



Vanderbilt Bill Wilkerson Center for Otolaryngology & Communication Sciences

Minimal Hearing Loss in Children: Possibilities and Limitations of Diagnostics and Hearing Aid Fittings

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Phonak Pediatric Amplification Conference
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Current Definitions of Minimal Hearing Loss

- Permanent mild bilateral HL = PTA at 0.5, 1.0, 2.0 kHz between 20 & 40 dB HL
- Permanent high frequency HL = PT thresholds > 25 dB HL at two or more frequencies above 2.0 kHz
- Permanent unilateral HL = PTA at 0.5, 1.0, 2.0 kHz \geq 20 dB or PT thresholds > 25 dB HL at two or more frequencies above 2 kHz in the affected ear

(Bess et al., 1998)



Unilateral Sensorineural Hearing Loss



Prevalence of UHL

~ 1/1000 in the newborn period (Prieve et al., 2000) and
~3/100 in the school-age population (Bess et al., 1998)





Possible Explanations for Change in Prevalence (from birth to school age)

- Progressive or late onset hearing loss
- Low follow-up rates in NBHS programs may be underestimating true prevalence (less assertive follow up for UHL)



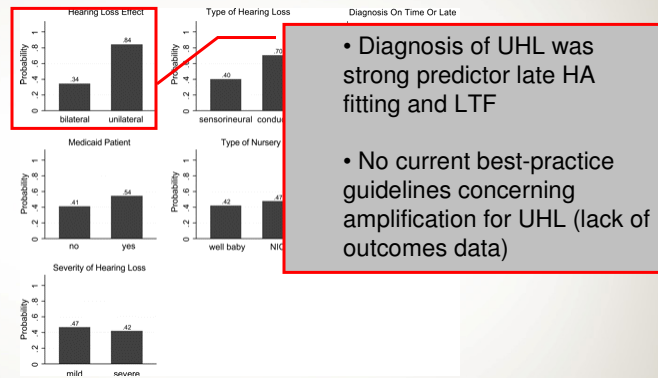
Follow up Concerns: Unilateral to Bilateral HL

- Some unilateral losses prove to be progressive
 - Cytomegalovirus (CMV)
 - Enlarged vestibular aqueduct (EVA)
 - Hereditary progressive loss
 - Unknown causes

(Neault, 2005)

Newborn Hearing Screening Follow-Up: Factors Affecting Hearing Aid Fitting by 6 Months of Age

L. Spivak, H. Sokol, C. Auerback, S. Gershkovich; *American J of Audiology*, 18:24-33 (2009)



- Diagnosis of UHL was strong predictor late HA fitting and LTF

- No current best-practice guidelines concerning amplification for UHL (lack of outcomes data)

Figure 1 The effect of each of the seven factors on the probability of loss to follow-up. Probability of loss to follow-up is significantly increased if infants have unilateral hearing loss, coverage by Medicaid, conductive hearing loss, or late diagnosis.

Follow up Concerns: Unilateral to Bilateral HL

- Of 159 unilateral refers who were found to have HL, 64% had UHL and 36% had bilateral HL
- Two groups who move from UHL to BHL:
 - Those who had BHL at time of screening
 - Those who had UHL at time of screening but develop BHL later

(Neault, 2005)



CT Scan Findings in UHL:

- Of 18 children with unilateral sensorineural hearing loss (mild to profound) who underwent CT scans of the temporal bone, 8 (45%) had abnormal findings, including:
 - Enlarged vestibular aqueduct
 - Mondini deformity
 - Cochlear hypoplasia
 - Dysplastic vestibule and semicircular canals

The CT scan findings were abnormal **BILATERALLY** in 5 of the 8 children

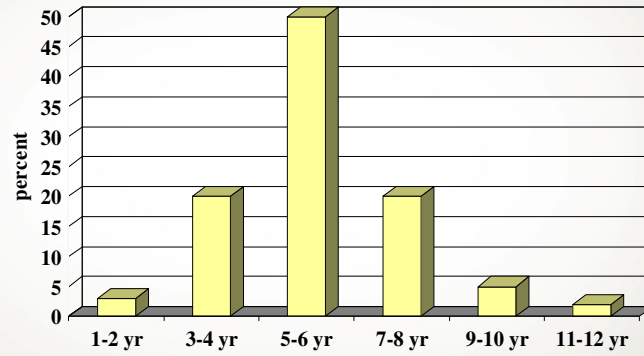
(Licameli, Robson & Kenna, Children's Hospital Boston)



