

# Audiological outcomes validation for children with hearing loss

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1

## Conflicts of Interest



2

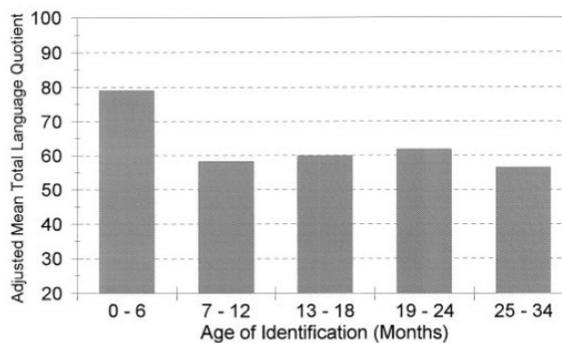
## University of Northern Colorado Lab School



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## Benefits of early identification



Pure Tone Average:	63	62	80	72	64
Cognitive Quotient:	88	74	82	76	71

Yoshinaga-Itano et al. 1998

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4

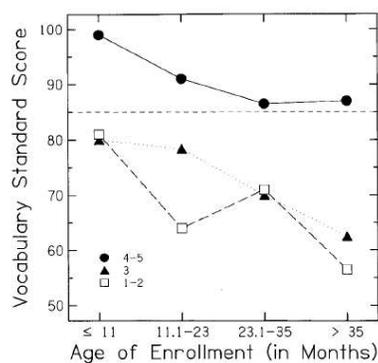
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## Moeller, 2000



Family involvement  
Circle – High  
Triangle – Average  
Square – Below average

Fig 2. Mean vocabulary scores plotted as a function of the two key variables, age of enrollment and family involvement ratings. The area above the horizontal dashed line represents the lower end of the average range for normal hearing students (average range is  $100 \pm 15$ ). The rating 4 to 5 (filled circle) represents the highest levels of family involvement; 3 (filled triangle) represents average family involvement; 1 to 2 (open square) represents below average family involvement.

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## What is a pediatric audiologist?

Works at a children's hospital or specialty clinic?

Likes children?

Pediatric training and experience?

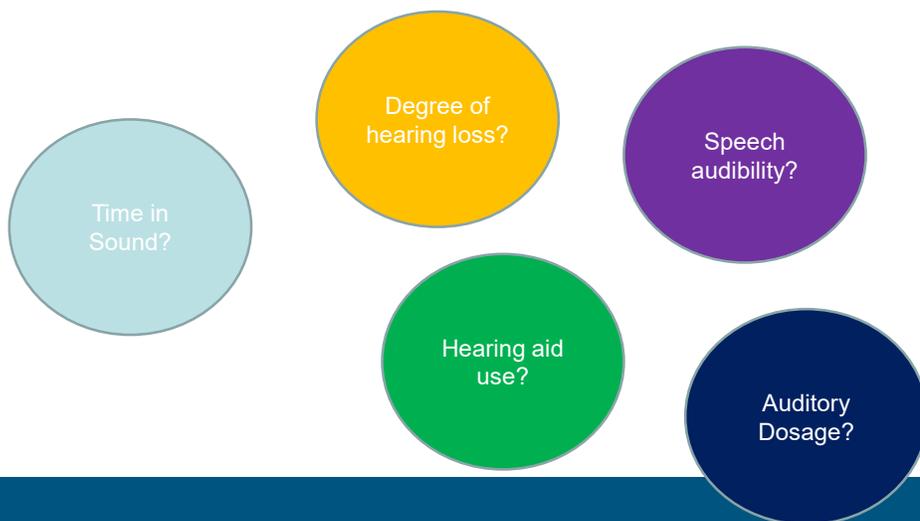
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If the patient in your booth is a child, you're a pediatric audiologist!

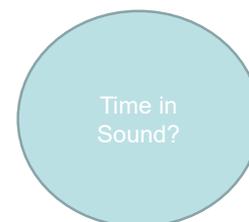
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## How can we measure auditory experience?



9

## Duration Variables?



- Age of:
  - Identification
  - Amplification
  - Intervention

10

## Duration variables and JCIH

- Age of identification (by 3 months)
- Age of amplification (within 1 month of ID)
- Age of intervention (by 6 months)

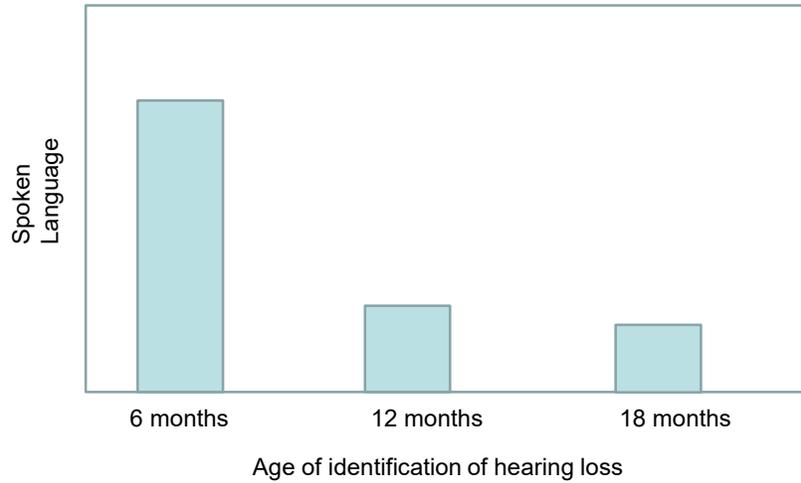
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## Age of identification

- Earlier is better
  - Before 6 months vs. after 6 months  
(Moeller, 2000; Yoshinaga-Itano et al. 1998)
- Led to widespread adoption of universal newborn hearing screening and early intervention programs

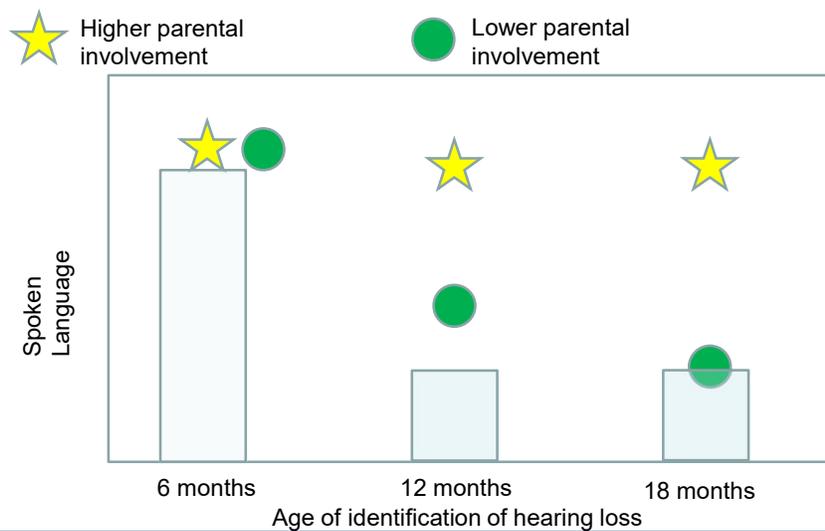
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## 1998 – Yoshinaga-Itano et al.



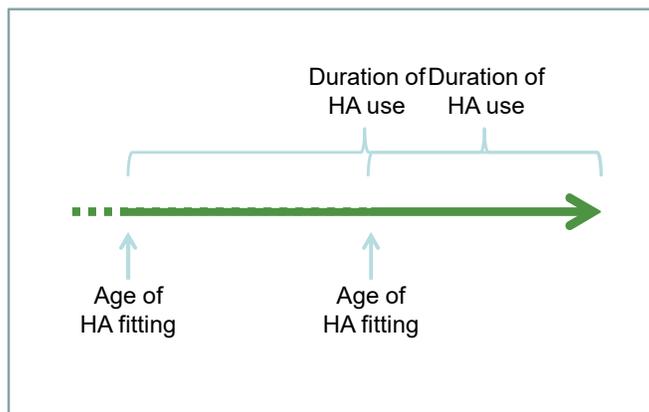
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## 2000 - Moeller



14

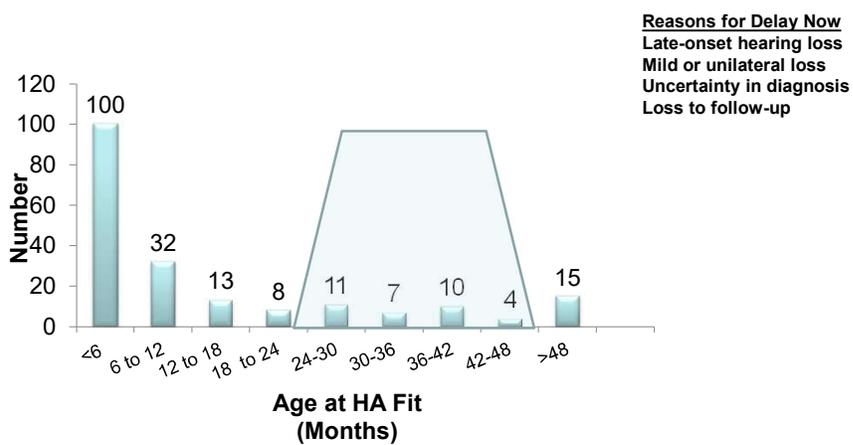
## Duration variables



Time

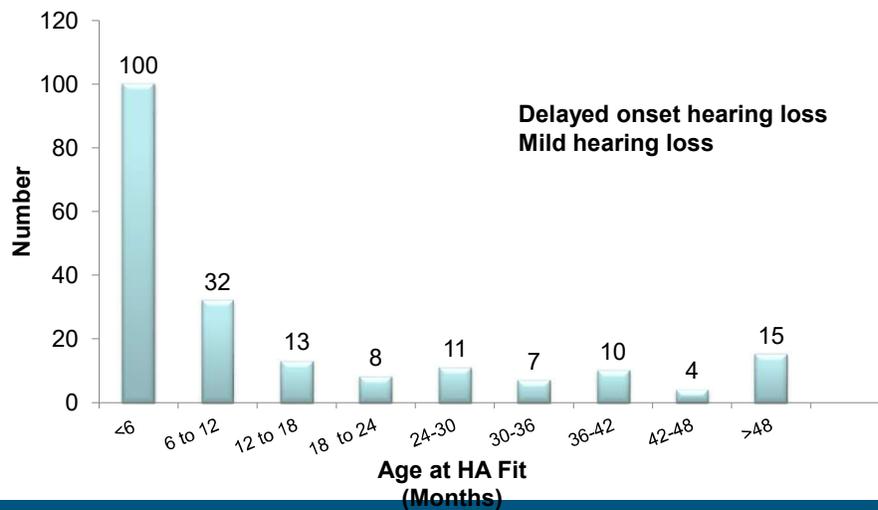
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## Age at HA FIT: After UNHS



16

## Age at HA FIT: After UNHS



17

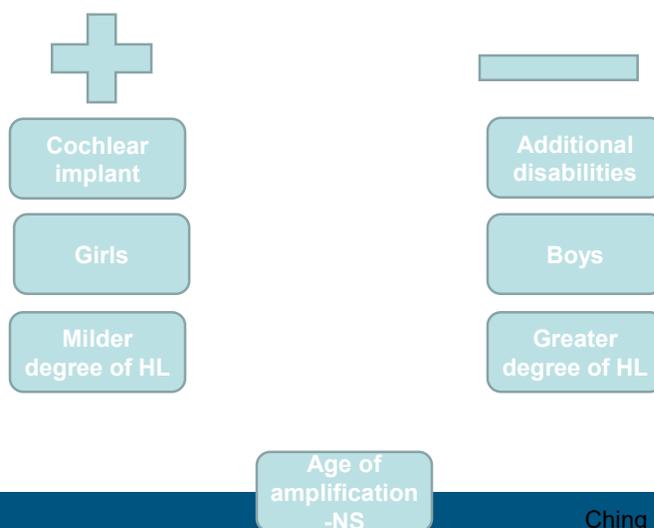
## What now?

- Duration variables do not explain
- Demographic factors
  - Degree of hearing loss
  - Socioeconomic status
  - Additional disabilities?
  - Cochlear implants
  - Non-English-speaking homes



18

## Demographic Factors



Ching et al. 2013

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## Demographic Factors

### Advantages

- Puts findings in context
- Target intervention?

### Disadvantages

- Not **malleable**
- Assumes demographic groups are homogeneous
  - i.e. Girls, Mild HL, Late ID
- Send a frustrating message to parents/caregivers

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## Poll Question

- What pure-tone average do you start to recommend hearing aids for children with bilateral hearing loss?
  - A. 20 dB HL
  - B. 25 dB HL
  - C. 30 dB HL
  - D. 35 dB HL

21

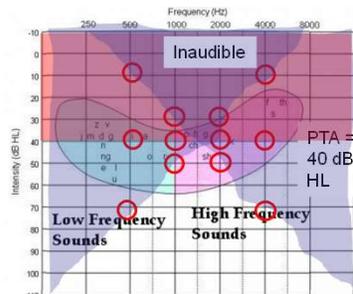
## Findings are mixed between pure-tone average and outcomes



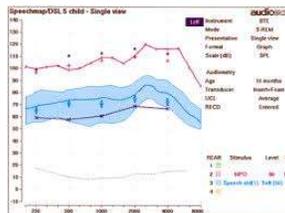
Fitzpatrick et al., 2007	Davis et al., 1986
Wake et al., 2005	Moeller, 2000
Delage & Tuller, 2007	Ramkalawan & Davis, 1992
	Gilbertson & Kamhi, 1995

22

# What does PTA not tell us?



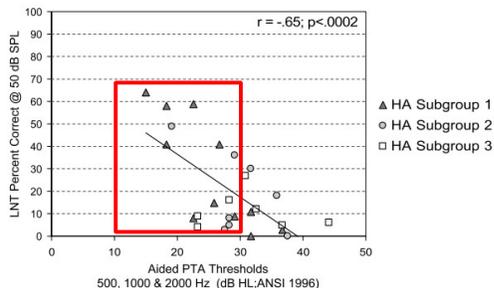
How different configurations may impact speech understanding



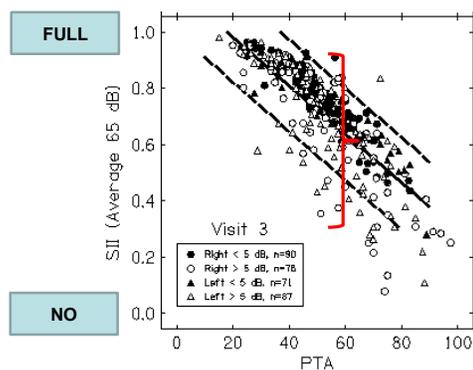
How patient will perceive speech with hearing aids (aided audibility)

# Limitations for predicting speech recognition

Figure 6. Aided PTA (at 0.5, 1.0, and 2.0 kHz; dB HL) as a function of LNT score (% correct) at the 50 dB SPL presentation level for the 26 children. Linear regression line, r value, and significance level are also shown. The symbols are triangles, circles, and squares for Aids 1, 2, and 3, respectively.

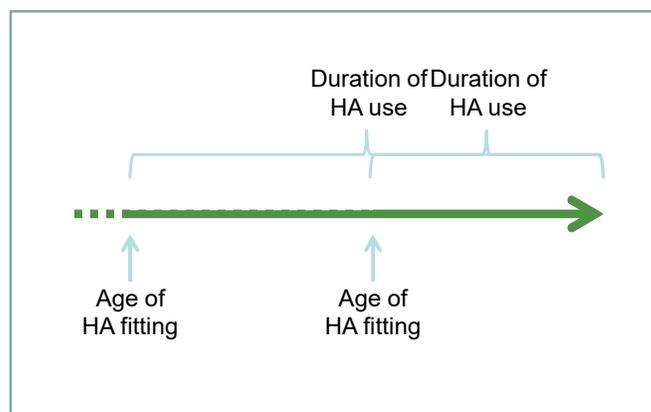


## Problems with Pure Tone Average (PTA)



25

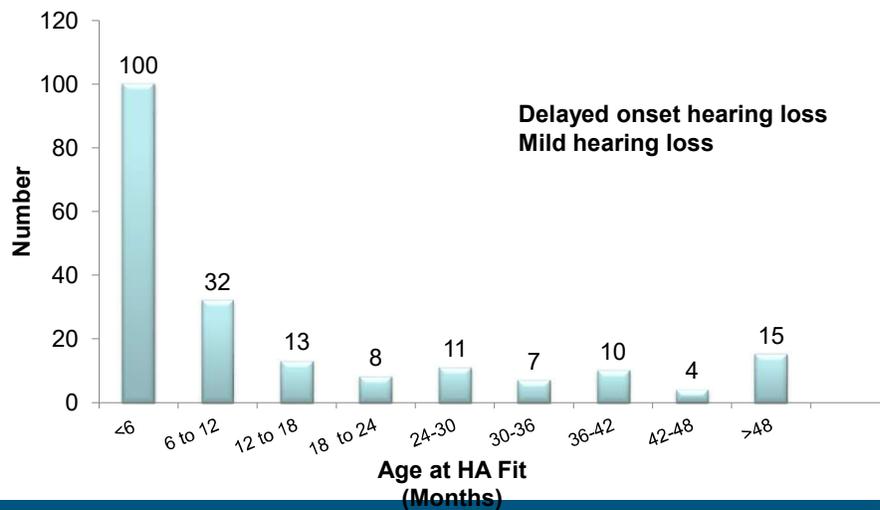
## Duration variables



Time

26

## Age at Hearing aid fitting: After UNHS



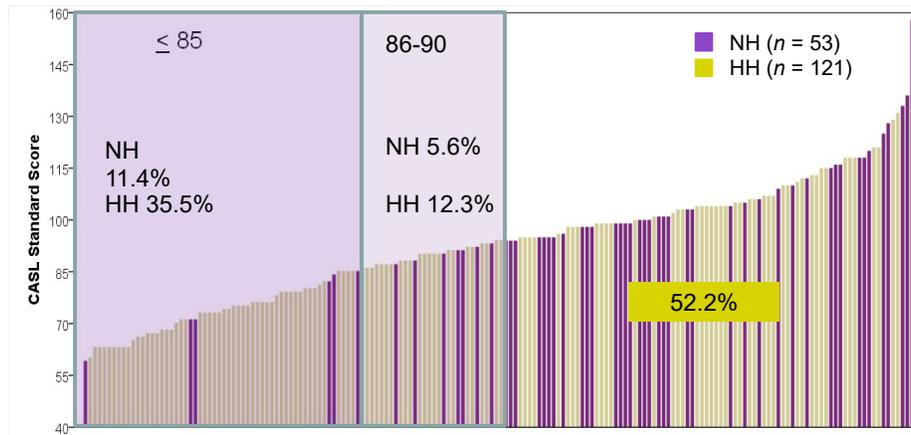
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Outcomes of Children  
with Hearing Loss

28

## Language at 3 years of age



Mean NH = 101.32; Mean HH = 88.83 ( $p = .001$ ,  $d = 0.747$ )

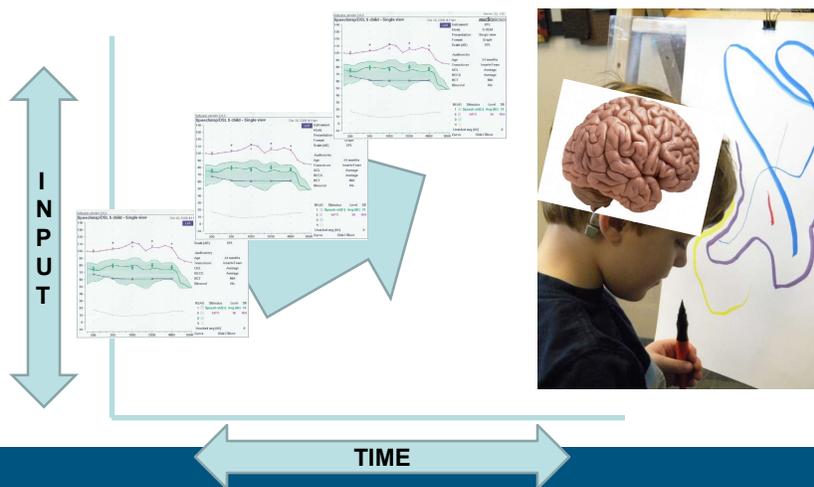
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## Today's Agenda

- Introductions
- Current state of outcomes in children who wear hearing aids
- Cumulative Auditory Experience
- Speech audibility
- Hearing aid use
- Special considerations for unilateral hearing loss

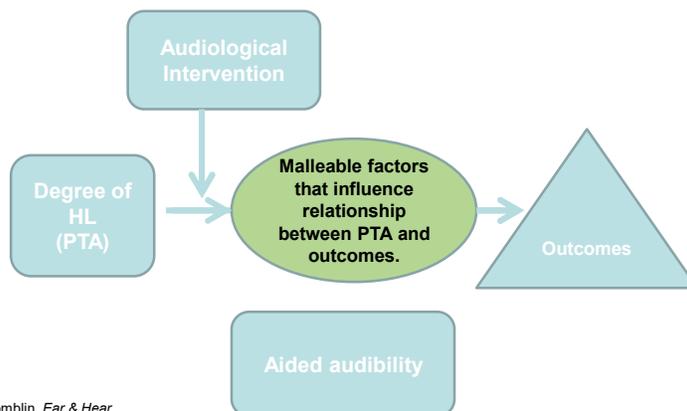
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## Cumulative Auditory Experience



31

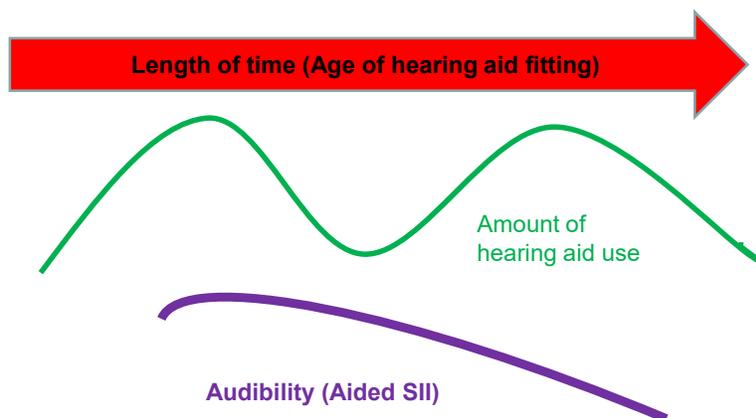
## Does it matter if hearing aids are optimally fit?



