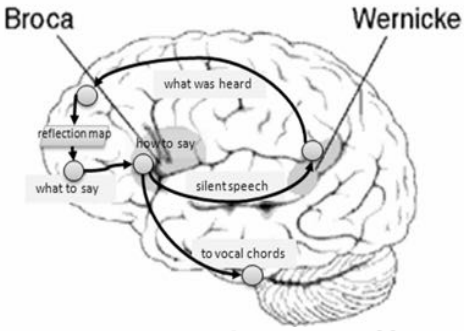
Differences in Pediatric Quality of Life Inventory™ (Peds QL™) mean scores among children with unilateral HL (n = 35), bilateral HL (n = 45), and normal hearing (n = 35). *Note*: HL = hearing loss. *p < 0.05 (Amy M. Umansky, et al 2011)



SpeechPathology.com 76 Cincinnati Children's

Cortical Issues





Hearing is a "Brain Thing"

SpeechPathology.com 77 Cincinnati Children's

Cortical Reorganization Issues

- The human brains continues to develop after birth
- Circuitry for processing with 2 ears is inborn and is functioning soon after hearing begins
- Matures in more than 10 years
- UHL/SSD/AHL result in significant cortical reorganization of the brain
- Normal "aural preference" for the opposite ear for processing speech and Language is disrupted
- (Gordon, K., Henkin, Y., Kral, A. Asymmetric Hearing Development: Aural Preference: Syndrome and Treatment Options. PEDIATRICS Vol. 136, July 2015

SpeechPathology.com 78 Cincinnati Children's

Cortical Reorganization Issues

- Schmithorst et al. suggested that if the scenario above happens in children (different than in adults), the development of spoken language can be permanently impacted. UHL, SSD, AHL in children changes the auditory cortex, but the impaired ear also affects the development of the vital cortical connections for optimal speech and language development, auditory processing, attention, executive function and speed of processing. (Schmithorst VJ, Plante E, Holland S. Unilateral deafness in children affects development of multi-modal modulationand default mode networks. Front Hum Neurosci. 2014;8:164)
- Resting state fcMRI identified differences in brain network interconnections between children with UHL and NH and can shed light into the educational and behavioral difficulties experienced by children with UHL (Umansky, A., Jeffe, D., Lieu, J.: The HEAR-QL: Quality of Life Questionnaire for Children with Hearing Loss. J Am Acad Audiol. 2011 Nov-Dec; 22(10): 644–653. doi: 10.3766/jaaa.22.10.

SpeechPathology.com 79 Cincinnati Children's

Cortical reorganizations issues

- Greater central auditory reorganization to the right hemisphere for children (ages 7-12) with left USNHL and to left hemisphere for right USNHL (Schmithorst, V.., Holland, S.., Ret, J., Duggins, A., Arjmand, E., Greinwald, J. . Cortical reorganization in children with unilateral sensorineural hearing loss. In Neuroreport 2005 Apr 4;16(5):463-7)
- This “aural preference syndrome” reorganizes the brain in many ways and delayed therapy further compromises the benefit of the dead or impaired ear resulting in slow progress in listening and speech language development.
- Early identification and intervention is crutial. This includes **early** appropriate, effective device fitting (hearing aids, BAHA, CROS and COCHLEAR IMPLANTS). ((Gordon, K., Henkin, Y., Kral, A. Asymmetric Hearing Development: Aural Preference: Syndrome and Treatment Options. PEDIATRICS Vol. 136, July 2015

SpeechPathology.com 80 Cincinnati Children's

Therapy: EARLY Listening, speech & language

- Gordon and others conclude that the effects of asymmetrical HL is greatly underrated. We need to abandon the minimalistic approach to UHL: 1 ear is sufficient
- Early identification and intervention is crutical. This includes **early** appropriate, effective device fitting (hearing aids, BAHA, CROS and **COCHLEAR IMPLANTS**).
- Early listening, speech and language services and parent training, strong preschool programs and school programs. Training in vocabulary, attention, cognitive activities, executive functioning should be included in therapy. (Gordon, K., Henkin, Y., Kral, A. Asymmetric Hearing Development: Aural Preference: Syndrome and Treatment Options. PEDIATRICS Vol. 136, July 2015