Academic, Social, & Behavioral Outcomes

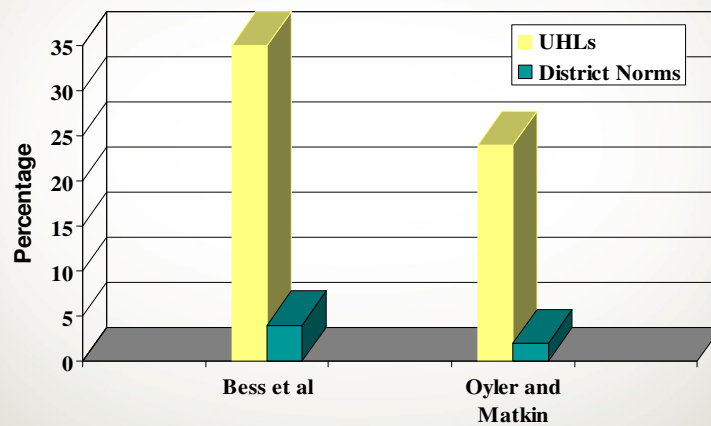


Age of Identification: UHL



Bess & Tharpe, 1986

Percent Failing at Least One Grade: UHL

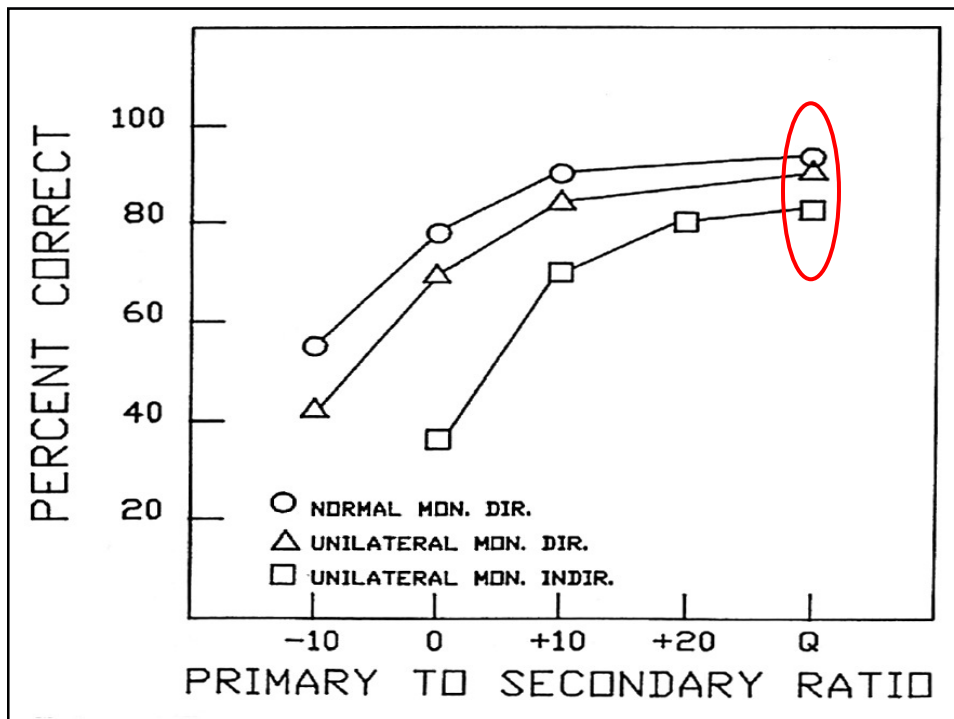
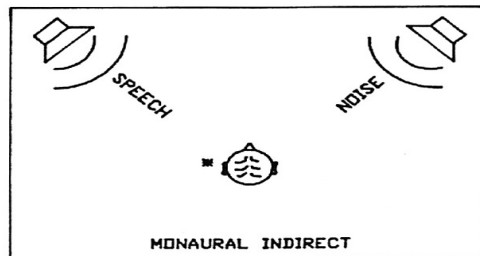
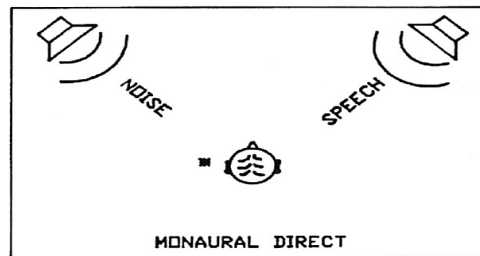


Studies of Unilateral Hearing Loss

Investigation	Failed (1 or more grades)	Resource Help (1 or more years)	Combined (failed and/or resource help)
Bess (1986)	35%	13.3	48.3%
Oyler (1987)	27.3%	40.7	68.0%
Jensen (1988)	18.0%	36.0%	54.0%
Bovo et al (1988)	22.0%	12%	34%
Martini (1988)	25.0%	?	?
Wautier-Launey et al (1988)	40.4%	?	?
English & Church (1990)	?	54%	?