Moeller & Tomblin, *Ear & Hear*  
(2015)

32

## Auditory Experience



33

## Components of “early intervention”

Language  
intervention

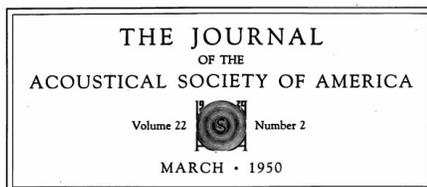
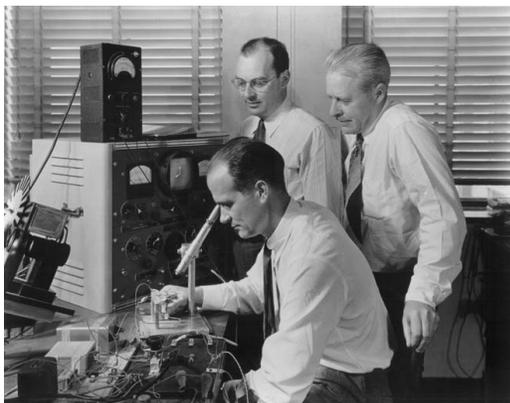
Hearing  
aid factors

**Other factors**  
Family caregiver factors  
Demographic factors



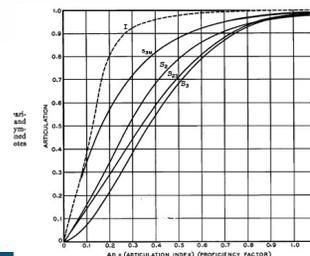
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# Audibility and telephony



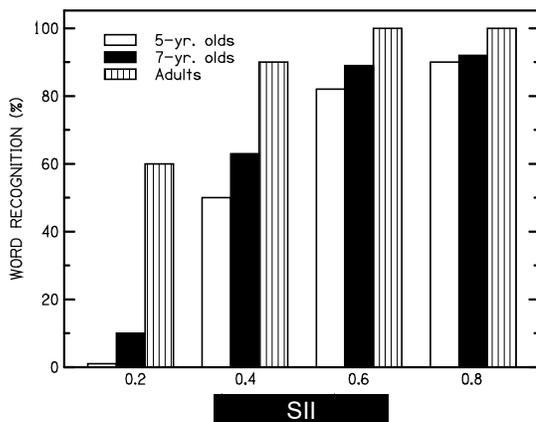
The Perception of Speech and Its Relation to Telephony

HARVEY FLETCHER AND ROBERT H. GALE  
Bell Telephone Laboratories, Inc., Murray Hill, New Jersey  
(Received December 3, 1949)



35

# Audibility by age



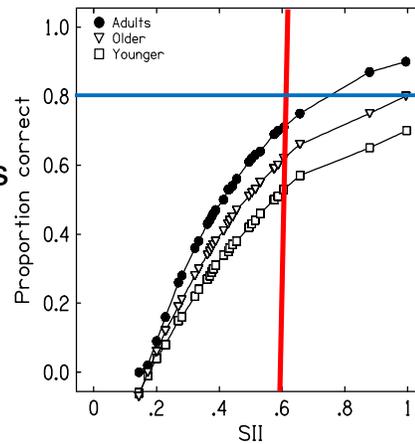
Stelmachowicz et al. 2000



36

## Audibility and speech recognition

- Depends on age
  - Adults
  - Older (9-12 years)
  - Younger (5-8 years)



From McCreery &  
Stelmachowicz, 2011

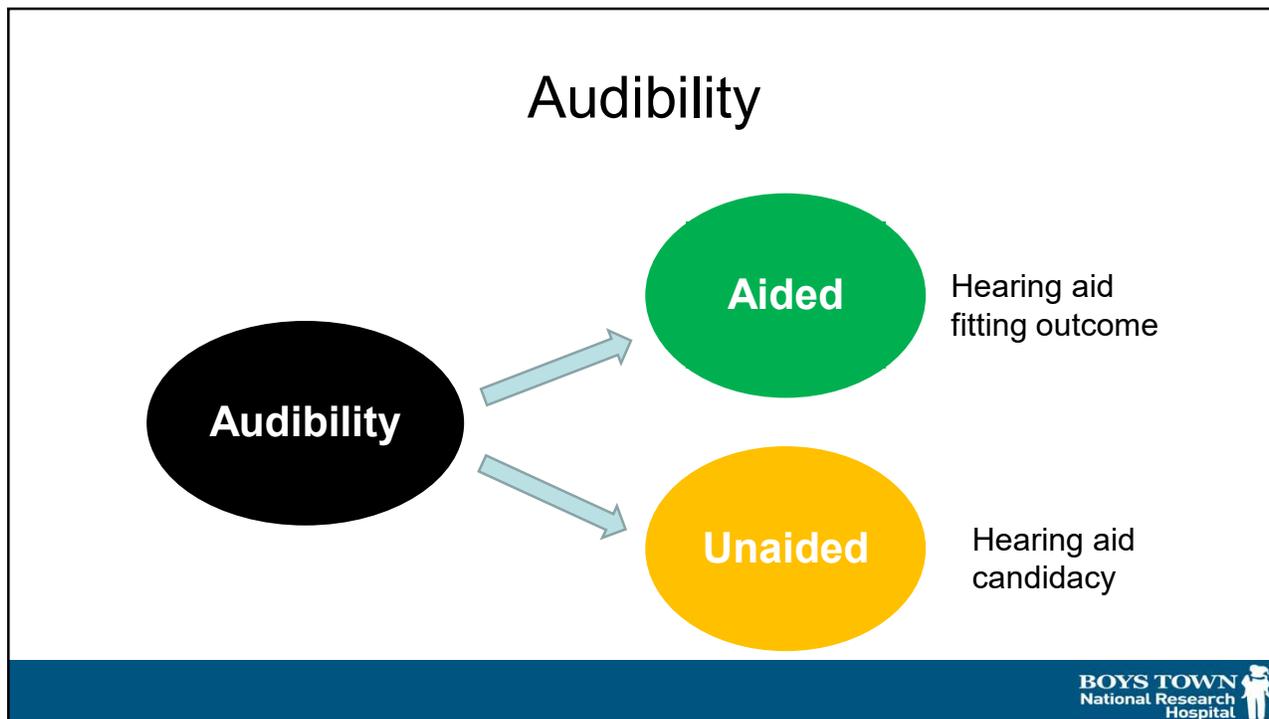
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## Audibility

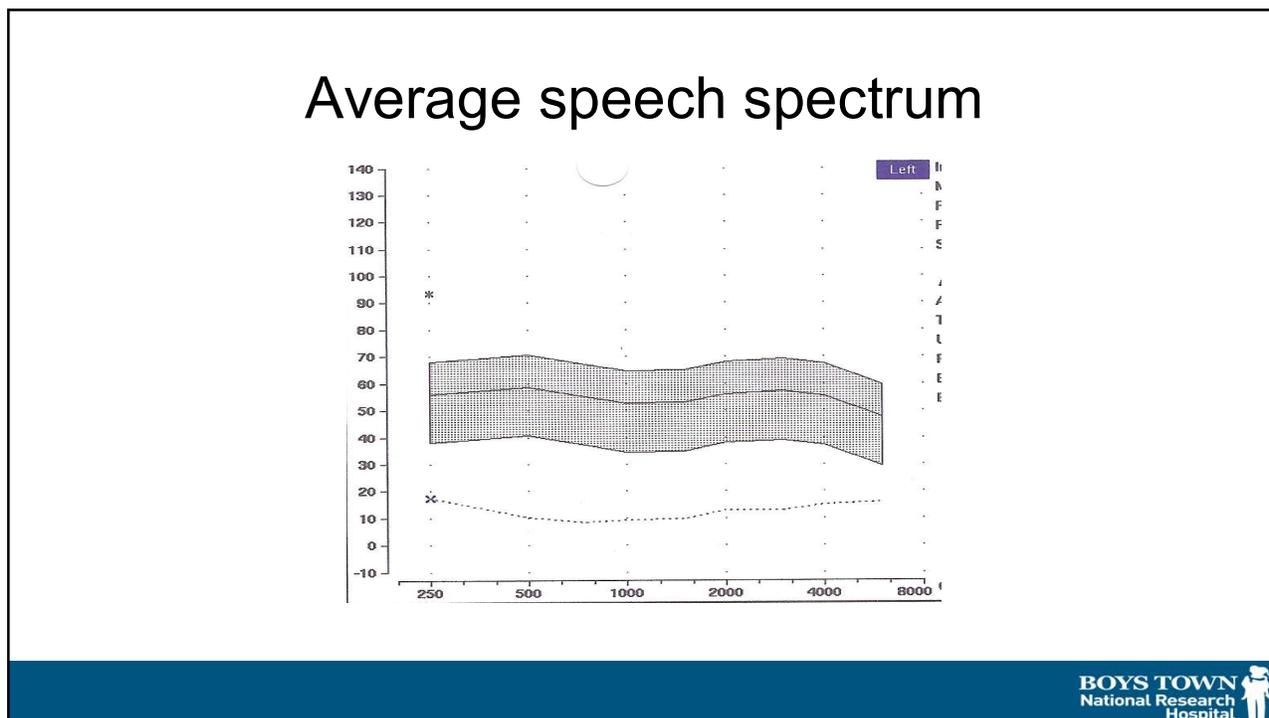


- How well we can hear a specific sound
- Children can only develop what they hear
- Determined by:
  - Hearing thresholds
  - **Level and location**
  - Noise
  - Device (if present)

38



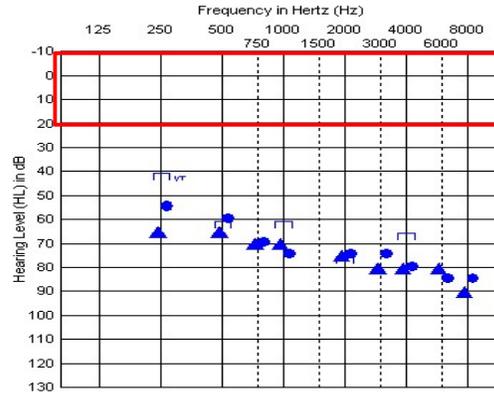
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40

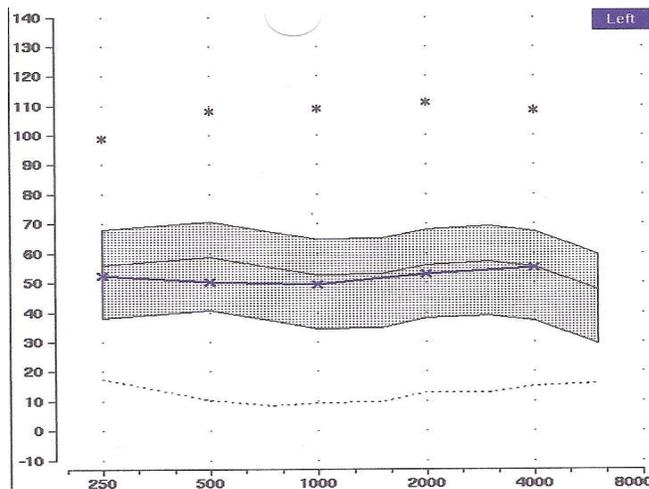
# Hearing Thresholds

- Hearing loss results in loss of audibility for speech and other important sounds.
- Greater hearing loss = more limited audibility



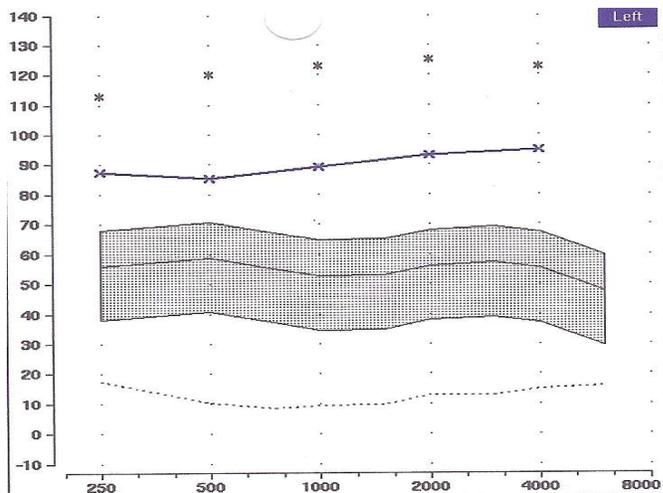
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# Audibility with Mild Hearing Loss

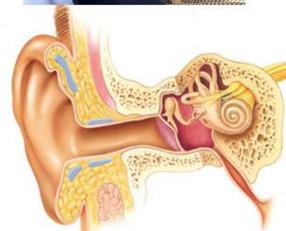
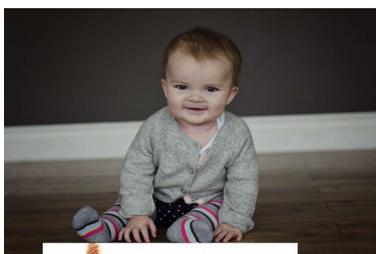


42

# Audibility with Severe Hearing Loss



43



44

Hearing aid gain

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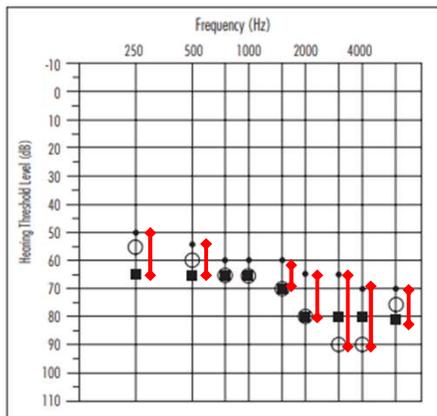
Hearing thresholds

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# Infants are not average adults: Implications for audiometric testing

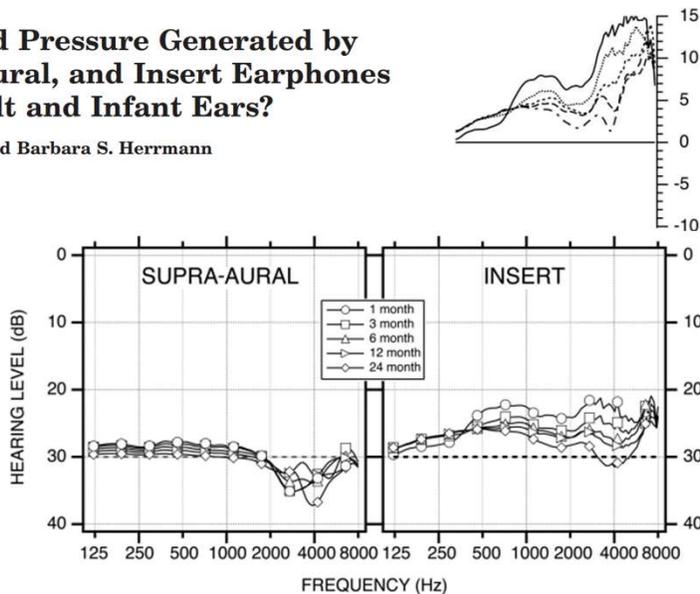
By Richard C. Seewald and Susan D. Scollie



47

## How Does the Sound Pressure Generated by Circumaural, Supra-aural, and Insert Earphones Differ for Adult and Infant Ears?

Susan E. Voss and Barbara S. Herrmann



48

## Ear canal acoustics

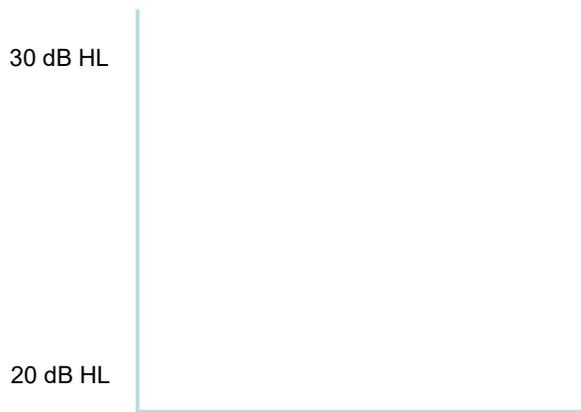
- Assessment
- Hearing aid fitting



## Hearing aid candidacy

- Audibility
  - How does ear canal acoustics influence diagnostic assessment?
  - How does the hearing loss impact audibility?

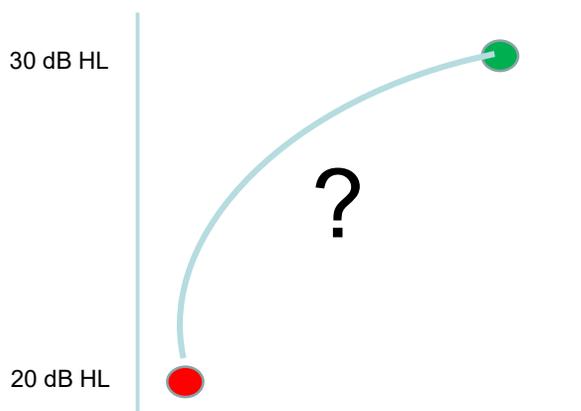
## Fit children with mild bilateral hearing loss?