SpeechPathology.com 81 Cincinnati Children's

Cochlear Implants in pediatric SSD: an individual approach

- Results of CI surgery in young children with acquired or progressive SSD demonstrates benefits comparable to adults with SSD.
- On a study of 3 young children authors reported improvements in speech comprehension in noise and localization of sound following after CI surgery with no mention of speech and language. (Arndt, S., Prosse,S., Laszig, R., Wesarg, T., Aschendorff, A., Hassepass, F., Cochlear Implantation in Children with Single-Sided Deafness: Does Aetiology and Duration of Deafness Matter? Audiol Neurotol 2015;20(suppl 1):21–30 DOI: 10.1159/000380744)
- A study of 4 SSD children implanted at 17 mos, 4.5, 6.6 and 9 yrs showed children with congenital SSD children older than 4 were poorer performers on speech audiometry and sound localization than the youngest child who showed excellent benefit from CI. It was theorized that SSD congenitally deaf children may need CI intervention before the age of 4 years (Tavora-Vieira, D., Rahan, G. Cochlear implantation in children with congenital and noncongenital unilateral deafness: case series. Otol Neurotol.: 2015, Feb: 36(2):235-9. Doi: 10.1097/MAO.0000000000000771)

SpeechPathology.com 82 Cincinnati Children's

Case Studies

- Children with Asymmetric Hearing Loss
- Different levels in each ear
- Sometimes are aidable
- HA can cause distortion, so not aidable
- Help parents observe listening skills
- Work with the audiologist and share your observations

SpeechPathology.com 83 Cincinnati Children's

CI in SSD considerations Scott, M CCHMC

- Cochlear Implants in SSD
  - Only option that actually delivers sound to impaired auditory pathway
  - May be considered when cochlea is completely formed and auditory nerve is intact
  - Very much etiology dependent
  - Success also very much depends on age at implant

SpeechPathology.com 84 Cincinnati Children's

Consideration: CI in SSD

Scott, M CCHMC

12 months through 2 years of age
Profound, bilateral sensorineural hearing loss (>90 dBHL)
Use of appropriately fitted hearing aids for at least 6 months in children 2-17 years of age, or at least 3 months in children 12-23 months
Little or no benefit from appropriately fitted hearing aids.
Lack of progress in development of auditory skills with HA or other amplification (3 – 6 months of HA use, consistent speech/listening therapy)
High motivation and realistic expectations from family
No medical/surgical contraindications

SpeechPathology.com 85 Cincinnati Children's

Listening, speech, language therapy: Infants, Toddlers and Preschoolers

- Parent education regarding their child's challenges to hearing, listening, developing speech & language, behavior, adapting home environments, and audiologic management - Otitis Media
- Teach parents techniques to help enhance speech and language development: Remember normal infant's speech perception,
- Help parents develop observational techniques to notice subtleties in child's listening behavior

SpeechPathology.com 86 Cincinnati Children's

Listening, speech, language therapy: Infants, Toddlers and Preschoolers

- Develop speech and language protocols to monitor development of sounds, prelang skills, language skills – MCDI: WG, WS, Rossetti
- Complete diagnostic protocols every 6 months: preverbal communication, semantics, syntax, morphology, speech, and pragmatics. Take and analyse language samples (SALT)
- Track development of listening and attention skills with HI specialist available

SpeechPathology.com 87 Cincinnati Children's

Listening, speech, language therapy: Infants, Toddlers and Preschoolers

- Audiologist monitor HL and device, monitor frequently. Progressive hearing loss is very possible.
- Work with audiologist and Aural rehab audiologist. Some audiologist use the minimalistic approach, share with them your functional listening observations
- Develop and use questionnaires to assess functional listening: ELF, ABEL, Little Ears, McKay's

SpeechPathology.com 88 Cincinnati Children's

Listening, speech, language therapy: Infants, Toddlers and Preschoolers

- Frequent medical follow up: monitor OME, Progressive hearing loss
- Complete assessment by interdisciplinary team: Hg, vision, splg, cog, beh, medical,
- Complete Hx, at risk for multiple problems
- Guide parents to tech their child from the beginning that to advocate for themselves and place themselves for their best listening advantage

SpeechPathology.com 89 Cincinnati Children's

Listening, speech, language therapy: Infants, Toddlers and Preschoolers

- Parent Techniques
- Target rich vocabulary development, talk about objects in different ways (recast), books etc. Vocabulary can be an area of delay in UHL as vicarious learning can be limited in noisy environments
- Teacher education on UHL issues and what to watch for and adapt the classroom and use of devices and placement of child as recommended by the audiologist
- Questionnaires to monitor listening and behavior in the classroom

SpeechPathology.com 90 Cincinnati Children's

Listening, speech, language therapy: Infants, Toddlers and Preschoolers

- Get child's attention, make eye contact, follow their eyes, talk near good ear, adapt environment, make voice louder
- Supersegmentals; salient vowel preferences and visual speech stimulus
- Provide other visual cues: gestures, objects, later pictures
- Follow child's lead, follow child's eyes, here and now, daily routines, language dev techniques etc