Yoshinaga-Itano et al., (2008) Sems in Hearing, 29:196-211

- 15 children with early onset permanent UHL
- Between 15-62 months
- 27% had significant language delays



Use of Vision in Deaf Individuals

- Speech reading
- Sign language
- Monitoring environment



Sladen, D.P., Tharpe, A.M., Ashmead, D.H., Grantham, D.W., & Chun, M. (*JSHLR*, 2006). Visual attention in deaf and normal hearing adults: Effects of stimulus compatibility

- Used the Erikson Flanker Task to assess visual skills in deaf and normal hearing adults
- Requires participant to make judgment about a target stimulus in a fixed location when flanked by similar or dissimilar elements

Flanker task: Identify the target letter, N or H

Compatible

Incompatible

0.05

HHHHH

NNHNN

1.0

HHHHH

NNHNN

3.0

HHHHH

NNHNN

30 trials per condition

Flanker task: Identify the target letter, N or H

Compatible

Incompatible

Near

HH■HH

HH■HH

Far

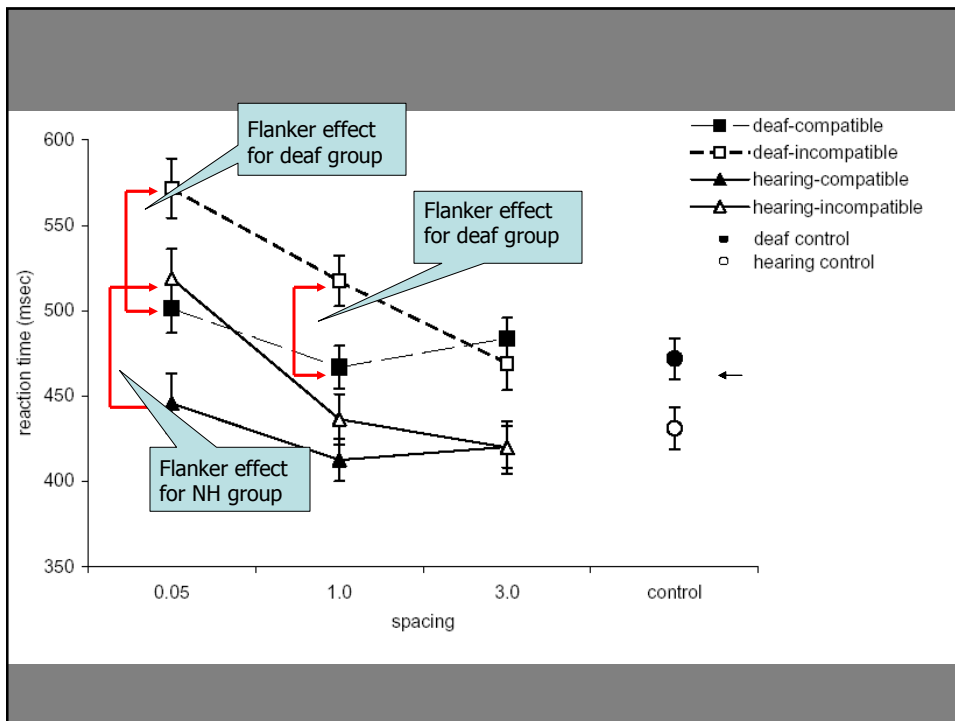
HH■HH

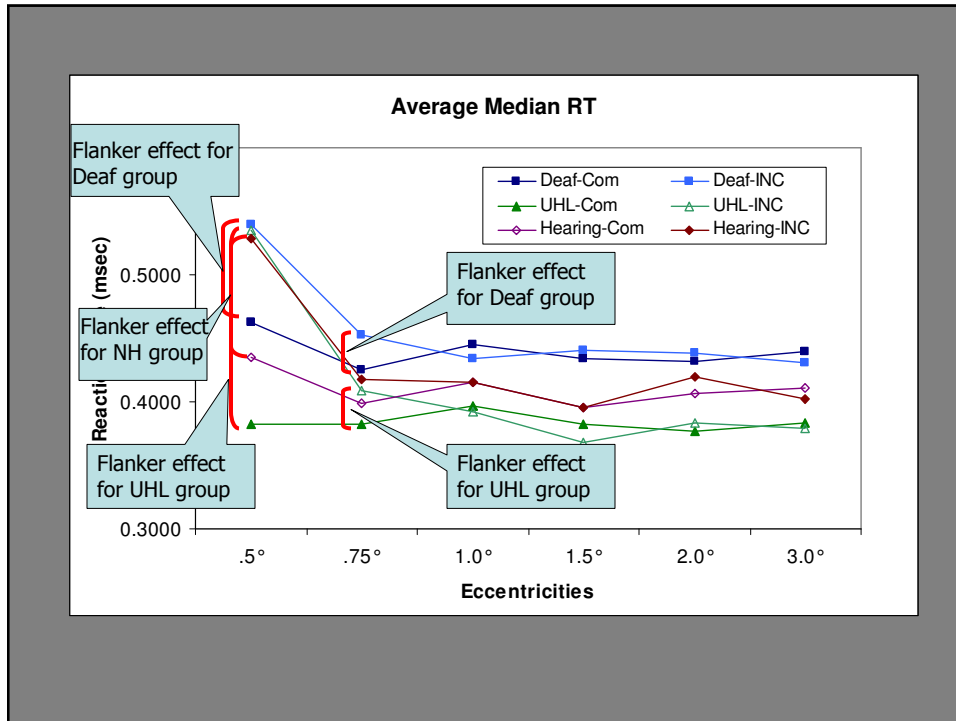
HH■HH



Flanker Task Study

- Deaf Group (N=10)
 - Mean age = 29.7 (18-45 years)
 - PTA > 80 dB HL bilaterally
 - Sign language was primary communication modality
- Hearing Group (N=10)
 - Mean age = 29.9 (18-45 years)
 - Hearing thresholds < 20 dB HL (500-4KHz) bilaterally
 - Not experienced sign language communicators





Possible implications...

- Allocation of visual resources over a greater area?
(consistent with Proksch & Bavalier, 2002)