To fit or not to fit?

51

## Fit children with mild bilateral hearing loss?



### Clinical equipoise

Uncertainty about clinical decisions in the face of limited or unclear evidence

To fit or not to fit?

52

# Is mild bilateral hearing loss a developmental risk?

Journal of Speech and Hearing Disorders, Volume 51, 053-062, February 1986

**EFFECTS OF MILD AND MODERATE HEARING IMPAIRMENTS ON LANGUAGE, EDUCATIONAL, AND PSYCHOSOCIAL BEHAVIOR OF CHILDREN**

JULIA M. DAVIS   JILL ELFENBEIN   ROBERT SCHUM   RUTH A. BENTLER  
The University of Iowa, Iowa City

An extensive psychoeducational evaluation was administered to 40 hearing-impaired children to investigate the effects of degree of hearing impairment, age, and other factors on intellectual, social, academic, and language behavior. Although children varied greatly in performance, hearing loss of any degree appeared to affect psychoeducational development adversely, leading to the conclusion that even minimal hearing loss places children at risk for language and learning problems.

Gp A =  $\leq 44$  dB

Gp B = 45-60 dB

Gp C =  $\geq 61$  dB

< 12 Years  
  $\geq 12$  Years

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53

# Is mild bilateral hearing loss a developmental risk?

Group

**HHS Public Access**  
Author manuscript  
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Child Dev. Author manuscript; available in PMC 2020 Jan 5.      PMID: PMC6456443  
 Published in final edited form as:      NIHMSID: NIHMS1009435  
 Child Dev. 2020; Jan; 91(1): e179-e197.      PMID: 30286910  
 2018 Oct 9. doi: 10.1111/cdev.13158

cy Predictors and Second-Grade Outcomes in Children Who Hearing

Jaka Oleson, Sophie E. Ambrose, Elizabeth A. Walker, and Mary P. Moeller

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## Is mild bilateral hearing loss a developmental risk?

Yes.

## Infants are not average adults: Implications for audiometric testing

By *Richard C. Seewald and Susan D. Scollie*      October 1999 • Vol. 52 • No. 10

### **Acoustic mechanisms that determine the ear-canal sound pressures generated by earphones**

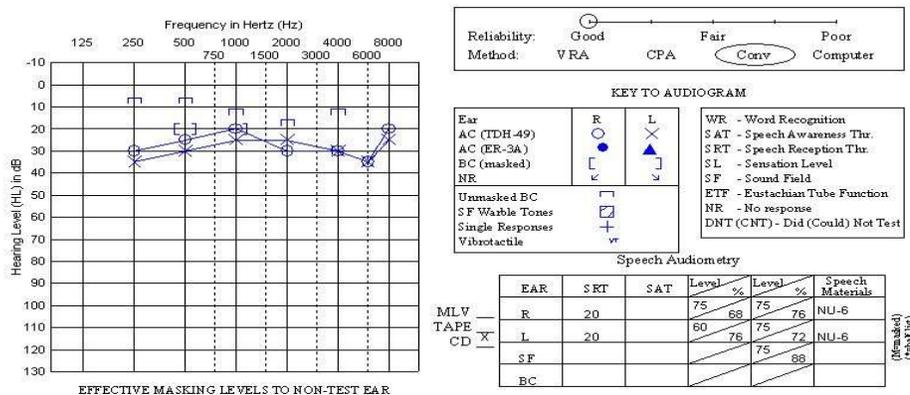
Susan E. Voss  
*Eaton-Peabody Laboratory, Massachusetts Eye and Ear Infirmary, 243 Charles Street, Boston, Massachusetts 02114, Speech and Hearing Sciences Program, Harvard-M.I.T. Division of Health Sciences and Technology, Cambridge, Massachusetts 02139, Research Laboratory of Electronics, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139, and Department of Otolaryngology, Massachusetts Eye and Ear Infirmary, 243 Charles Street, Boston, Massachusetts 02114*

John J. Rosowski  
*Eaton-Peabody Laboratory, Massachusetts Eye and Ear Infirmary, 243 Charles Street, Boston, Massachusetts 02114, Department of Otolaryngology, Massachusetts Eye and Ear Infirmary, 243 Charles Street, Boston, Massachusetts 02114, and Department of Otology and Laryngology, Harvard Medical School, Speech and Hearing Sciences Program, Harvard-M.I.T. Division of Health Sciences and Technology, Cambridge, Massachusetts 02139*

J. Acoust. Soc. Am. **107** (3), March 2000

# Hearing aid candidacy

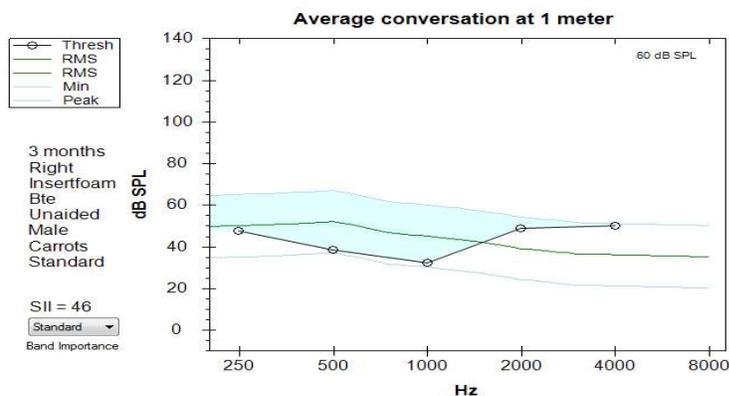
- Audiogram method



57

# Hearing aid candidacy

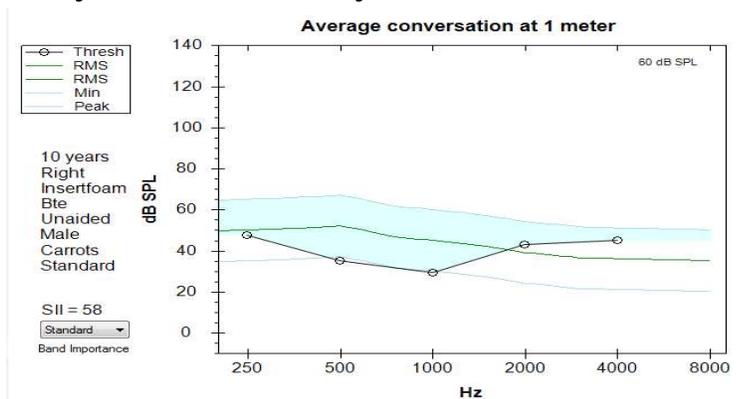
- Audibility method – 3 month-old



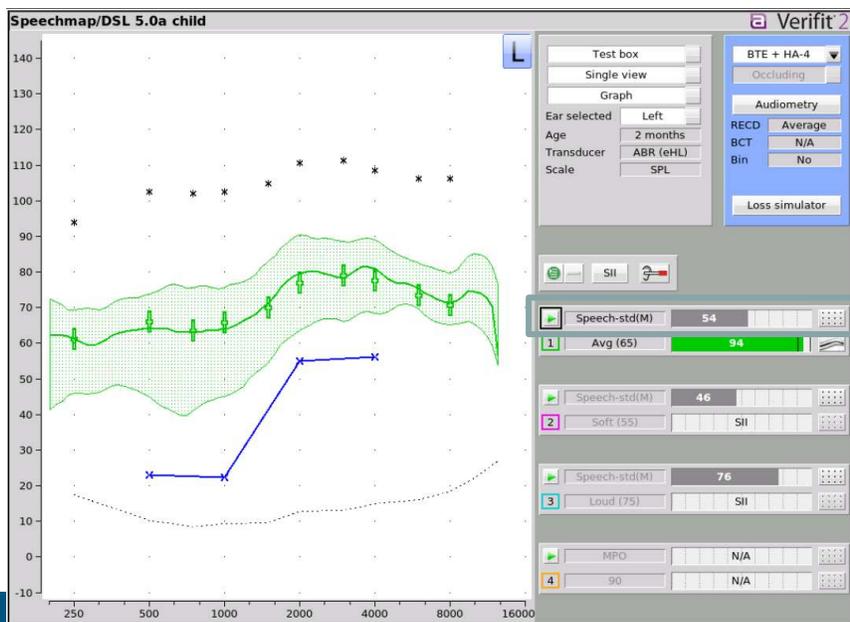
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# Hearing aid candidacy

- Audibility method – 10 year-old



59



60

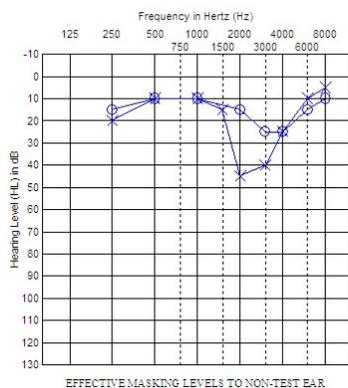
## Why do thresholds change?



We know the RECD affects hearing aid measurements, but how do they affect thresholds??

61

## Audiogram in HL



- Inserts / ABR transducer
  - Calibrated referenced to a 2 cc coupler

62

## Ear canal growth

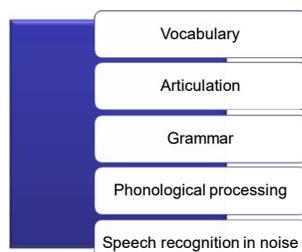


Effective stimulus level will decrease as the ear canal volume increases

In dB HL, thresholds will appear to be worse over time as ear canal grows

## QUESTIONS?

## Are there differences in outcomes for children with mild hearing loss, as a function of amount of hearing aid use?

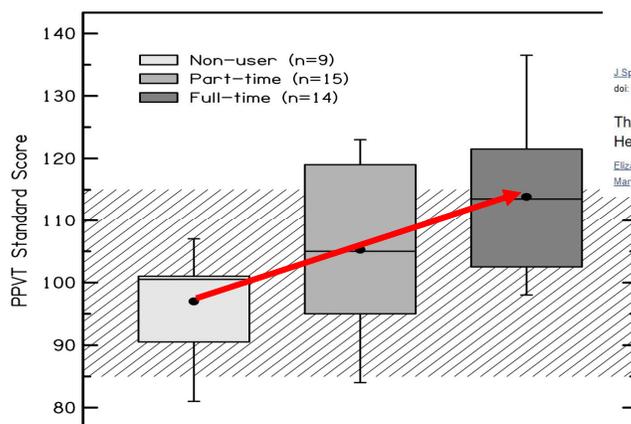


65

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## Does amplification help children with mild bilateral hearing loss?



ASHAWIRE JSLHR JOURNAL OF SPEECH, LANGUAGE, AND HEARING RESEARCH  
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J. Speech Lang. Hear. Res. 2015 Oct; 58(5): 1611-1625.  
doi: 10.1044/2015\_JSLHR-H15-0043

PMCID: PMC4686313  
PMID: 26151927

The Influence of Hearing Aid Use on Outcomes of Children With Mild Hearing Loss

Elizabeth A. Walker,<sup>1a</sup> Lenore Holte,<sup>2</sup> Ryan W. McCreary,<sup>3</sup> Meredith Spratford,<sup>4</sup> Thomas Page,<sup>5</sup> and Mary Pat Moeller<sup>6</sup>

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Journal List > Lang Speech Hear Serv Sch > PMC7251589



**ASHA WIRE**

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Lang Speech Hear Serv Sch. 2020 Jan; 51(1): 55–67. PMCID: PMC7251589  
 Published online 2020 Jan 8. doi: [10.1044/2019\\_LSHSS-OCHL-19-0021](https://doi.org/10.1044/2019_LSHSS-OCHL-19-0021) PMID: [31913801](https://pubmed.ncbi.nlm.nih.gov/31913801/)

## Audibility-Based Hearing Aid Fitting Criteria for Children With Mild Bilateral Hearing Loss

Ryan W. McCreery,<sup>a</sup> Elizabeth A. Walker,<sup>b</sup> Derek J. Stiles,<sup>c</sup> Meredith Spratford,<sup>a</sup> Jacob J. Oleson,<sup>d</sup> and Dawna E. Lewis<sup>a</sup>

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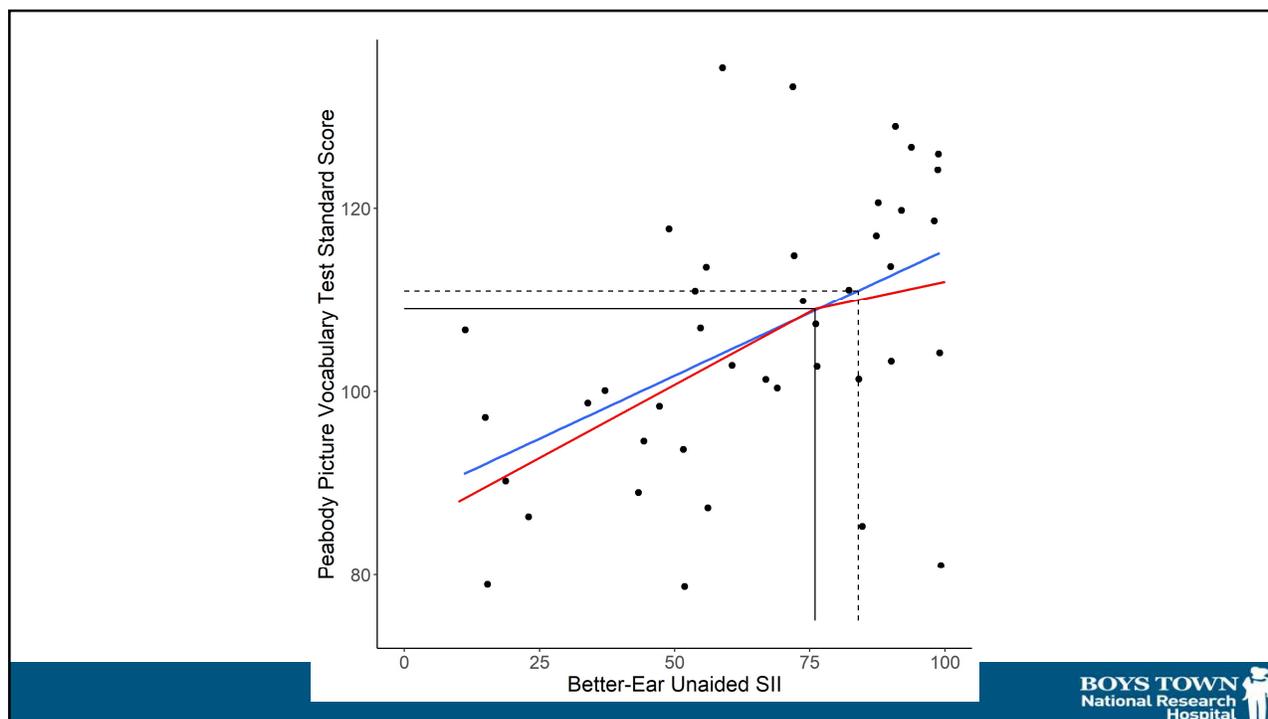
67

## Audibility-based candidacy

- Children who did not receive or did not wear hearing aids
- Compared two different criteria
  - Level = 50th percentile for children with normal hearing
  - Iterative piecewise regression
    - Finds point in unaided SII where relationship between SII and language changes



68

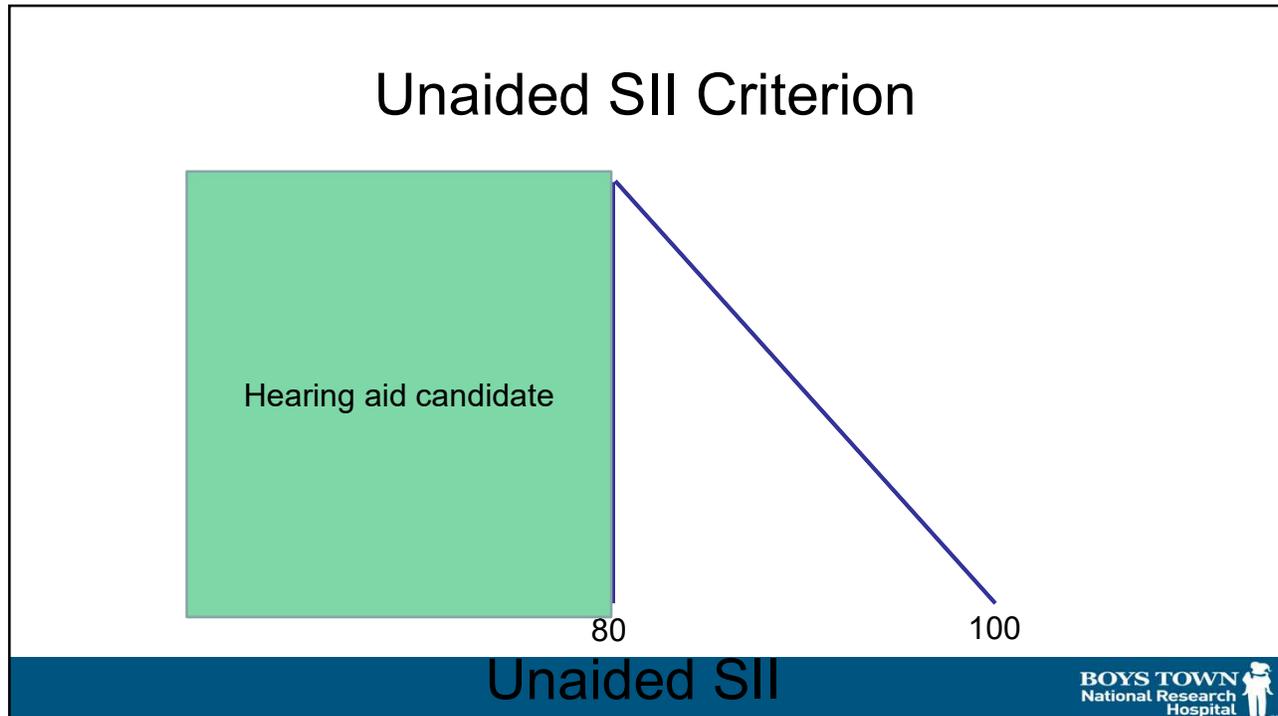


69

## Convergence

- Both criteria suggested a break-point around unaided SII = 80 across three language outcomes