SpeechPathology.com 91 Cincinnati Children's

Preschool & School Age Goals

- Imitation, comprehension, production (contrasted, MLS)
  - Single words
  - Two-word utterances
  - Subject + Verb + Object structure
  - Add descriptors
  - Prepositional phrases
  - Subject + Verb + Object + Prepositional phrases
  - Grammatical morphemes (is, am, s, :s, -ing, -ed)
    - Appending more difficult that stand alone *
  - Experiences to provide meaning

Ruder, C. C. (2004). Grammatical morpheme development in young cochlear implant users. *International Congress Series*, 1273, 320–323

Boons T., De Raeve, L., Langereis, M., Peeraer, L., Wouters, J., van Wieringen, A. (2013). Expressive vocabulary, morphology, syntax and narrative skills in profoundly deaf children after early cochlear implantation. *Research in Developmental Disabilities, 34(8)*, 2008-2022.

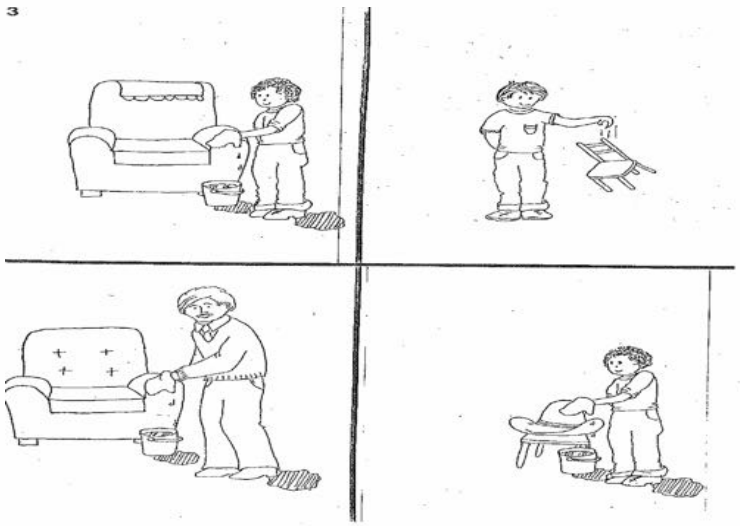
SpeechPathology.com 92 Cincinnati Children's

Subject-Verb-Object Matrix

	TOUCH CAR	KICK BALL	WASH CHAIR	DROP HAT	PULL TRUCK
BOY	T 1	T 2	T 3	T 4	T 5
GIRL	T 6				
MAN	T 7				
LADY	T 8				
DOCTOR	T 9				

Bunce, B, Ruder, K, Ruder, C. (1985). Using The Miniature Linguistic System in Teaching Syntax: Two Case Studies.. *Journal of Speech and Hearing Disorders,* 50, 247-253

SpeechPathology.com 93 Cincinnati Children's



SpeechPathology.com 94 Cincinnati Children's

Time for Discussion

.

SpeechPathology.com 95 Cincinnati Children's

Appendices

SpeechPathology.com 96 Cincinnati Children's

1. References: Audiology: UHL, SSD, AHL

- http://cochlea.purzuit.com/
- http://www.healthyhearing.com/report/40535-Heart-disease-hearing-loss
- (http://pedsinreview.aappublications.org/content/35/11/4 -56
- http://hearinghealthmatters.org/waynesworld/files/2015/03/Binaural-Squelch-2.jpg
- http://findarticles.com/p/articles/mi_m0816/is_8_21/ai_n13676520/
- http://www.audiology.org/news/binaural-loudness-summation
- http://www.certestechnologies.com/wp-content/uploads/2016/10/classroom-hearing-1.jpg