- Can this contribute to distractibility or other attentional factors?

Bilateral Minimal Hearing Loss



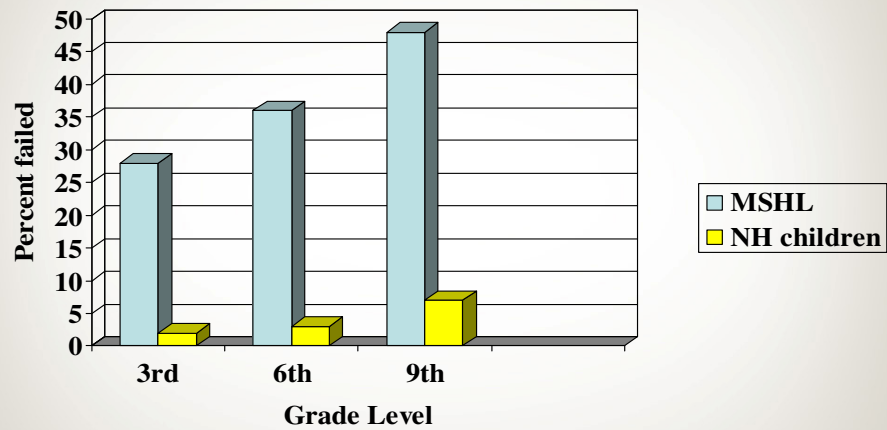
Hearing Loss in School-Age Children (3rd, 6th, & 9th grades; N=1218)

(Bess et al., 1998)

HL Category	N	Percent
BSNHL	12	1.0
HFSNHL	17	1.4
Minimal losses = 8.8 % !!!		3.0
CONDHL	41	3.4
OTHER	30	2.5
TOTAL	139	11.3



Failure Rates of Children with MSHL & with NH (Bess et al., 1998)



COOP CHARTS






- Screening tool for functional health
- Developed at Dartmouth
- Ten different charts

DOMAINS USED IN COOP CHARTS

- Emotional feelings
- School work
- Social support
- Stress
- Family
- Self esteem
- Behavior
- Energy
- Getting along with others
- Overall Health











STRESS

During the past month, how much stress or pressure did you feel from other people? (family, friends, teachers, other grown-ups or other kids)

1	None	
2	A little	
3	Some	
4	Quite a bit	
5	A lot	

SCHOOL WORK

During the last month you were in school, how did you do?

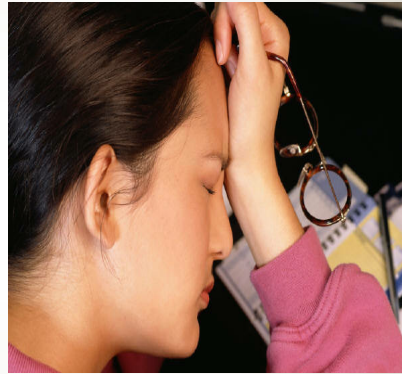
I did very well		
I did as well as I could		
I could have done <u>a little</u> better		
I could have done <u>much</u> better		
I did poorly		

COOP Results:

- For 6th graders -
 - scores were higher (more dysfunction) for MSHL group in 9 of 10 domains
 - Significant difference found on energy domain
- For 9th graders –
 - Scores were higher for MSHL group in 9 of 10 domains
 - Significant differences found on stress and behavior domains