70



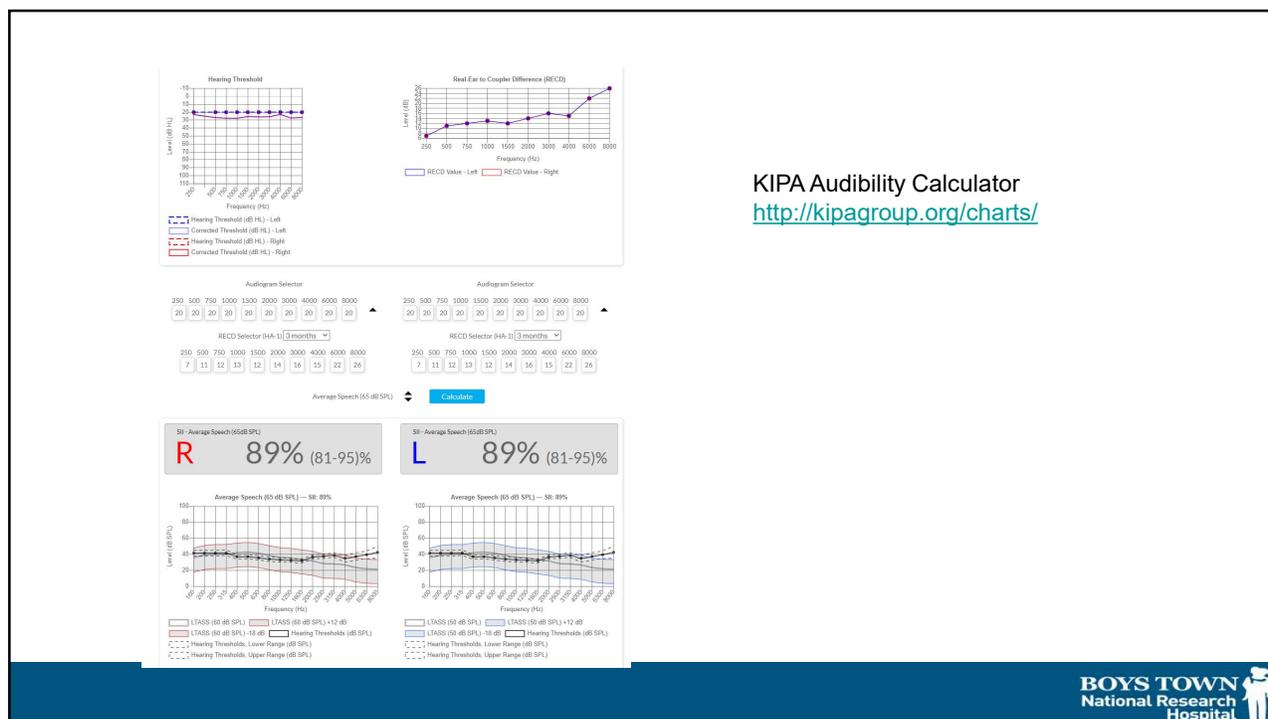
71

## Unaided SII Criterion

<p><b>PTA-based criterion</b></p> <ul style="list-style-type: none"> <li>• Did not reflect effects of ear-canal acoustics</li> <li>• Not based on language outcomes data</li> <li>• Not easy to quantify impact of hearing on audibility</li> </ul>	<p><b>Unaided SII criterion</b></p> <ul style="list-style-type: none"> <li>• Reflects effects of ear-canal acoustics on thresholds</li> <li>• Based on language outcomes data</li> <li>• Quantifies impact of hearing on audibility</li> </ul>
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72



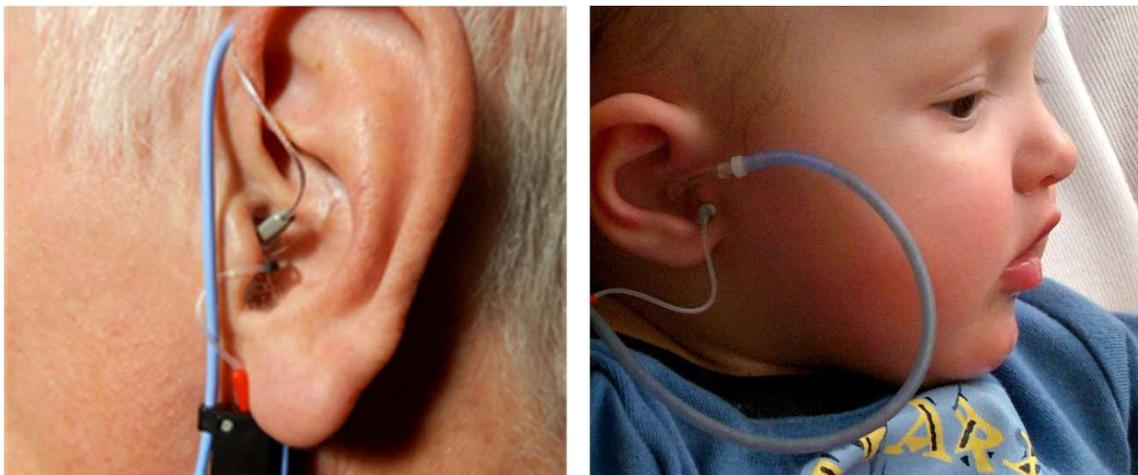
73

## Counselling Approach

- Non-dispensing Audiologist / SLP / Early Interventionist
  - Explain:
    - Audibility and why it is important for language
    - How even small disruptions in audibility can affect communication
    - Refer patient to fitting audiologist to assess impact of loss on audibility

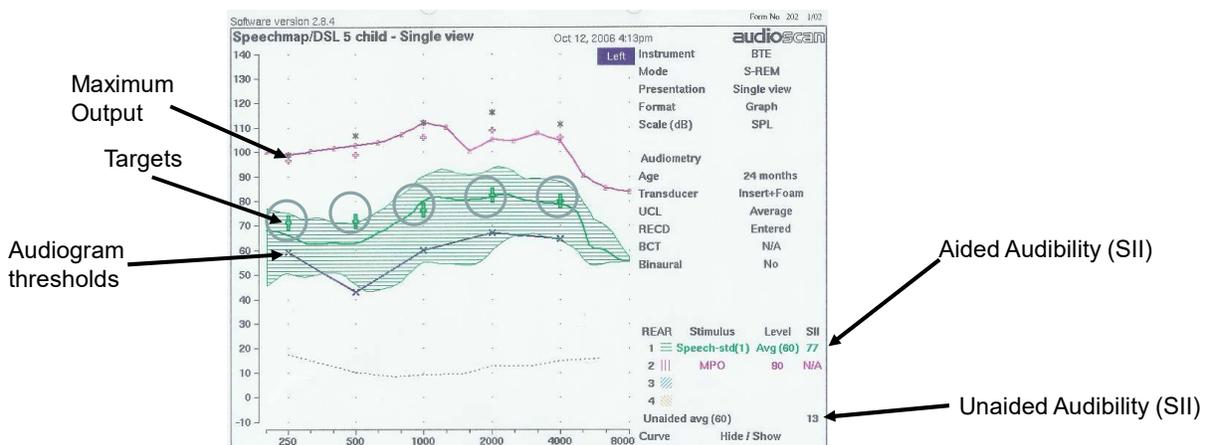
74

# What is hearing aid verification?

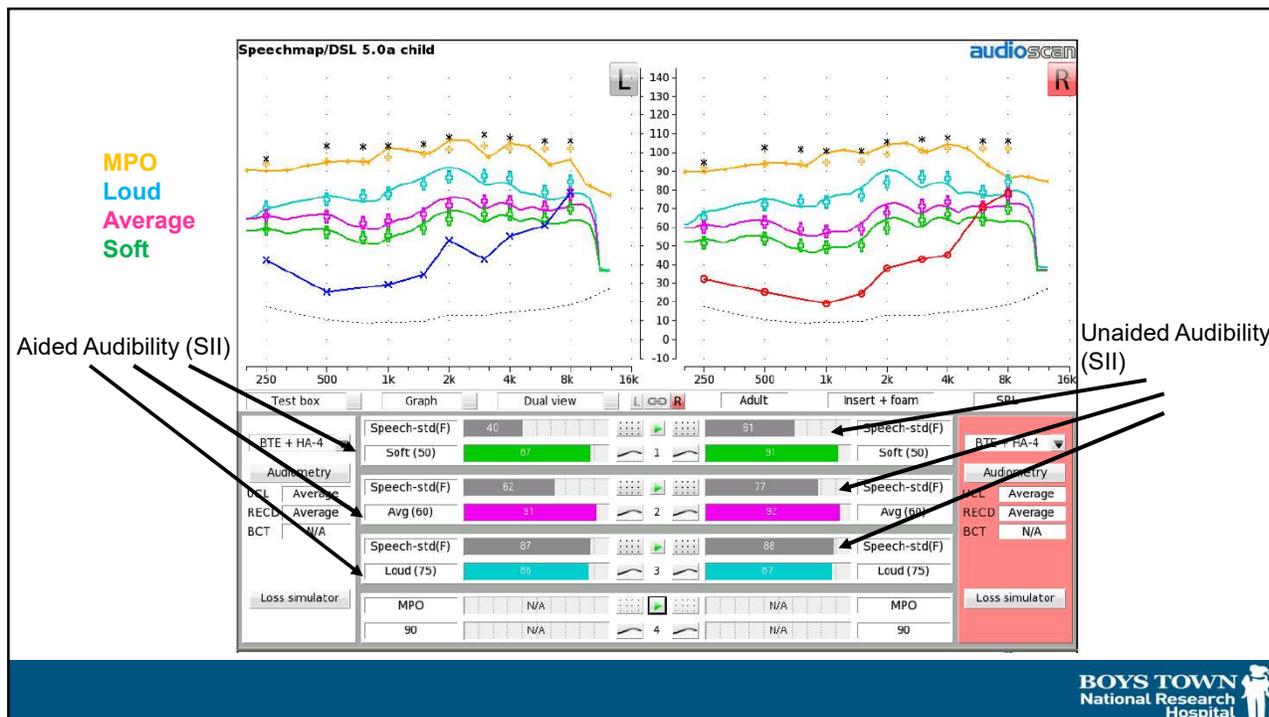


75

## Verification

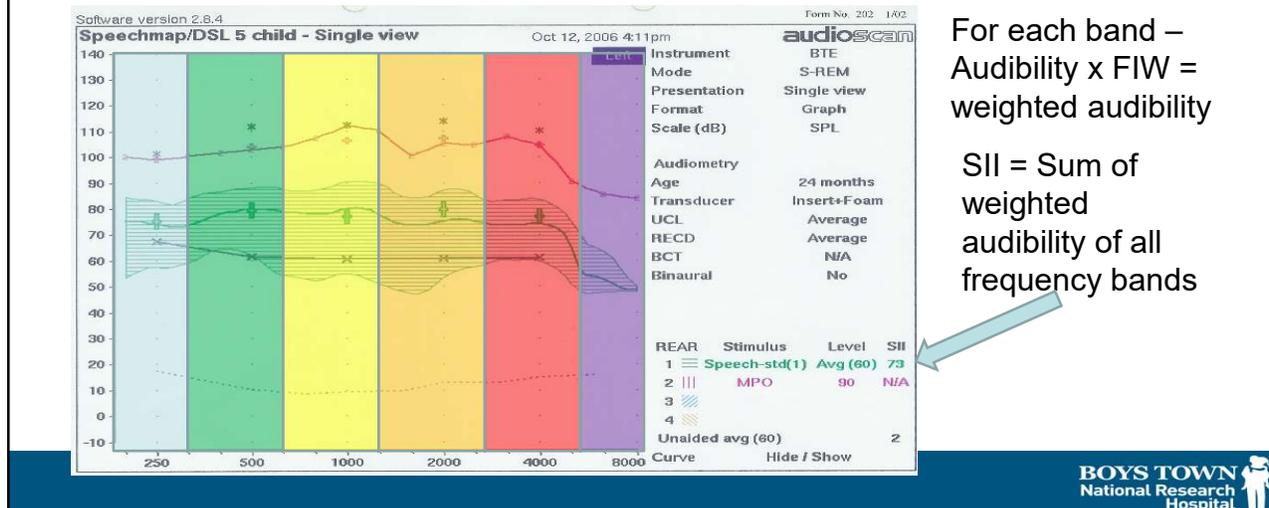


76



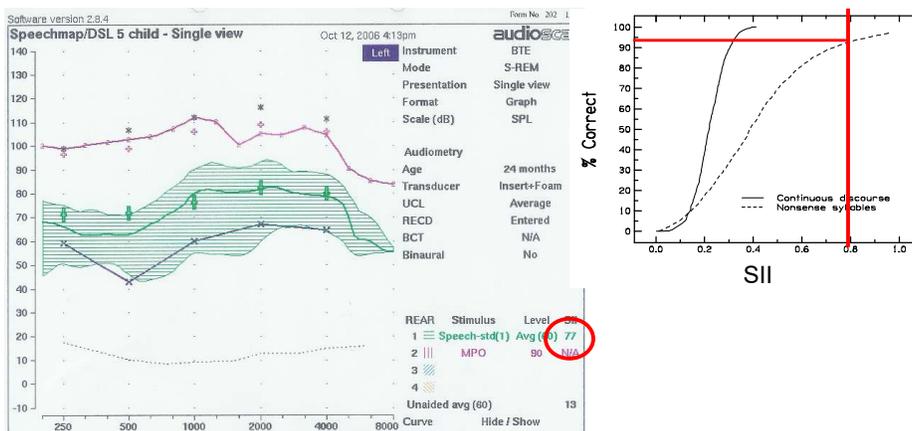
77

## Aided Audibility



78

# Aided Audibility (SII) to transfer functions



79

# SII band importance and bandwidth

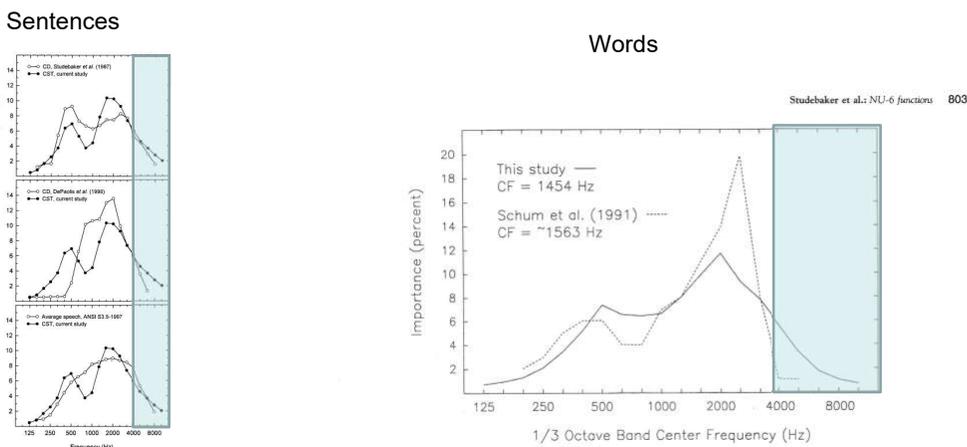
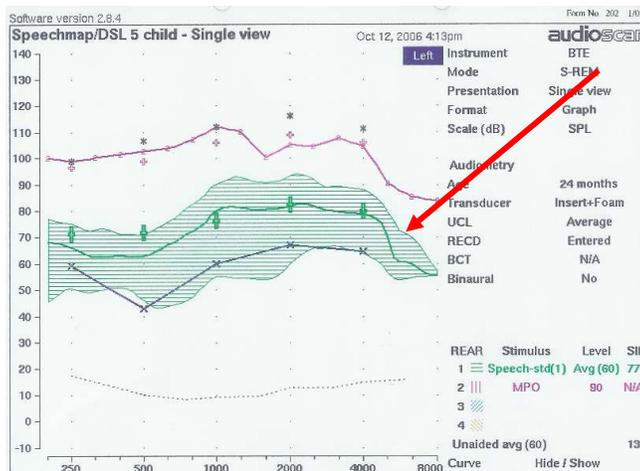


Figure 2. Frequency-importance functions for the CST, continuous discourse (top and middle panels), and average speech (bottom panel). All of the curves shown are 1/3-octave band functions.

FIGURE 2. Frequency-importance functions for the Auditec recordings of the NU-6 word test. The solid line indicates the importance function obtained in this study. The dashed line indicates the importance function from Figure 6 of Schum, Matthews, & Lee (1991). CF = crossover frequency.

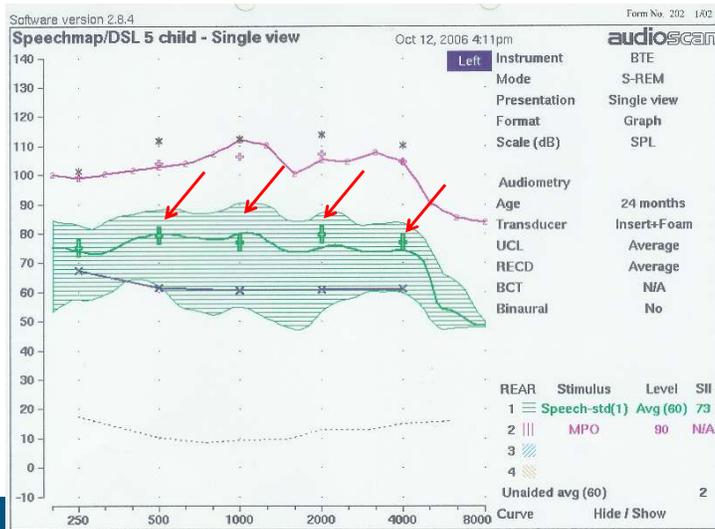
80

# Audible bandwidth



81

# Target vs. Actual (RMS error)

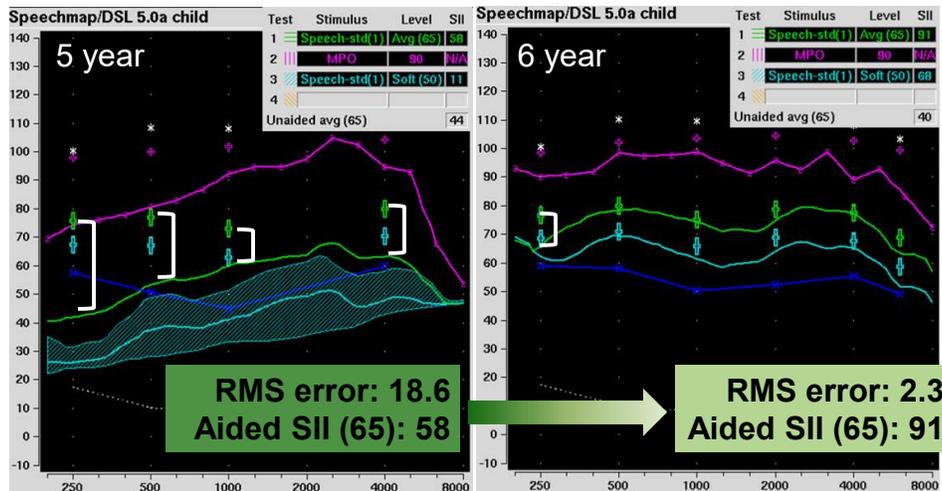


Fitting data compared to DSL targets

Calculate RMS error of deviations from target at 5., 1, 2, and 4 kHz

82

# Better match to targets → better audibility



83

## Does it matter if hearing aids are fit close to DSL targets?



INTERNATIONAL JOURNAL OF AUDIOLOGY  
<https://doi.org/10.1080/14992027.2023.2293645>



ORIGINAL ARTICLE



### Comparing criteria for deviation from hearing aid prescriptive targets in children

Kathryn B. Wiseman<sup>a</sup> , Elizabeth A. Walker<sup>b</sup> , Meredith Spratford<sup>c</sup> , Marc Brennan<sup>d</sup> and Ryan W. McCreery<sup>c</sup>

<sup>a</sup>Child Auditory Technology Laboratory, Boys Town National Research Hospital, Omaha, NE, USA; <sup>b</sup>Department of Communication Sciences and Disorders, University of Iowa, Iowa City, IA, USA; <sup>c</sup>Audibility, Perception, and Cognition Laboratory, Boys Town National Research Hospital, Omaha, NE, USA; <sup>d</sup>Department of Special Education and Communication Disorders, University of Nebraska–Lincoln, Lincoln, Nebraska, USA



84

## Hearing aid verification in children

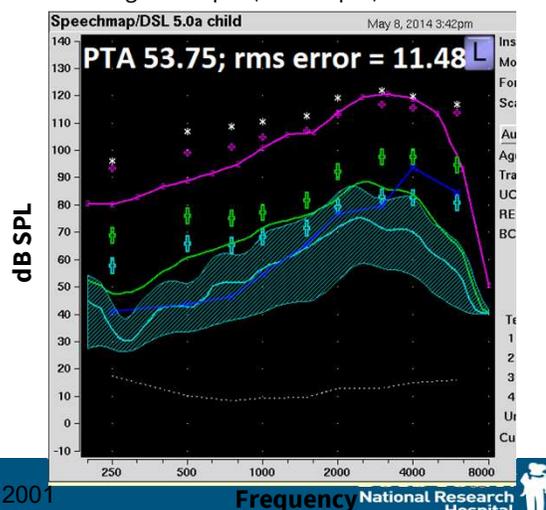
Fit to prescriptive targets

RMS error = mean error @ 500, 1000, 2000, 4000 Hz

5 dB RMS-error guideline

**Is < 5dB or < 3 dB for children?**

DSLv5 prescriptive targets +  
Hearing aid output (60 dB input) -----



Byrne & Cotton, 1988; Cox & Alexander, 1990; Baumfield & Dillon, 2001

85

Is a **3 dB criterion** more advantageous than  
a **5 dB criterion**?