- http://www.open.edu/openlearn/ocw/pluginfile.php/67780/mod_oucontent/oucontent/492/2729608a/caa48a7d/sd329_1_027i.jpg
- https://www.researchgate.net/profile/Liang_Sun6/publication/276473132/figure/fig1/AS:302616455204864@1449160793211/Figure-12-Interaural-Time-Difference-ITD-and-Interaural-Level-Difference-ILD.png
- www.successforkidswithhearingloss.com
- www.phonak.com
- Adopted by the July 2005 National Workshop on Mild and Unilateral Hearing Loss (sponsored by CDC and EDHI). Ear Hear 2000, Int'l Journal Pediatric Otorhinolarygnology1994
- Haffey T, Fowler N, Anne S. Evaluation of unilateral sensorineural hearing loss in the pediatric patient. Int J Pediatr Otorhinolaryngol. 2013;77(6):955–958.)
- Kiese-Himmel, C. Unilateral sensorineural hearing impairment in childhood: analysis of 31 consecutive cases. Int J Audiol, 41(1): 57-63, 202, [4b]
- Sharma, A.,Glick., Campbell, J., Torres, J., Dorman, M. Zeitler, D.; Otology & Neurotology: February 2016 - Volume 37 - Issue 2 - p e26–e34. doi: 10.1097/MAO.0000000000000904. Nashville CI Papers
- Wollet Ann Marie. Singling Out Single Sided Deafness ppt. Presentation at Cincinnati Children's Hospital Medical CCenter, (April, 2013).
- Yoshinga-Itano, C & Thomson, V. The work of the Village: creating a new world for children with hearing loss and their families. Int J of Audio, 47 Suppl 1:S14-22, 20008, [5]

2. References: Speech Pathology

Baker, B., Newman, R. Listen to your mother! The role of talker familiarity in infant streaming. Cognition, B 45-B53. 2004

Fischer, C., Lieu, J. Unilateral Hearing Loss is Associated with a Negative Effect on Language Scores in Adiolescents. Int J Fediatr Otorihniolaryngol. 2014 Oct: 78(10): 1611-1617. Published online 2014 12. Doi: 10.1016/j.ijport.201407.005

Gordon, K., Henkin, Y., Kral, A. Asymmetric Hearing Development: Aural Preference: Syndrome and Treatment Options. PEDIATRICS Vol. 136, July 2015

Hollich, G., Newman, R. Jusczyk, Infants' Use of Synchronized Vicual Information to Separate Streams of speech. Child Language Development. 76, 1-16 May, 2005) onlinelibrary.wiley.com/doi/10.1111/j.1467-8624.2005.00866.x/abstract

Kiese-Himmel, C. Unilateral sensorineural hearing impairment in childhood: analysis of 31 consecutive cases. Int J Audiol, 41(1): 57-63, 202, [4b]

Kuhl, P., Ramariz, Rey., Bosseler, A., Lin, J., & Imada, T. Infants' brain responses to speech suggest Analysis by Synthesis. vol. 111 no. 31. 2014 11238 11245, doi:10.1073/pnas.1410963111

SpeechPathology.com 99 Cincinnati Children's

Kuhl, P., et-al. Early Speech Perception and Later Language Development. isites.harvard.edu/fs/docs/icb.topic724278.files/03-24/Kuhl-et-al.-2005.pdf

Lieu, J. Unilateral hearing loss in children: speech-language and school performance. HHC Access. B-ENT. 2013; Suppl 21: 107-115(National Center for Hearing Assessment and Management. [Accessed May 4, 2009}. EDHI/UNHS Mandates. Summary Table 2008. Available at: http://www.infanthearing.orglegislative/summary/index.html

Lieu, J., Unilateral hearing loss in children: speech-language and school performance. HHS Public Access. *B-ENT*. 2013 ; Suppl 21: 107–115.

National Center for Hearing Assessment and Management. [Accessed May 4, 2009}. EDHI/UNHS Mandates. Summary Table 2008. Available at: http://www.infanthearing.orglegislative/summary/index.html

Newman, R. The Cocktail Effect revisited. Listening to one's own voice in noise. Dev Psychology: 41, 352-362. 2005

Newman, R., Jusczyk, P. The Cocktail part effect in infants. Perception & Psychophysics. August 1996, Volume 58, Issue 8, pp 1145–1156)

SpeechPathology.com 100 Cincinnati Children's

- Nozza, R., Miller, S. Infant Speech-sound discrimination in noise. J. Acoustic Society of America. 87(1):339-50. February, 2011
- Polke, L & Bohn,O. (2003). Asymmetries in Vowel Perception. Speech Communication – 41-221-223.
- Polka L.., Rvachew, S., The impact of otitis media with effusion in infant phonetic perception *Infancy*. 8: 101-117. 2005
- Polka, L., Rvachew, S., Molnar, M. Speech Perception by 6- to 8-Month-Olds in the Presence of Distracting Sounds. Infancy. Sep/Oct2008, Vol. 13 Issue 5, p421-439. 19p. 1)
- Schmithorst, V.J., Holland, S.K., Ret, J., Duggins, A., Arjmand, E., Greinwald, J. Cortical reorganization in children with unilateral sensorineural hearing loss. In Neuroreport 2005 Apr 4;16(5):463-7
- Schmithorst VJ, Plante E, Holland S. Unilateral deafness in children affects development of multi-modal modulationand default mode networks. Front Hum Neurosci. 2014; 8:164)