Listening Effort

Effort = the exertion of physical or mental power



Dual-Task Paradigm (Effort)

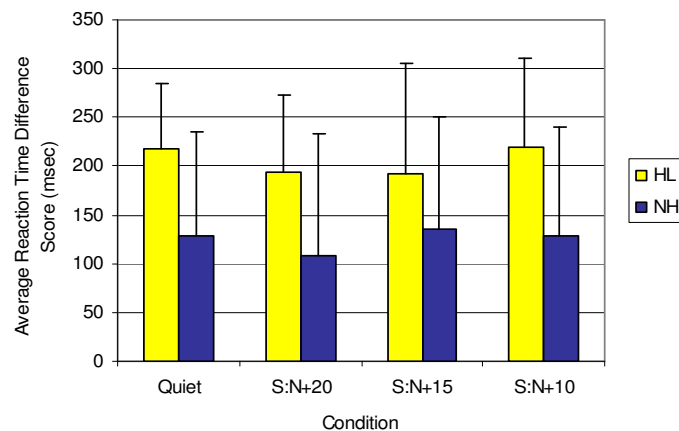
- Subjects
 - 14 children with mild or HF HL matched with NH children for grade level
 - Ages between 6 – 11 years

(Bourland-Hicks & Tharpe, 2002)

Dual-Task Paradigm

- Primary task: speech recognition in noise (PBK)
- Secondary task: button push to random presentations of probe light
- Reaction times were calculated for button push

Dual Task Paradigm

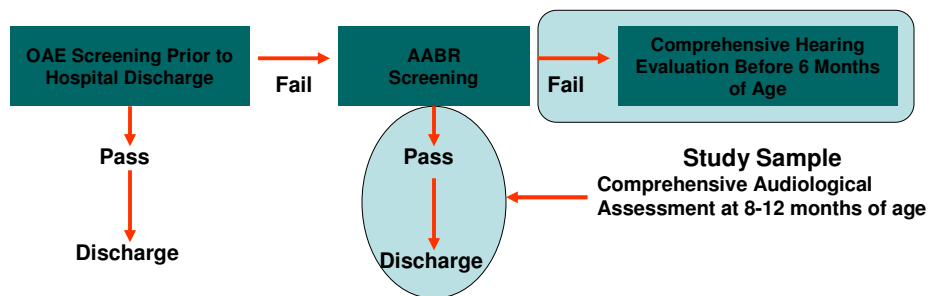


No difference in baseline RTs between groups

Johnson et al., Pediatrics 2005

- Multi-Center study (7 centers screened 86,634 babies)
- Purpose: To determine estimate of children who pass UNHS when hearing loss is present
- Design: Follow-up children at 9 mos. of age who failed OAE, but passed A-ABR in 2-stage UNHS programs

Does a 2-stage (OAE/AABR) newborn hearing screening protocol miss babies with mild hearing loss?



Johnson et al., 2005

Conclusions:

- ~23% of all infants with PHL \geq 25 dB will not be identified by a 2-stage screen
- The majority of those not identified will have mild hearing loss (>70% in this study)
- Not known what proportion of PHL was congenital vs. late-onset
- A-ABR equipment was designed to identify moderate or greater bilateral HL

Audiological Management of Children with UHL & MHL





Hearing Technology Options for UHL & MBHL

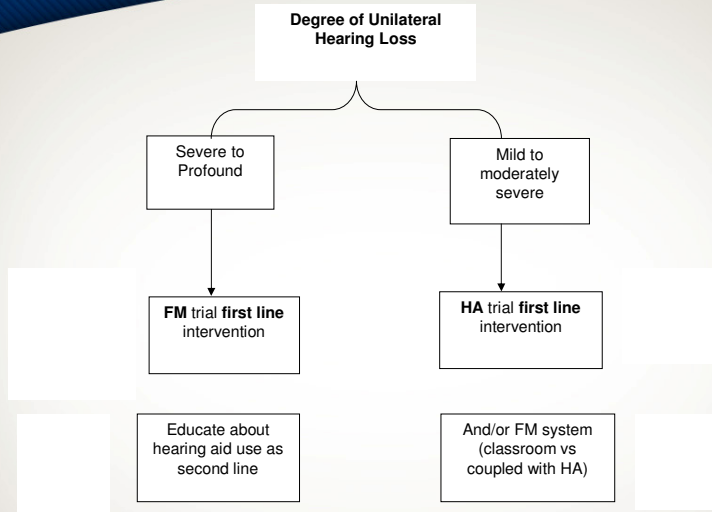
- Traditional hearing aids
- Contralateral Routing of Signal (CROS) hearing aids
- Frequency modulated (FM) systems