Does a 3 dB criterion result in...

**Better  
audibility?**

**Better speech  
recognition?**

**Better  
language?**

...than a 5 dB criterion?

Wiseman (2022); Wiseman et al. (in prep)

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**N = 307 children with hearing aids**  
**Age = 5 months – 11.5 years**

**Hearing aid fitting error**

RMS error of deviation from DSL v5 prescriptive targets at 500, 1000, 2000, and 4000 Hz

**Aided audibility**

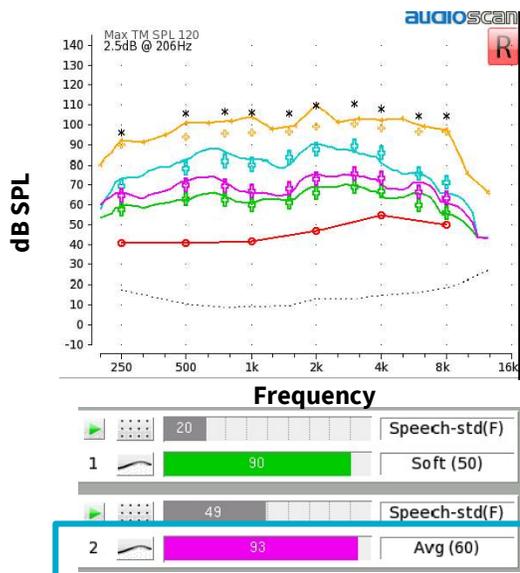
Aided Speech Intelligibility Index (SII) @ 60 dB input

**Speech recognition**

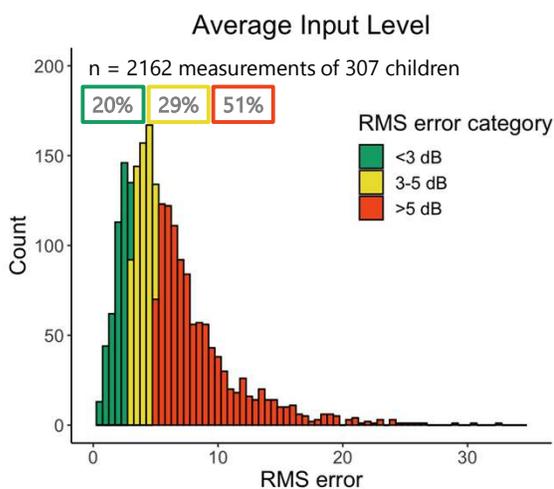
PBK words in quiet

**Language measures**

Expressive vocabulary (WASI Vocabulary)  
 Morphosyntax (CASL Syntax Construction)



87

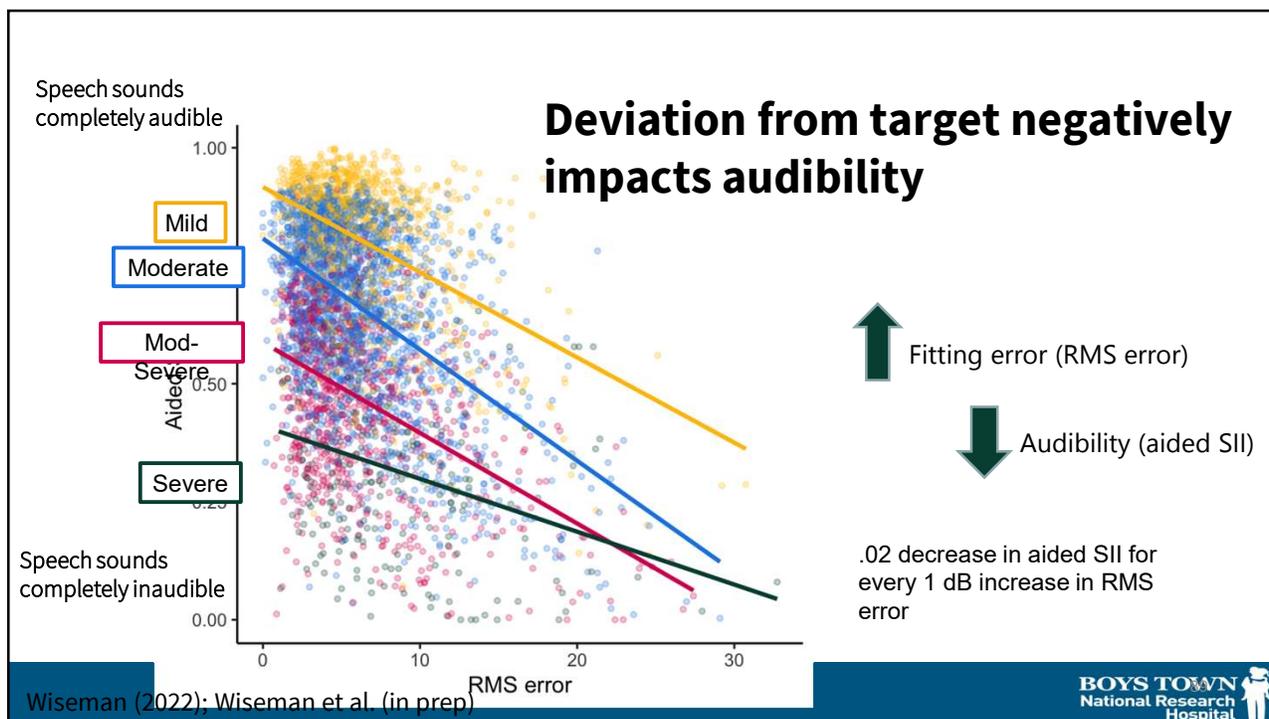


**Half of hearing aid fittings had large error**

Wiseman (2022); Wiseman et al. (in prep)

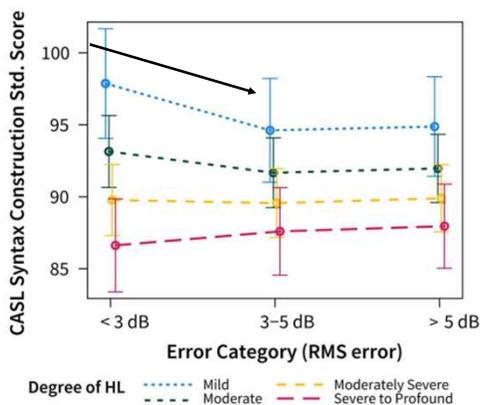


88

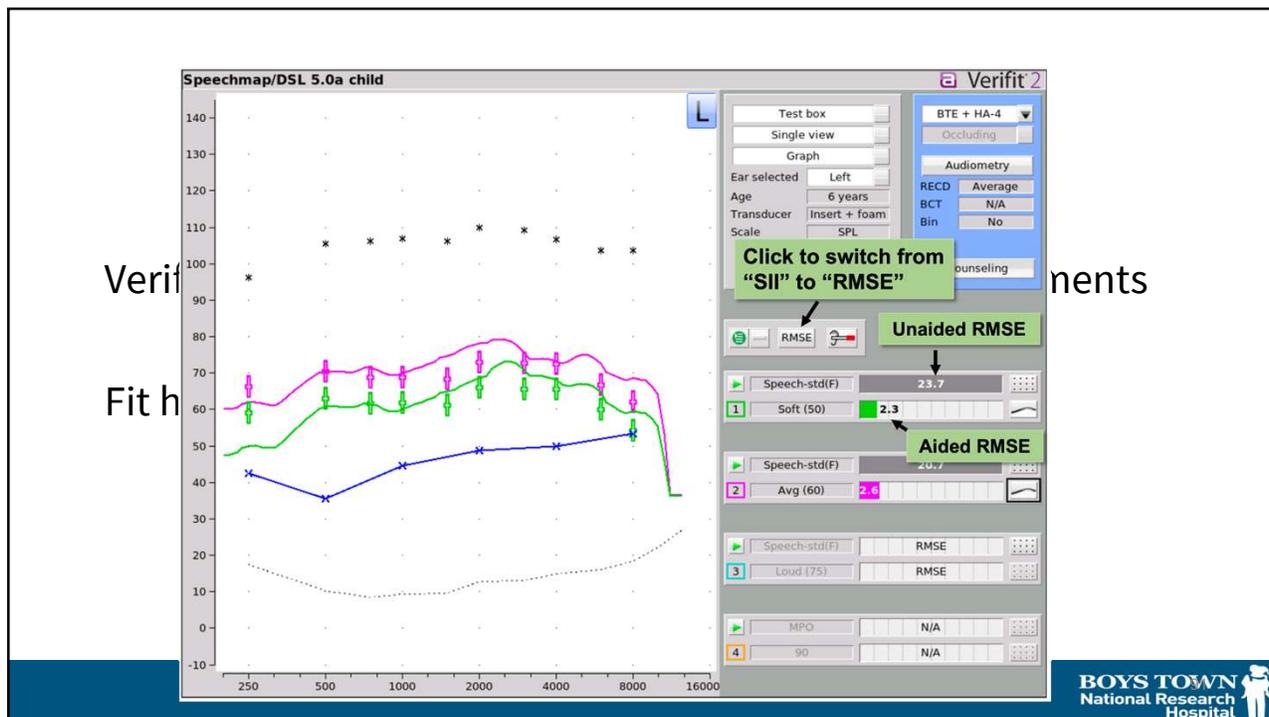


89

## Lower RMS error criterion has advantages for language outcomes, esp. for milder HL



90



Verifit

Fit h

ments

91

## How can you measure RMS error?

Speechmap/DSL 5.0a child

	250	500	750	1000	1500	2000	3000	4000	6000
RESR	98	110		114		119		118	113
Entered UCL									
Target1	74	80		84		91		94	86
Test 1	58	64	65	69	76	87	91	82	36
Target2	64	71		73		79		80	75
Test 2	51	57	60	63	69	79	80	74	36
Target3	96	102		109		113		113	109
Test 3	84	86	89	99	99	110	104	75	56
Target4									
Test 4									
SPL threshld	51	56		67		73		83	76
Unaided (65)	56	59	55	53	53	56	57	55	48
Entered HL	35	45		60		60		70	70
Entered BCT									
nHL to eHL	30	20	17	15	12	10	7	5	5
HA-2 RECD	2	5	6	6	5	7	7	11	3
MAP	18	10	9	9	10	13	13	15	16

audioScan

Instrument: BTE + HA-4  
 Mode: Test box  
 Format: Table  
 Scale (dB): SPL

Audiometry

Age: 9 years  
 Transducer: Insert+Foam  
 UCL: Average  
 RECD: Measured  
 BCT: N/A  
 Binaural: No

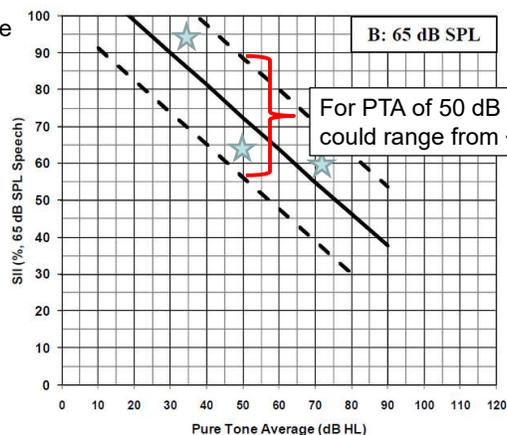
Test	Stimulus	Level	SII
1	Speech-std(1)	Avg (65)	49
2	Speech-std(1)	Soft (50)	30
3	MPO	90	N/A
4			

Unaided avg (65): 13

92

## Confidence intervals for SII when hearing aids are fit appropriately

Below dashed line  
= poor fit



Bagatto, et al.,

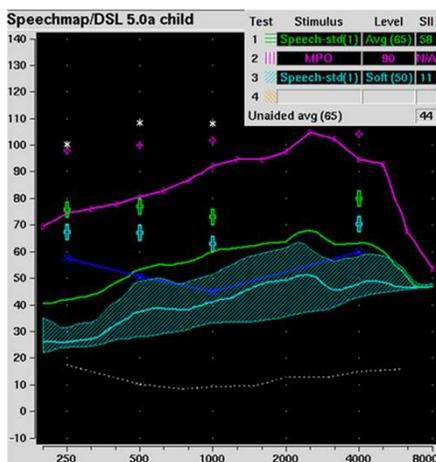
2011

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93

## When we can't match target?

- Degree of hearing loss
  - Severe +
- Configuration
  - Sloping / Reverse Sloping
- Bandwidth
- Poor earmold fit
  - Replace

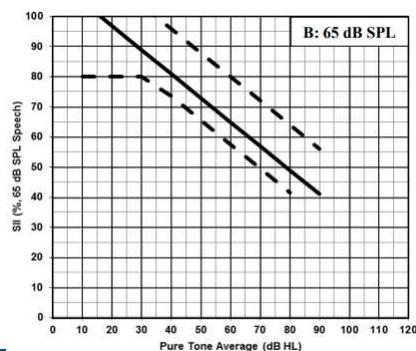


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94

## Children: How much audibility?

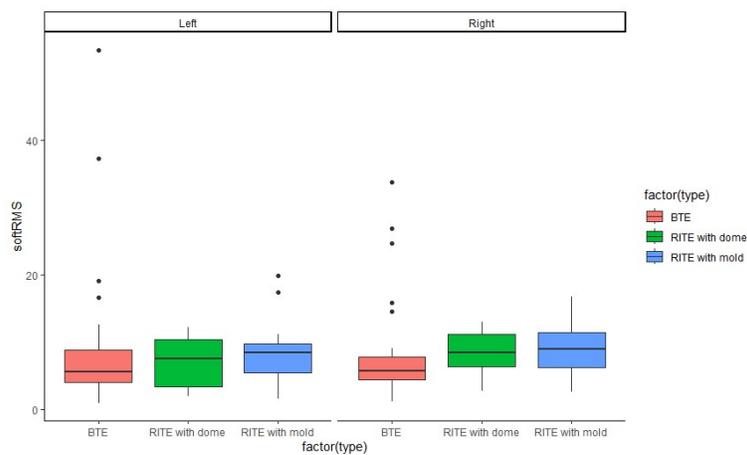
- Low RMS error (< 3 dB ideally)
- Normative range for audibility



Bagatto et al.  
2015  
[www.dslio.com](http://www.dslio.com)

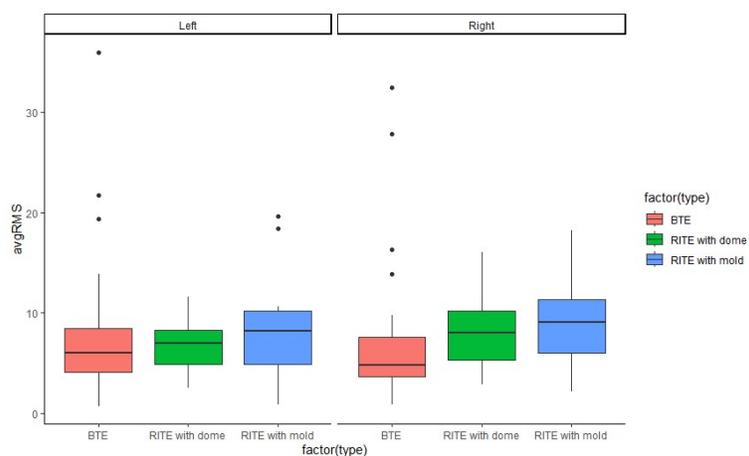
95

## RMS error for soft by coupling



96

## RMS error for average by coupling



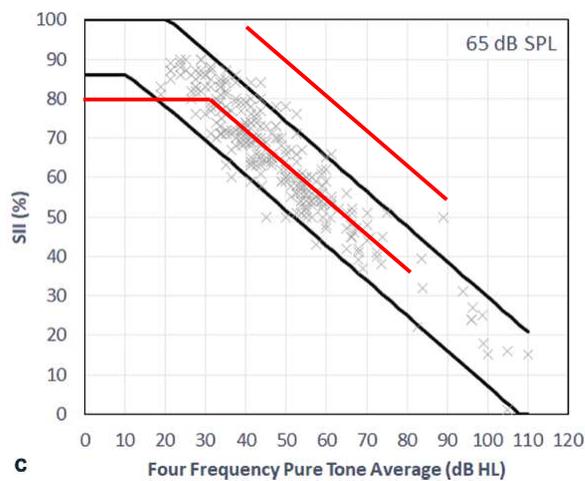
97

## Conclusions for teen fitting quality

- RMS errors are larger than were observed at younger ages
  - 5.5 dB RMSe (6 months – 12 years in McCreery et al. 2013)
  - 8.1 dB RMSe (12-19 years in Walker et al. in preparation)
- RMS error did not vary by fitting type
  - Trend for larger RMSe with RITE and non-custom dome fittings

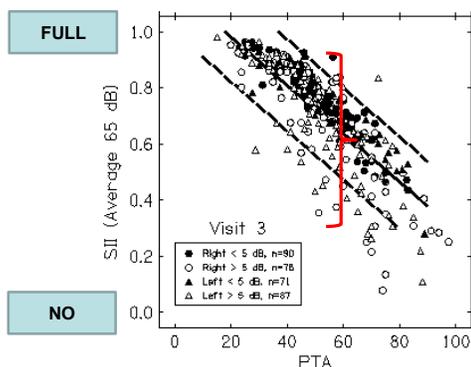
98

## Children vs. Adults – DSL norms



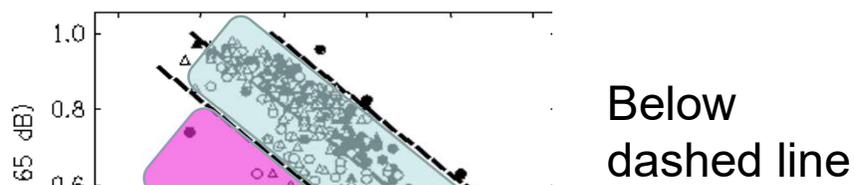
99

## Variation in Audibility (SII)



100

## Actual hearing aid fit quality

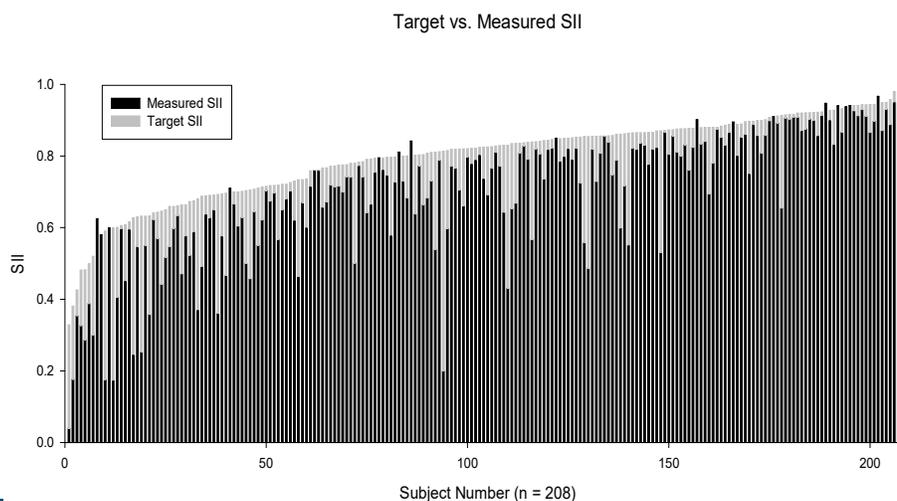


### Take home message:

Hearing aids are not appropriately fit for all children – 35% below normative mean, 10% below 95% confidence intervals