- Sharma, A; Glick, H., Campbell, J., Torres, J., Dorman, M., Zeitler, D.: Otology & Neurotology: February 2016 - Volume 37 - Issue 2 - p e26–e34doi: 10.1097/MAO.0000000000000904. Nashville CI Papers
- Tibbetts K, Ead B, Umansky A, et al. Interregional brain interactions in children with unilateral hearing loss. Otolaryngol Head Neck Surg. 2011; 144(4):602–611. [PubMed: 21493243]
- Umansky, A., Jeffe, D., Lieu, J.: The HEAR-QL: Quality of Life Questionnaire for Children with Hearing Loss. J Am Acad Audiol. 2011 Nov-Dec; 22(10): 644–653. doi: 10.3766/jaaa.22.10.
- (Umansky, A., Jeffe, D., Lieu, J.: The HEAR-QL: Quality of Life Questionnaire for Children with Hearing Loss. J Am Acad Audiol. 2011 Nov-Dec; 22(10): 644–653. doi: 10.3766/jaaa.22.10.
- Werker, J., Currin, S. (2005). PRIMIR: A developmental framework of speech processing. Language, Learning and Development. 1 (2) 197-234.
- Yoshinga-Itano, C & Thomson, V. The work of the Village: creating a new world for children with hearing loss and their families. Int J of Audio, 47 Suppl 1:S14-22, 2008, [5]

Appendix 3

Language Strategies for Parents
Birth to Three
Preschool Age

You are welcome to share these handouts with parents

Language Strategies: 0-6 months

- Keep baby's face close when talking
- Direct eye contact with baby's eyes (follow baby's eyes)
- Silly sounds with lots of facial expressions
- Vary inflection
- Imitate baby's sounds
- Talk about activities: feeding, changing, bathing
- Use baby's name
- Name objects
- Sing to the baby
- Use simple signs
- Minimize background noise and talk closer to good ear
- Let baby watch your face

Language Strategies: 6-12 months

- Speak close to baby's face
- Eye level
- Minimize background noise and talk closer to good ear
- Talk about what's happening
  - Things baby is doing, seeing, hearing, touching, feeling, tasting
- Name objects/actions
- Repetition
- Narrate daily routines
- Short sentences
- Variation in voice

SpeechPathology.com 105 Cincinnati Children's

Language Strategies: 6-12 months

- Stress important words
  - "You want UP"
  - "Here's MORE cereal"
  - "Ball. Here comes the BALL"
- Encourage vocalization
- Inflection – make voice interesting
- Use simple signs
- Look at books and help child point to pictures that you name
- Investigate sounds: running water, toys that make music or loud noises, telephone ringing, dog barking

SpeechPathology.com 106 Cincinnati Children's

Language Strategies: 6-12 months

- Take turns making sounds
  - Pause with expectant face
  - Wait for baby to make sounds
  - When baby stops, reinforce their productions by imitating the infant's sounds
  - Smile/be pleased when infant uses voice
- Respond to baby's movements, gestures, and facial expressions to reinforce early attempts at communication

SpeechPathology.com 107 Cincinnati Children's

Language Strategies: 1-3 years

- Get child's attention
- Get of child's level (follow child's eye, follow child's lead)
- Talk about the here and now
- Label objects and actions repeatedly
- Pause so the child can imitate
- Talk about what the child is doing: parallel talk
- Talk about what you are doing: self talk
- Imitate and then expand on what the child says
- Model answers by providing choices when asked a question ("do you want a cookie or cracker"; "truck or ball"; "doll or bottle")

SpeechPathology.com 108 Cincinnati Children's

Language Strategies: 1-3 years

- Bring objects near your mouth to increase awareness of speech reading cues and encourage eyes contact, especially in situations with **noise**
- Use sign for clarification and further language development
- Encourage requesting - place desired items out of reach
- Make meaningful responses to child's utterances
- Ask child meaningful questions and open ended questions
- Require child's language to be at appropriate levels of production
- Look at books
  - Predictable books
  - Label objects and actions
  - Let child "read"/fill in familiar parts
  - Goal: 10 books per day

SpeechPathology.com 109 Cincinnati Children's

Expand your Expertise with "Speech Tools"

"Speech Tools" will be delivered to you monthly from the speech-language pathology experts at Cincinnati Children's.

Sign up below:
https://www.cincinnatichildrens.org/service/s/speech/hcp/newsletter

SpeechPathology.com 110 Cincinnati Children's