Traditional Hearing Aids for UHL

- Unaidable hearing
 - Profound SNHL
 - Very poor word recognition
 - Marked intolerance for amplified sounds

(Valente et al., 2002)



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Traditional Hearing Aids for UHL

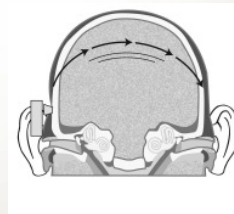
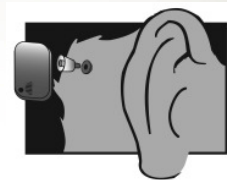
- Binaural interference - decrease in bilateral performance when an individual is receiving asymmetric auditory input (Jerger et al, 1993)
- Evidence of BI for adults, but not children, when listening to asymmetrically degraded speech (Rothpletz et al, 2004)
- No binaural advantage when listening to asymmetrically-degraded speech (Rothpletz et al, 2004)

CROS HAs for UHL

- CROS HAs are considered for those ineligible for other technology
- CROS HAs are not recommended for consideration until child is able to control his/her communication environment (AAA, 2003; Kenworthy et al., 1990)
- Useful for children who do not have access to FM or need assistance outside of school

Transcranial CROS Aids

- Quasi-transcranial – high level AC signal creates vibration of skull to stimulate opposite ear
- True transcranial – BC signal is transmitted from poor ear to opposite normal cochlea (eg, BAHA)
- BAHA can be considered at age 5 years and above; however, data from the pediatric population are lacking (AAA, 2003)





Traditional HAs for Infants & Young Children with MBHL

- Will have large RECDs leaving only a few dB recommended gain across frequencies
- Consider acoustic modifications, shorter speaker-listener distance, and increased voice volume
- Counsel regarding need for amplification as RECD decreases
- Consider noise floor of HAs – typically not heard by those with greater degrees of HL



When to fit minimal losses?

Babies are usually at a close distance to the caregiver allowing for an optimal signal-to-noise ratio





After 12 months, they venture off...



FM Fitting with MBHL or UHL: The Problem

- Need for enhanced signal from teacher
- Need for communication with fellow students
 - Classroom discussions
 - Question/answer sessions
 - Other group or social interactions



Study Design

- Equipment
 - Phonak MicroEar
 - Sound delivery options
 - Skeleton mold
 - Open mold
 - Configuration
 - monaural fitting
 - bilateral fitting



(Tharpe, Ricketts, Sladen, 2004)

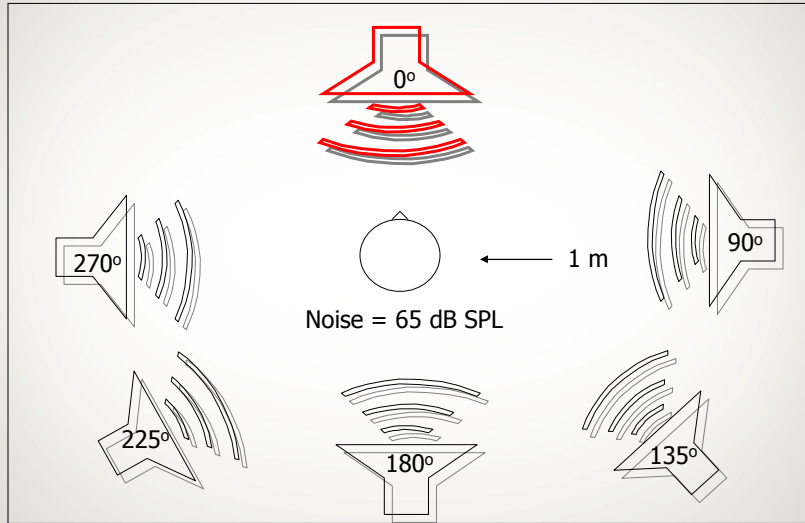


Study Design

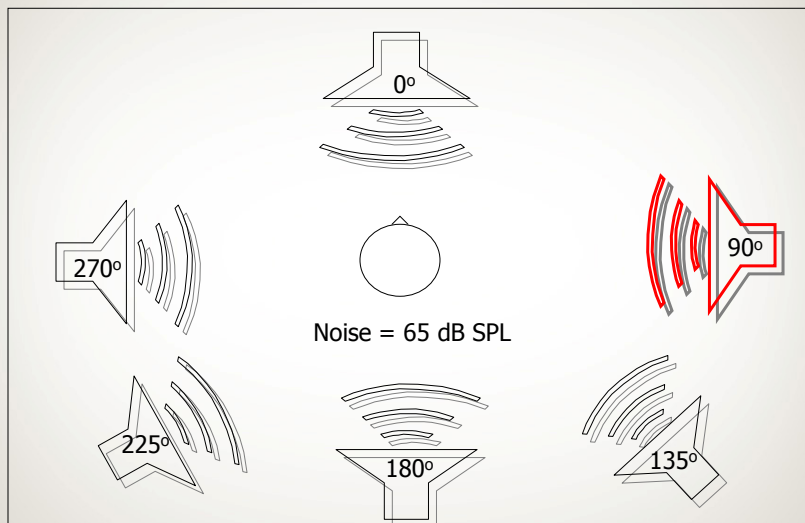
- Schedule
 - baseline testing
 - 2 week acclimatization with each device followed by testing
 - Total of 6 weeks