101

## Can we assume all children have well-fit hearing aids?



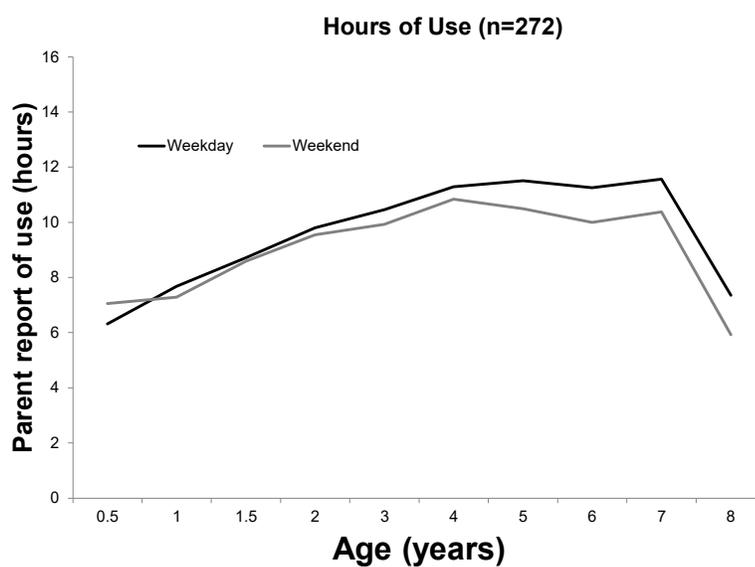
102

## Consistent hearing aid use

Hearing aids for children can only benefit them when they are wearing them

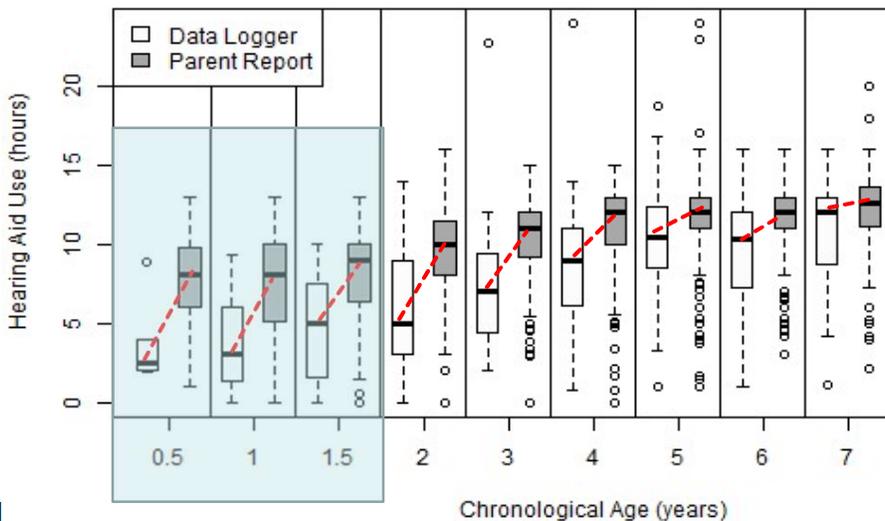
103

What factors predict the amount of time children wear HAs on a daily basis?



104

# Hearing aid use



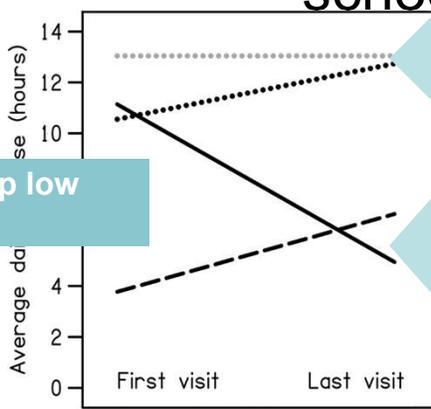
Walker et al., in review



105

# 16% end up as low users in elementary school

16% end up low users



**Routine users:**

- Mothers with a bachelor's or post-grad degree
- Worse hearing loss (higher BEPTA)

**Limited users:**

- Mothers with some college
- Milder hearing loss (lower BEPTA)

- Start high increase (n=20)
- Start high non-increase (n=43)
- Start high decrease (n=6)
- - - Start low increase (n=6)

Walker et al., 2015



106

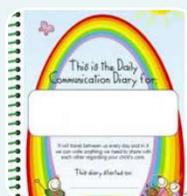
## What child and family factors relate to HA use?

- Chronological age, SES, degree of hearing loss (Walker 2013)
- Issues with managing hearing aids (Munoz et al. 2014)
  - frustration
  - confusion
  - lack of confidence
- Perception of benefit with hearing aid

**Malleable!**

107

## How can we counsel consistency of use?



Find times when initial use is most practical

Communication diary

Datalogging

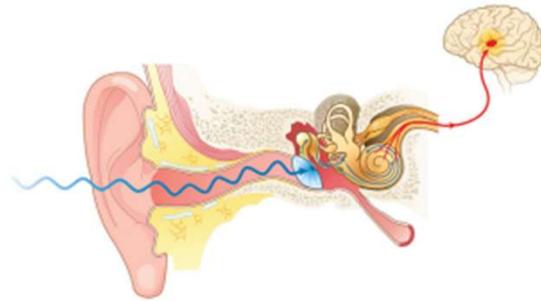
Emphasize link between auditory stimulation and language

108

## BRAIN COMMUNICATIONS

### Auditory experience modulates fronto-parietal theta activity serving fluid intelligence

Elizabeth Heinrichs-Graham,<sup>1,2,3</sup> Elizabeth A. Walker,<sup>4</sup> Brittany K. Taylor,<sup>1,2,3</sup>  
Sophia C. Menting,<sup>3,5</sup> Jacob A. Eastman,<sup>1,3</sup> Michaela R. Frenzel<sup>1,3</sup> and Ryan W. McCreery<sup>6</sup>

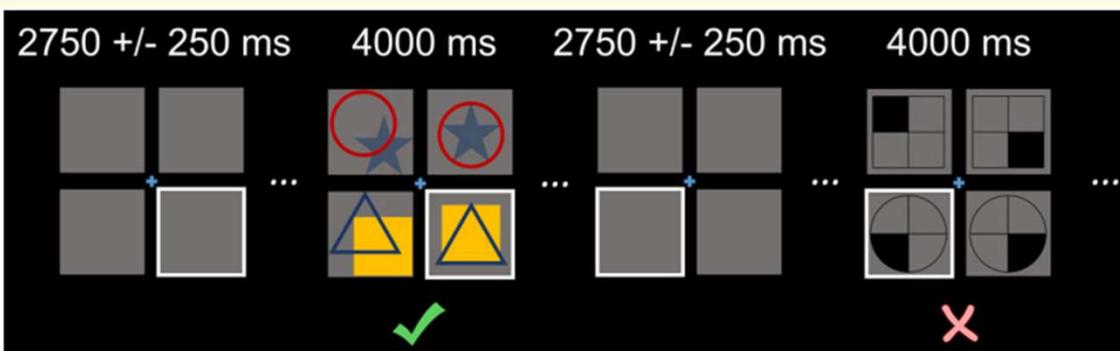


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109

## Fluid intelligence task

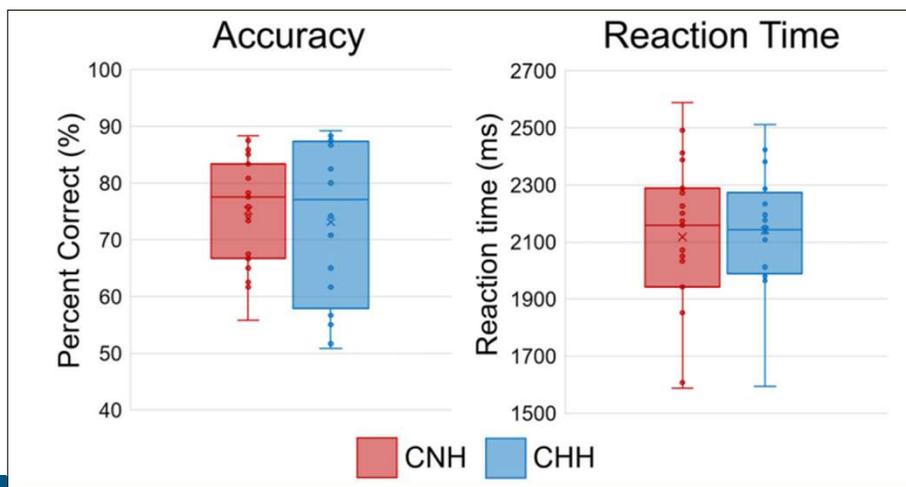


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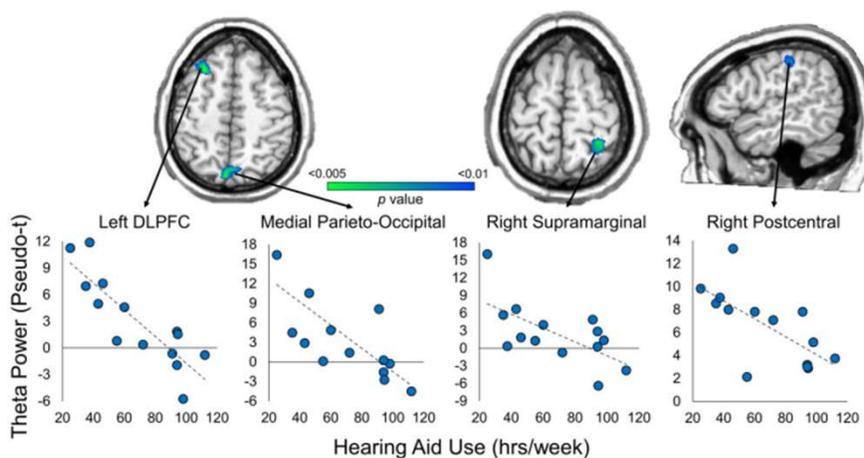
110

## No difference in accuracy or reaction time



111

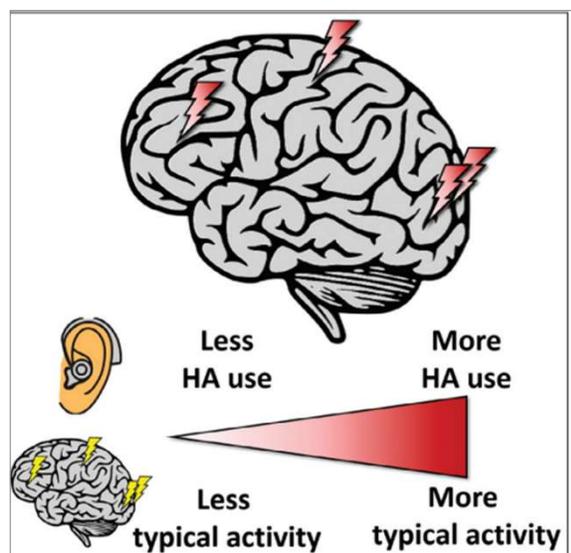
For children with HL, more hearing aid use associated with greater normalization of brain activity in the frontal-parietal parts of the brain



112

## Clinical implications

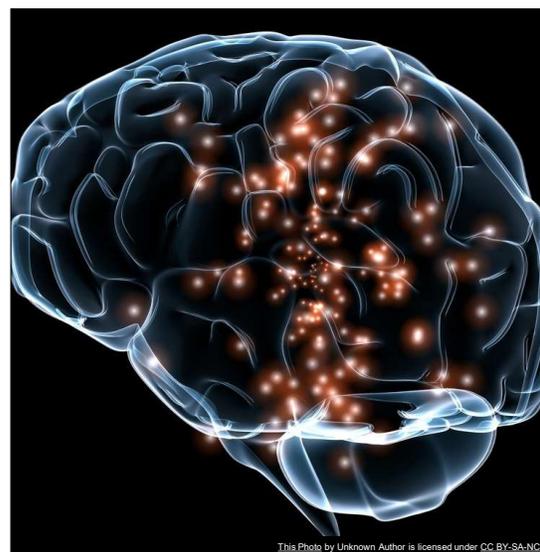
Children who wear their hearing aids less than 60 hours/week (~8.5 hours/day) show atypical neural activity during working memory encoding and maintenance and fluid intelligence tasks.



113

## Clinical implications

- Brain is having to “work harder” to maintain functions
- Does that have an impact on fatigue?
- How can we measure fatigue throughout the day?



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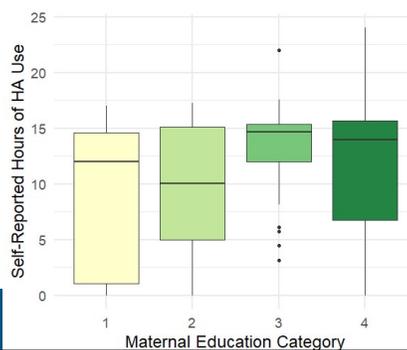
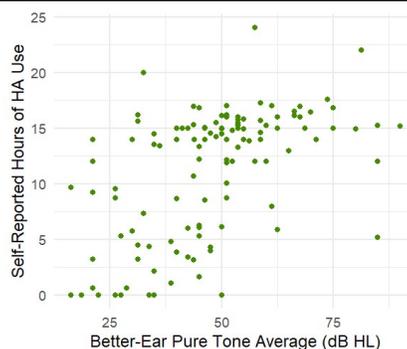
114

Severity of Hearing Loss	Mild HL (n = 37)	Moderate HL (n = 65)	Severe-Profound HL (n = 24)	F Statistic	p-value
Mean	6.89	12.69	14.74	23.58	< .001
SD	6.06	4.50	3.77		
95% Confidence Interval	5.30-8.48	11.49-13.89	12.76-16.72		
Maternal Education Level	Some College or Less (n = 44)	College Degree (n = 40)	Post-Graduate (n = 43)	F Statistic	p-value
Mean	9.57	13.17	11.48	4.44	.014
SD	6.13	3.88	6.18		
95% Confidence Interval	7.92-11.22	11.44-14.91	9.81-13.16		
Root-Mean-Square Error	< 3 dB SPL (n = 22)	3-5 dB SPL (n = 28)	> 5 dB SPL (n = 45)	F Statistic	p-value
Mean	11.90	12.79	12.00	.27	.764
SD	5.36	4.61	5.11		
95% Confidence Interval	9.77-14.03	10.91-14.68	10.51-13.49		

115

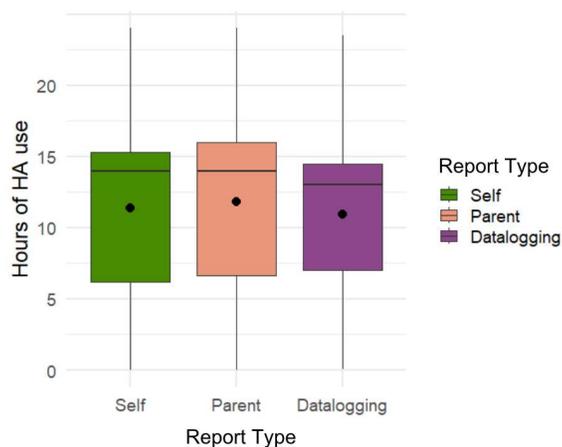
### What variables are associated with HA use time?

- Better-ear PTA and maternal education level significant (Higher PTA and higher maternal education level associated with higher use)
- Chronological age, age at hearing aid fitting, and optimality of hearing aid fitting were not significant



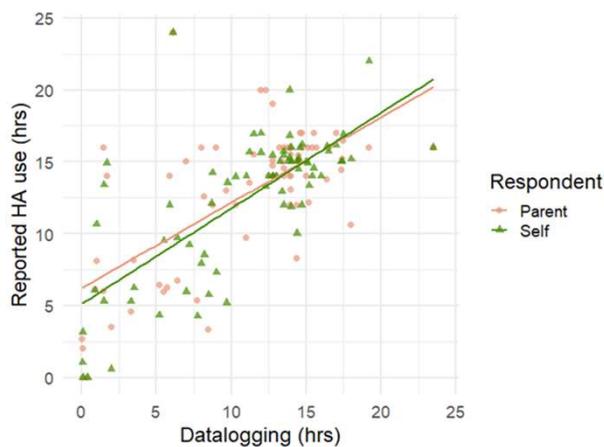
116

## Type of report



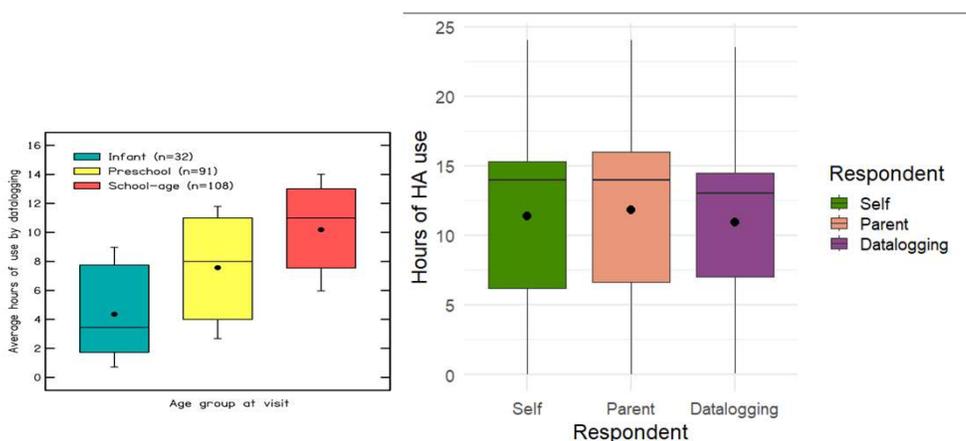
117

## Association between self/parent report



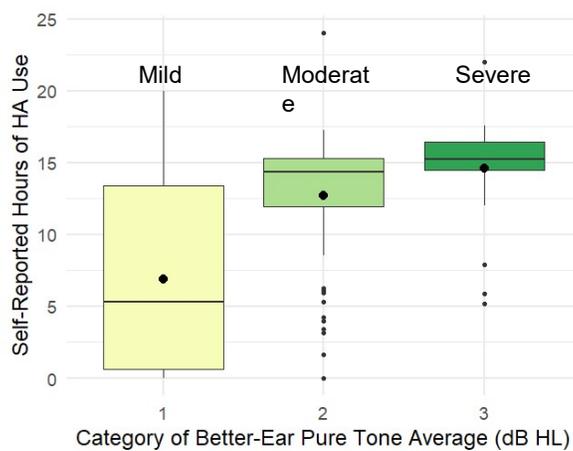
118

## How often do adolescents wear HAs?



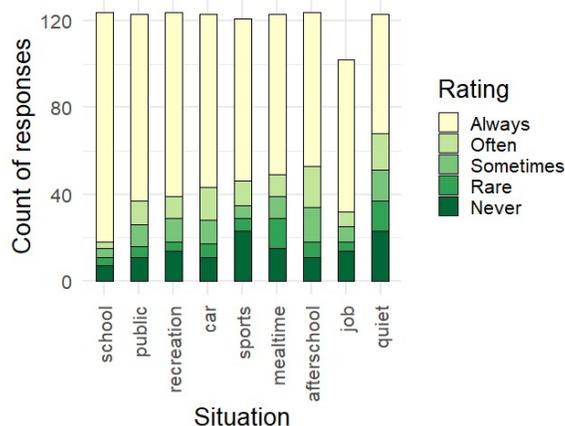
119

## Self-report by degree of hearing loss



120

## Situational hearing aid use



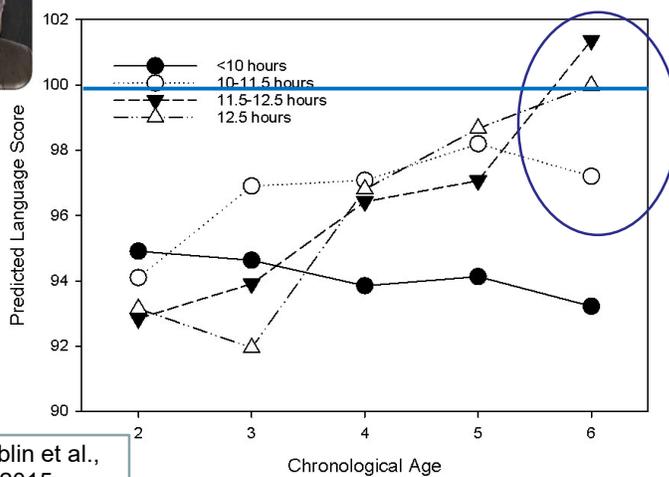
121

## Take-aways

- Teens are using their hearing aids about 10-12 hours/day
- Good agreement between self/parent report and datalogging
- Same trends observed as in studies of younger children
  - Degree of hearing loss
  - Socioeconomic status (\*)
  - Situational patterns

122

## Language scores by daily HA use



Tomblin et al.,  
2015

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123

## Consistent hearing aid use matters

- Support quality time vs. quantity of time
- Is their evidence to support “all waking hours”?

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124

## Consistent hearing aid use

# Audiologist's Role

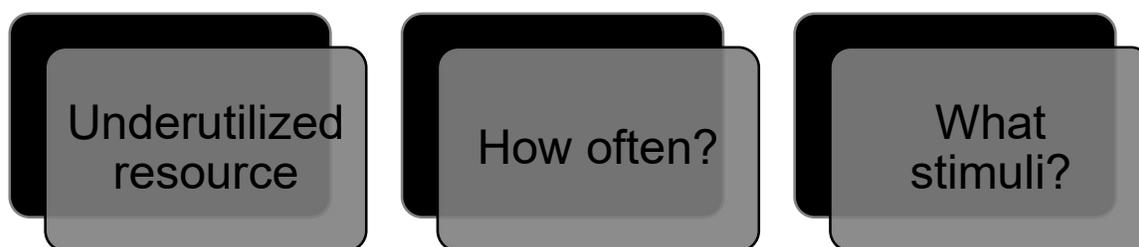
- Ask about hearing aid use and use data logging
  - What situations are challenging?
  - Where are you experiencing success?
- Support families
- Work with early intervention and other providers to support use

125

# QUESTIONS

126

## Aided speech recognition



127

## Pediatric Minimum Speech Test Battery

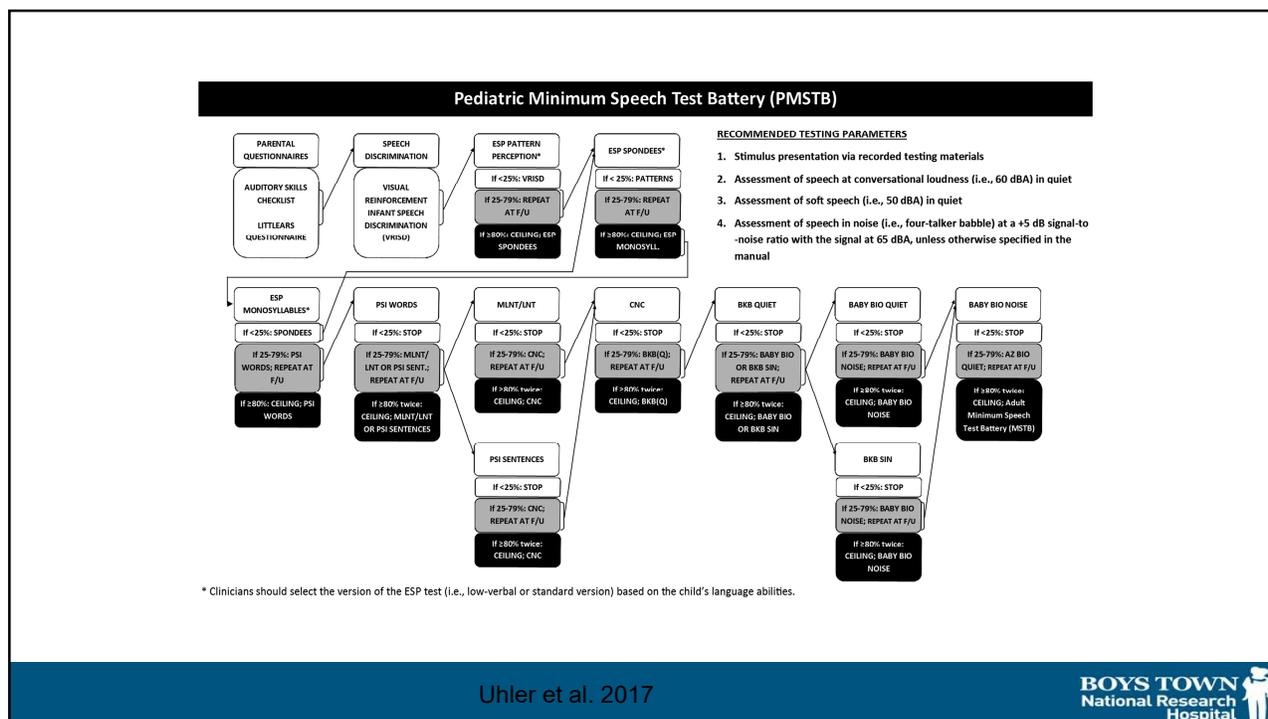
Described by Uhler et al. 2017

Developed with input from a large number of pediatric audiologists, mostly in North America

English-based

Goal of standardizing pediatric speech recognition assessment

128



129

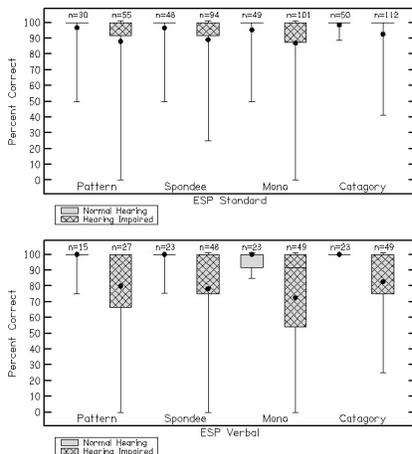
## Pediatric MSTB

### RECOMMENDED TESTING PARAMETERS

1. Stimulus presentation via recorded testing materials
2. Assessment of speech at conversational loudness (i.e., 60 dBA) in quiet
3. Assessment of soft speech (i.e., 50 dBA) in quiet
4. Assessment of speech in noise (i.e., four-talker babble) at a +5 dB signal-to-noise ratio with the signal at 65 dBA, unless otherwise specified in the manual

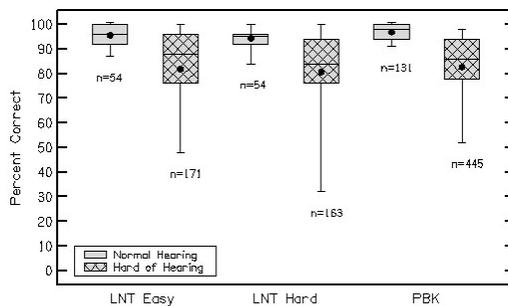
130

# What makes a good speech recognition test?



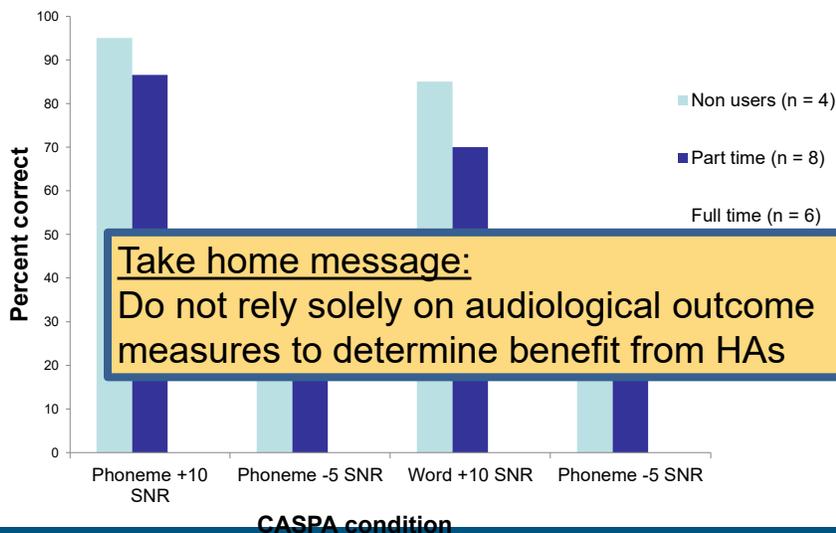
131

# Performance on monosyllabic words in quiet



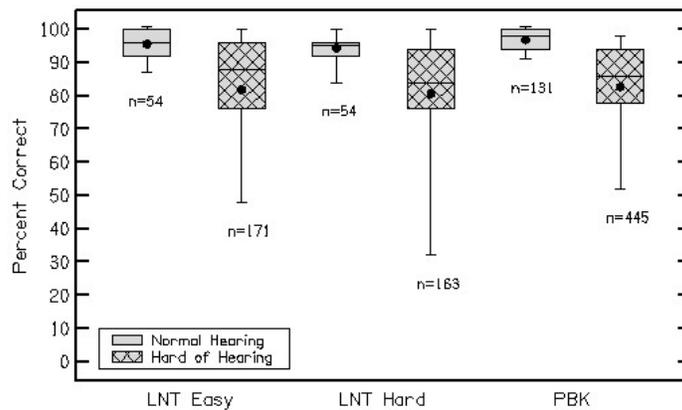
132

### There were no differences between groups for speech recognition in noise



133

### Performance on monosyllabic words in quiet



134

# FASTRAK Speech Recognition Tests

Two-talker speech  
masker

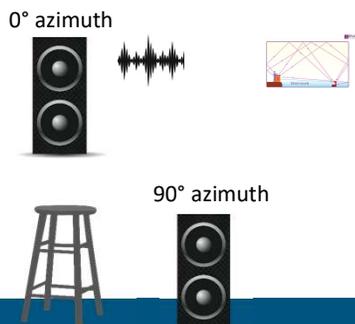
Reverberation

Spatial separation of  
target and masker

135

## Conditions

1. Speech Shaped Noise (SSN) Co-located
2. Two-Talker Masker (TTM), Co-located, No Reverberation
3. Two-Talker Masker, Co-located, Reverberation
4. Two-Talker Masker, spatially separated



136

# Introduction

Masker (M)

Target (T)

CO-LOCATED

BOYS TOWN National Research Hospital

The diagram illustrates a 'CO-LOCATED' scenario. At the top, the word 'Introduction' is centered. Below it, the text 'Masker (M)' is positioned above an illustration of a grey 3D figure holding a yellow and green shield. Below this, the text 'Target (T)' is positioned above another grey 3D figure. At the bottom, a light blue circle with a black border and a small triangle at the top contains the text 'CO-LOCATED'. The entire diagram is set against a white background within a black-bordered frame. A dark blue footer bar at the bottom right contains the 'BOYS TOWN National Research Hospital' logo and a small icon of a person.

137

# Introduction

Target (T)

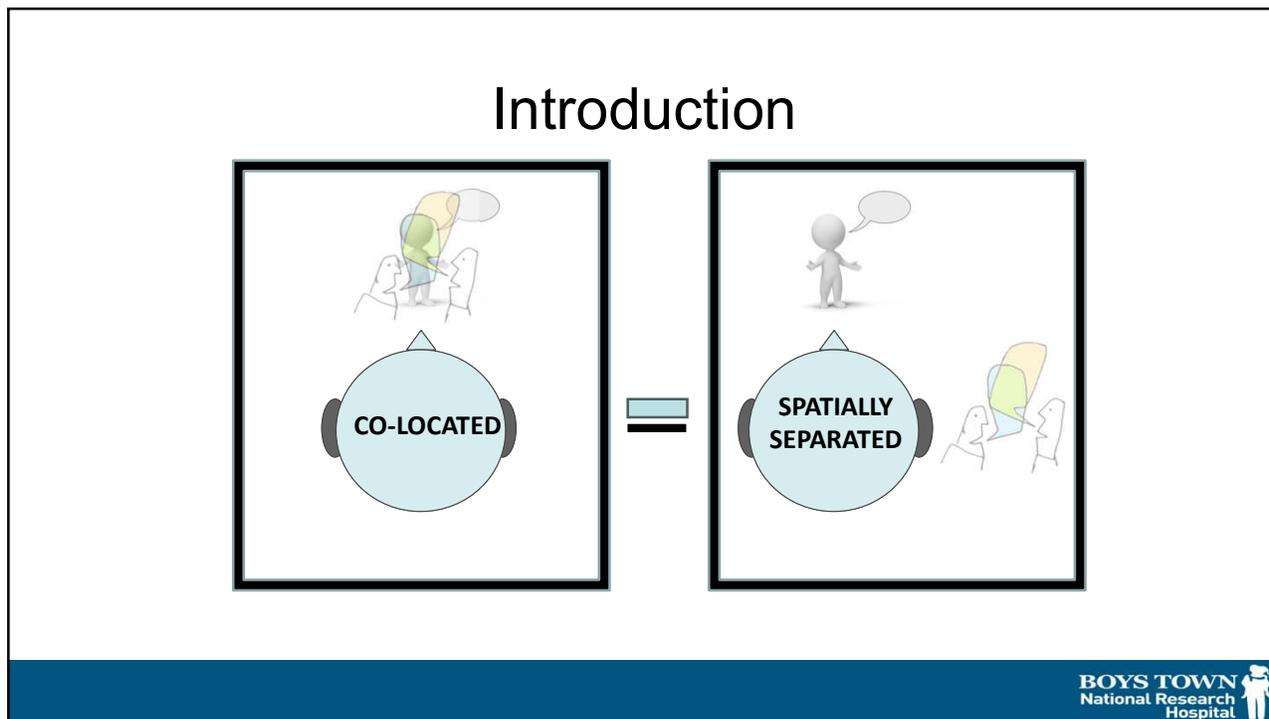
SPATIALLY SEPARATED

Masker (M)

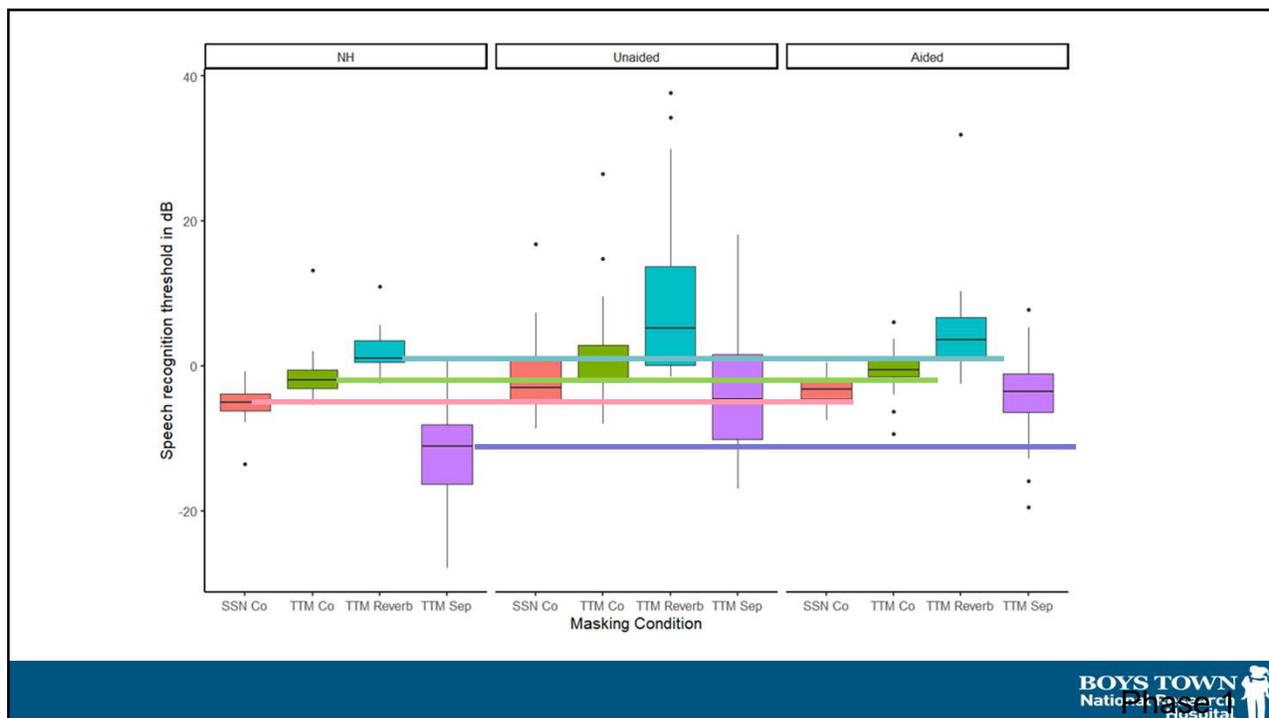
BOYS TOWN National Research Hospital

The diagram illustrates a 'SPATIALLY SEPARATED' scenario. At the top, the word 'Introduction' is centered. Below it, the text 'Target (T)' is positioned above a grey 3D figure with a speech bubble. Below this, the text 'SPATIALLY SEPARATED' is inside a light blue circle with a black border and a small triangle at the top. To the right of the circle, the text 'Masker (M)' is positioned above an illustration of a grey 3D figure holding a yellow and green shield. The entire diagram is set against a white background within a black-bordered frame. A dark blue footer bar at the bottom right contains the 'BOYS TOWN National Research Hospital' logo and a small icon of a person.

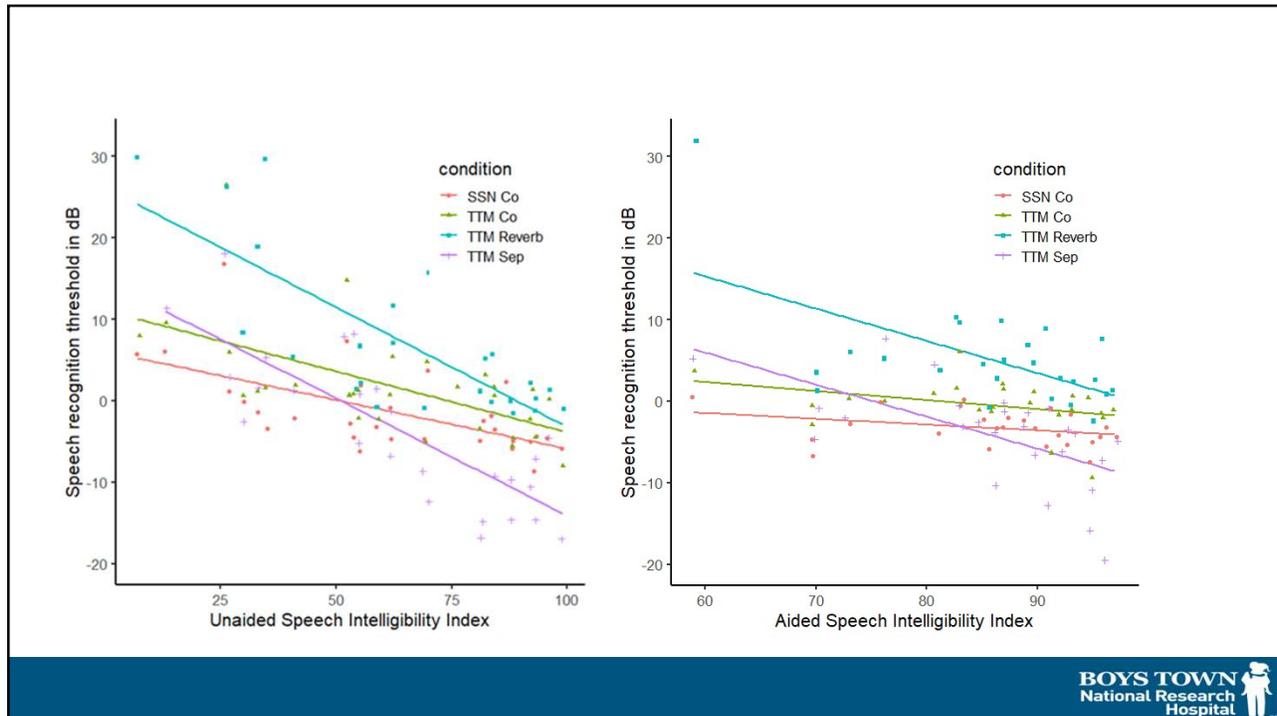
138



139



140



141

2020                      2021                      2022

**Develop audibility-based candidacy tools for children with mild, bilateral hearing levels**

Validate clinical tools in complex listening conditions in the laboratory

Test a clinical battery of hearing assessment and technology candidacy tools in clinical environments

The screenshot shows the 'FASTRAK BKB Sentence Recognition' software interface. It includes fields for 'Hearing Aids', 'Record ID', 'Threshold 1', and 'Threshold 2'. Under 'Conditions', there are checkboxes for '2T - Separated - No Reverb', 'SSN - Colocated - No Reverb', '2T - Colocated - Reverb', and '2T - Colocated - No Reverb'. 'Sentence Options' includes 'Starting List' (3), 'Starting Sentence' (7), and 'Starting SNR' (10). 'Conditions with Hearing Aids' has checkboxes for '2T - Colocated - Reverb', '2T - Separated - No Reverb', 'SSN - Colocated - No Reverb', and '2T - Colocated - No Reverb'. 'Masker' has radio buttons for 'SSN' and '2-Talker'. 'Spatial Config' has radio buttons for 'Colocated' and 'Separated'. 'Reverb' has radio buttons for 'No' and 'Yes'. A 'Start' button is at the bottom.