(Tharpe, Ricketts, Sladen, 2004)

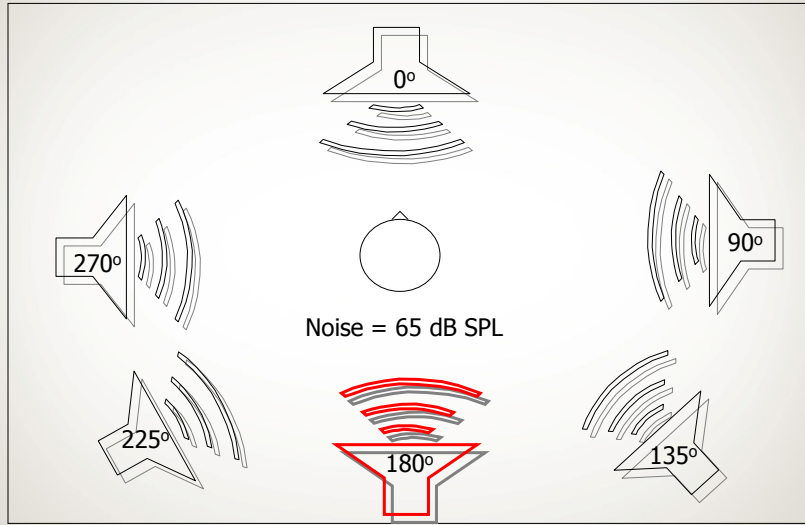
Loudspeaker Placement



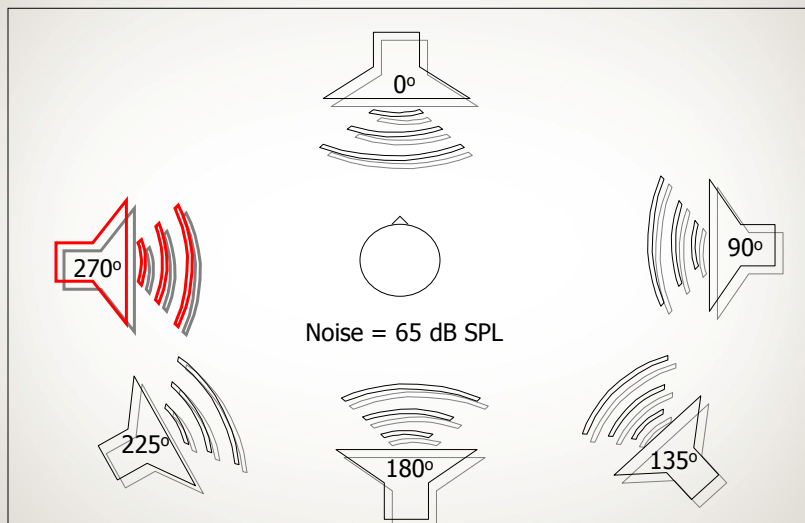
Loudspeaker Placement



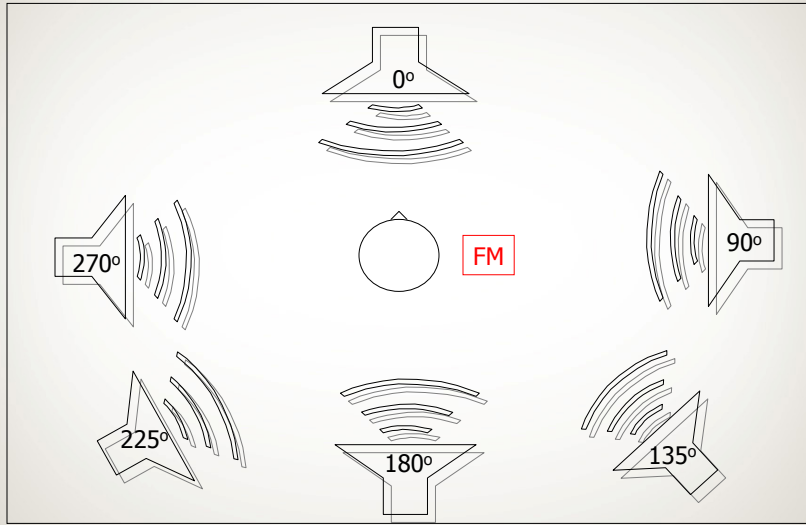
Loudspeaker Placement



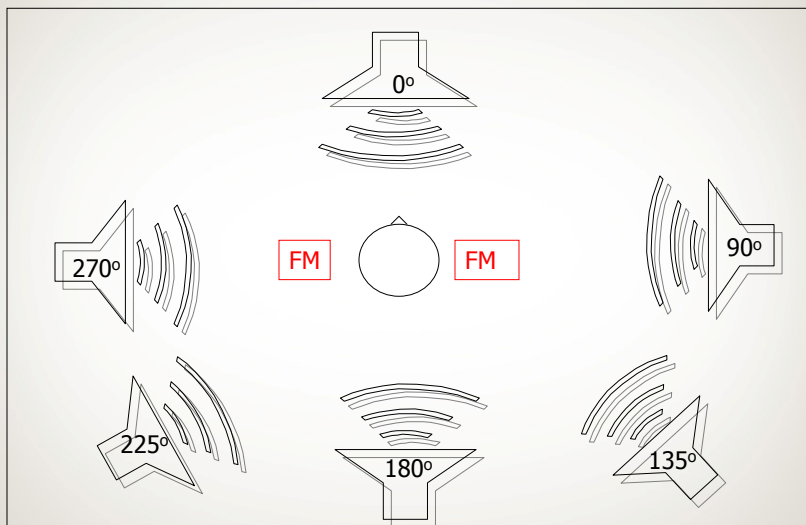
Loudspeaker Placement



Loudspeaker Placement

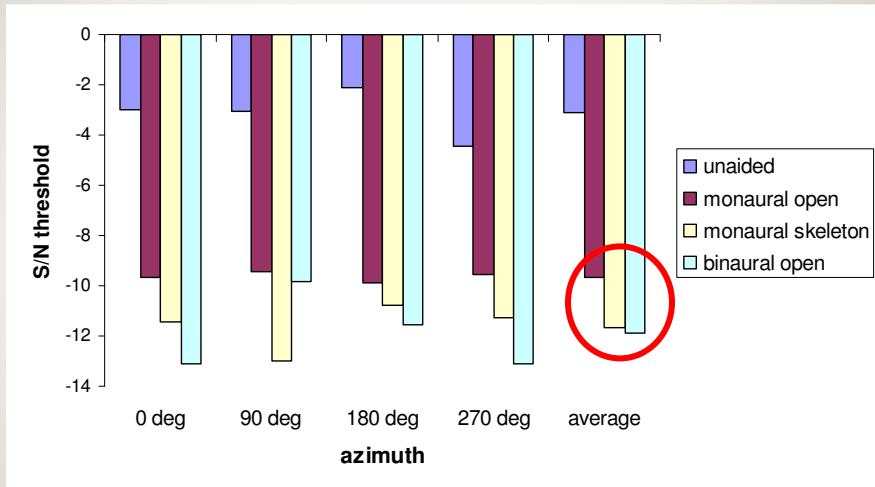


Loudspeaker Placement





HINT Results



(Tharpe, Ricketts, Sladen, 2004)



Summary of HINT Results:

- Significant improvement in FM vs. No-FM condition
- No effect of “teacher” location