2

Speech recognition test that is sensitive to difficulty of children with mild hearing levels



142

2020      2021      2022

Boys Town National Research Hospital  
Ryan McCreery, Ph.D.

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Elizabeth Walker, Ph.D., CCC-SLP/A

Washington University at St. Louis | St. Louis, MO  
Lisa Davidson, Ph.D.

Arkansas Children's Hospital | Little Rock, AR  
Patti Martin, Ph.D.

University of North Carolina - Chapel Hill | Chapel Hill, NC  
Emily Buss, Ph.D.

Boston Children's Hospital | Boston, MA  
Derek Stiles, Ph.D., CCC-A, CH-AP

Test a clinical battery of hearing assessment and technology candidacy tools in clinical environments

202

Enroll children at satellite clinics across the US

**BOYS TOWN**  
National Research Hospital

143

Arkansas Children's

THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL

Boston Children's Hospital  
Where the world comes for answers

Washington University in St. Louis

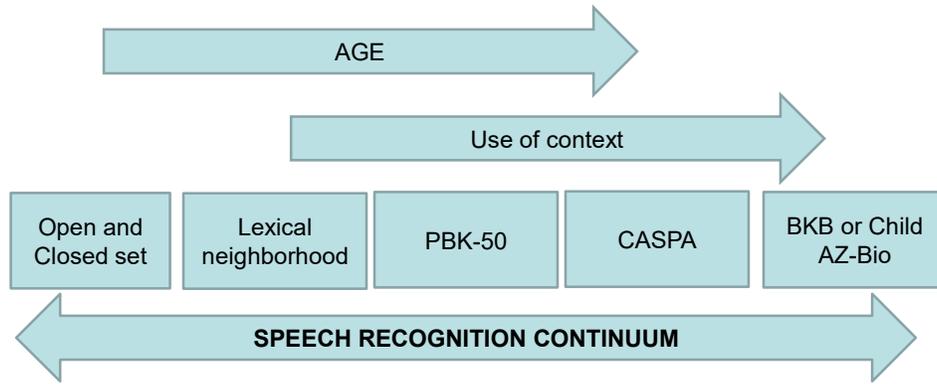
IOWA

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144

## Aided Speech Recognition Battery



145

## Open & Closed Set Test (O&C)

- Developed by: Ertmer, Miller, & Quesenberry, 2004
- Appropriate for ages 18 to 24 months
- A measure of perception and production
- 10 items using realistic pictures
- Production followed by picture identification

KEYS

dertmer@purdue.edu

146

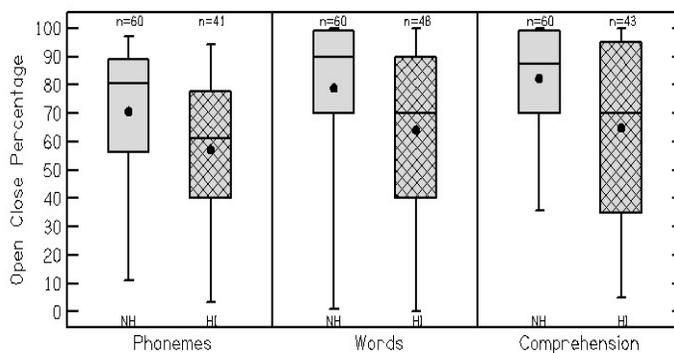
## O&C: Administration



Mom: And "keys"... Child: /tis/... Mom: uh huh, where are they?  
 Child: /tis/ + point. Mom: very good.

147

## Open and Closed Set Task



**2 year-olds**

148

## Questionnaires

Parent, teacher,  
or child report

Track progress

Can be  
completed from  
infancy through  
adulthood

149

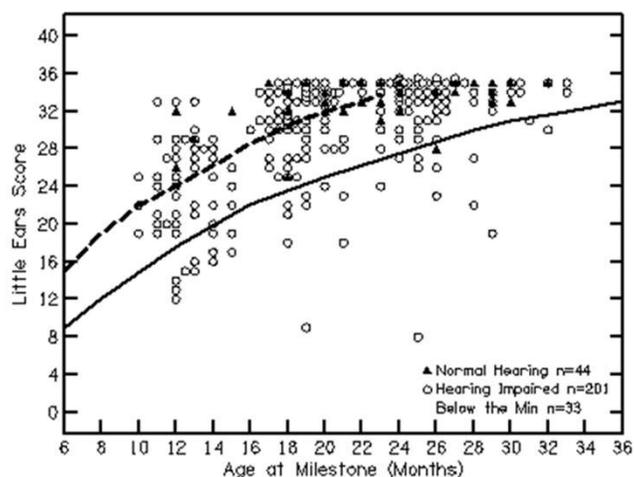
## Auditory Development Questionnaires

LittleEars – 6  
months – 2  
years

PEACH  
2 years or >  
28 on LittleEars

150

## LittIEARS



151

## LittIEars Predictors

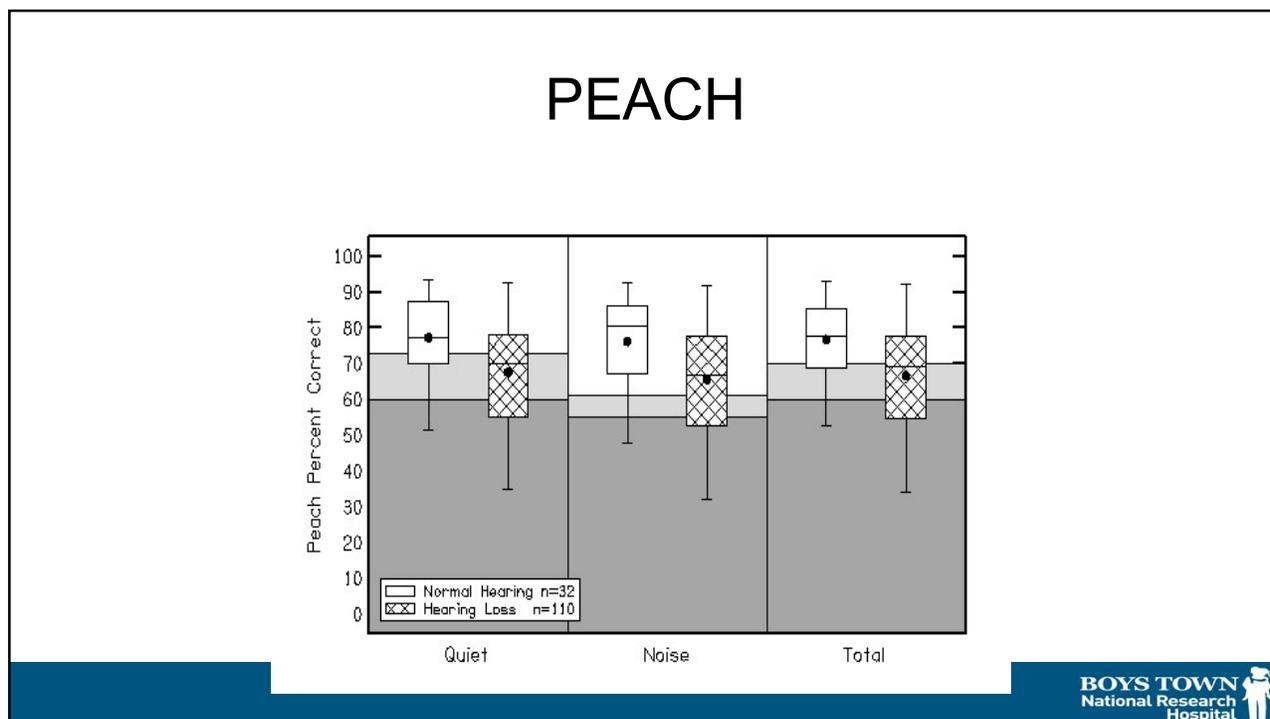
### Positive predictors

- Age
- Audibility
- Receptive Language
- Open and Closed Set Speech Recognition
- Hearing Aid Use

### Not predictive

- Maternal education

152



153



154

## Questionnaires Conclusions

Use questionnaires from early ages

Discuss progress over time with parents and team

Available in many languages other than English

155

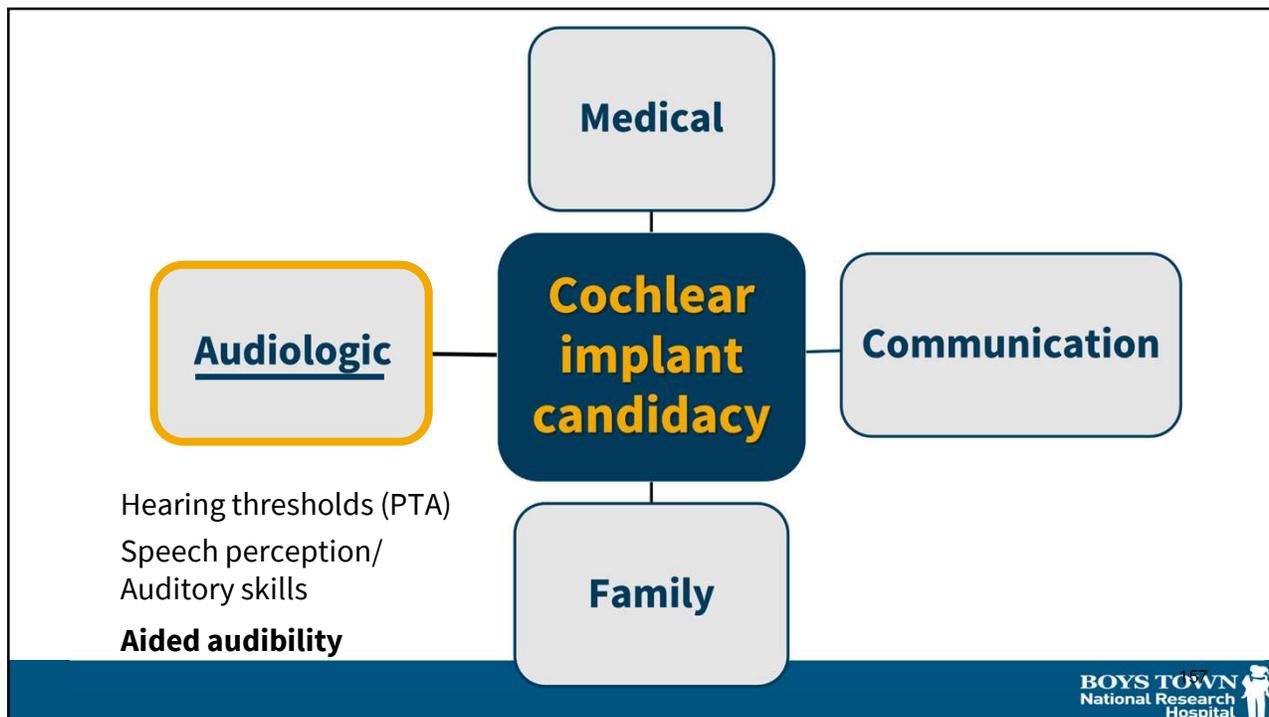
## To refer or not to refer?

Wait and see with hearing aid?



Refer for cochlear implant candidacy evaluation

156



157

## Using audibility adds to CI candidacy

**Hearing aid output**

**Effect of ear canal acoustics on threshold**

**Impact of hearing loss on speech audibility**

**Hearing loss configuration**

Frequency (Hz)	Hearing Level (dB HL)
250	10
500	20
1000	30
2000	40
4000	50
8000	60

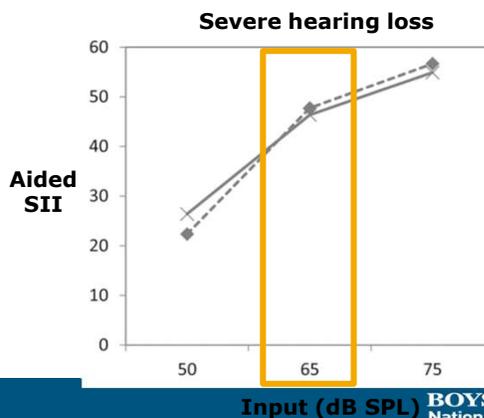
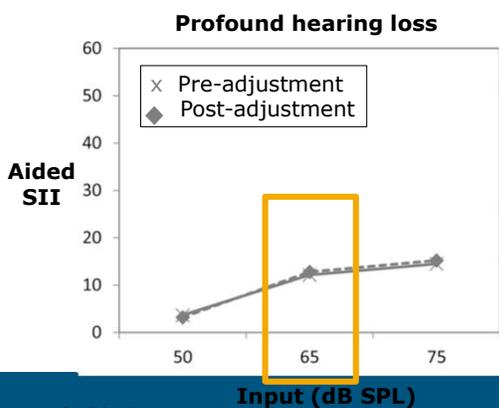
Leal et al., 2016; Nickerson et al., 2019

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158

# Hearing aid fitting outcome: audibility

How much audibility is enough?



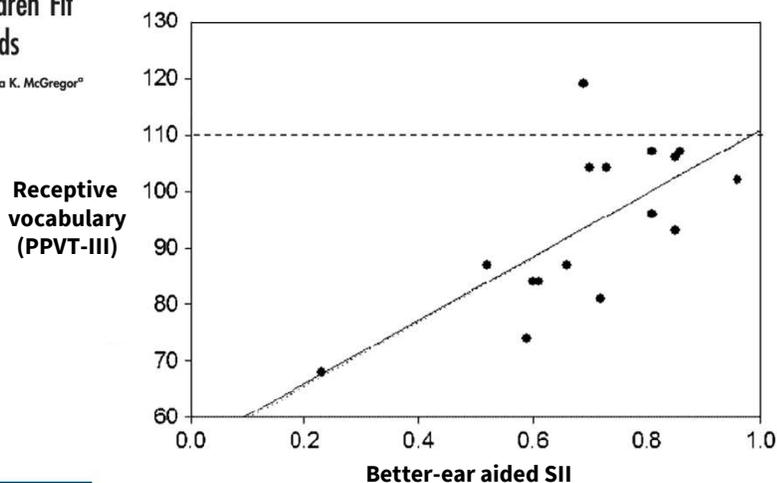
Quar et al. 2019



159

JSLHR  
Article  
**The Speech Intelligibility Index and the Pure-Tone Average as Predictors of Lexical Ability in Children Fit With Hearing Aids**

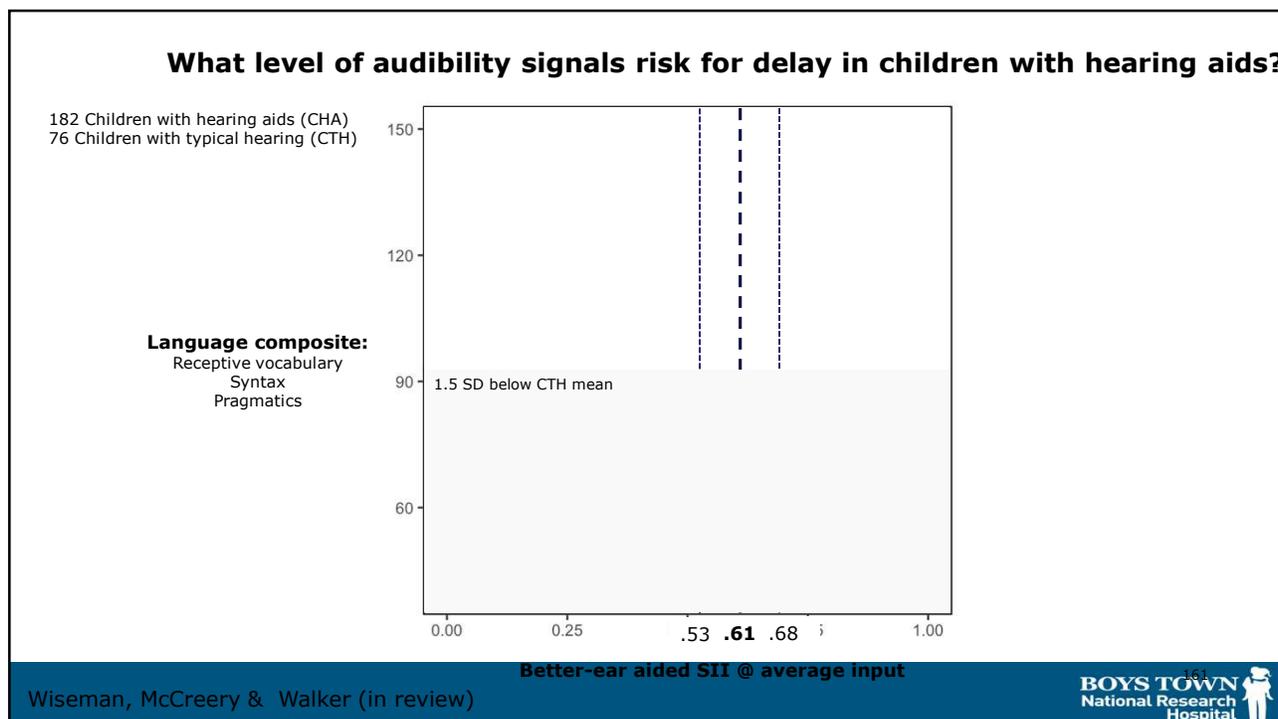
Derek J. Stiles,<sup>a</sup> Ruth A. Bentler,<sup>a</sup> and Karla K. McGregor<sup>a</sup>



Stiles, Bentler & McGregor, 2012



160



161


AJA 

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**Tutorial**

**The Speech Intelligibility Index: Tutorial and Applications for Children Who Are Deaf and Hard of Hearing**

Kathryn B. Wiseman,<sup>a</sup> Caitlin Sapp,<sup>b</sup> Derek Stiles,<sup>c</sup> Elizabeth A. Walker,<sup>d</sup> and Ryan W. McCreery<sup>a</sup>

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162