- On average, 2 dB advantage with skeleton vs. open EM in monaural condition
- On average, 2.2 dB binaural advantage

(Tharpe, Ricketts, Sladen, 2004)

Centers for Disease Control & Prevention Workshop Proceedings (2005)

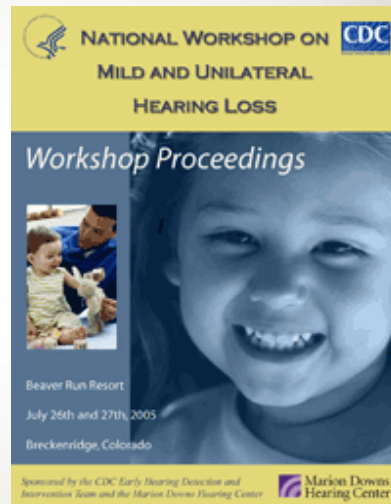
Summarizes

- presentations &
- breakout group discussions
- future research needs

Online Literature Review

- Includes summary tables (by topic)
- Over 100 articles
- All available on the CDC EHDI website:

www.cdc.gov/ncbddd/ehdi/



Thank You!

- Dan Ashmead
- Fred Bess
- Marvin Chun
- Wesley Grantham
- Hollea Ryan
- Todd Ricketts
- Douglas Sladen