Optimizing amplification for children and adolescents with hearing loss

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TEXAS ACADEMY of AUDIOLOGY

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Conflicts of Interest

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NIH National Institute on Deafness and Other Communication Disorders
Advancing the science of communication to improve lives

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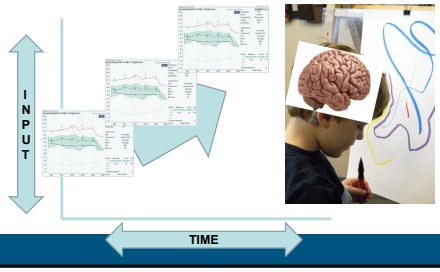
Cumulative Auditory Experience



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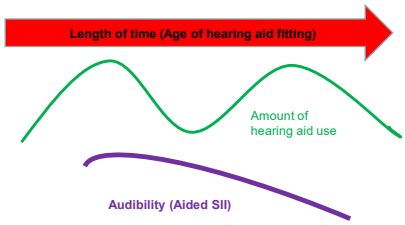
Auditory Experience



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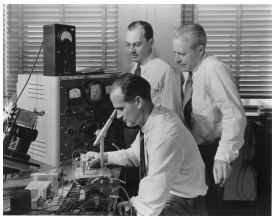
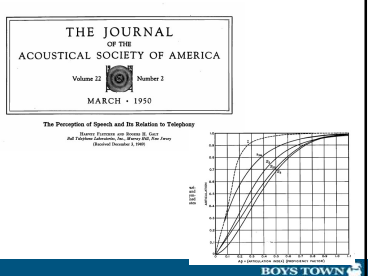
Audibility and telephony





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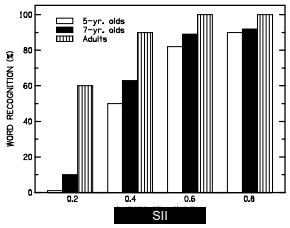
Audibility by age



Stelmachowicz et al. 2000

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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)

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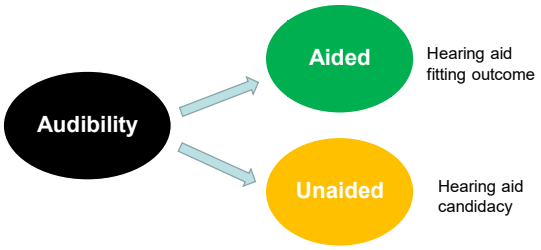
Audibility



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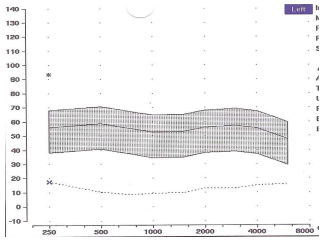
Average speech spectrum



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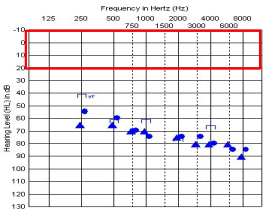
Hearing Thresholds

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



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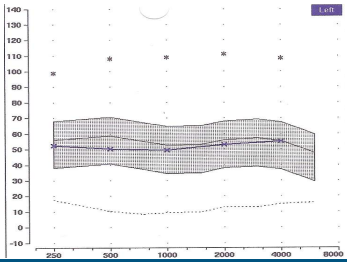
Audibility with Mild Hearing Loss



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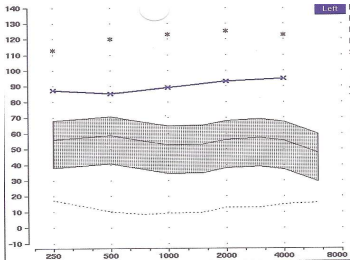
Audibility with Severe Hearing Loss



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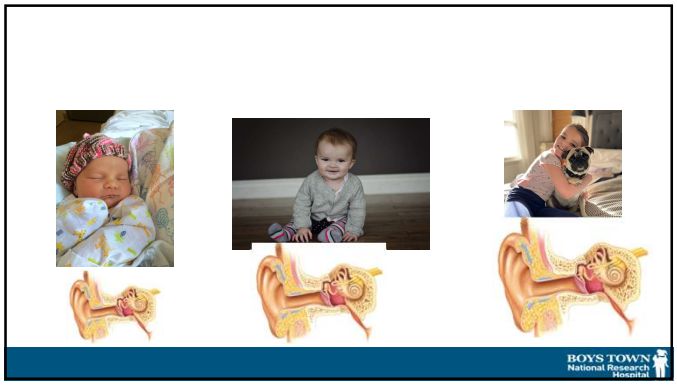

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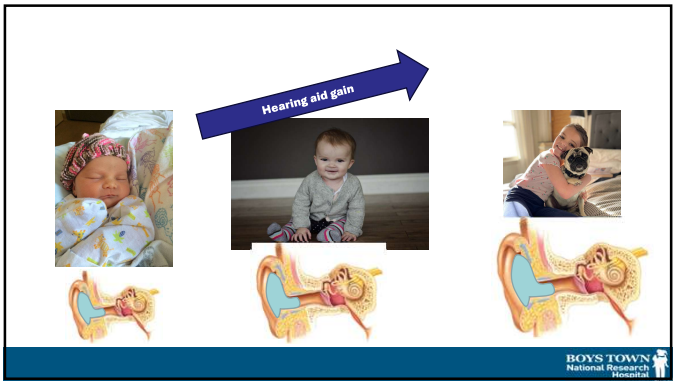

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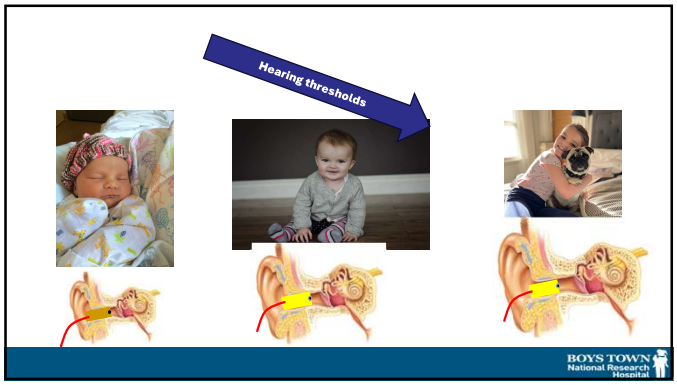

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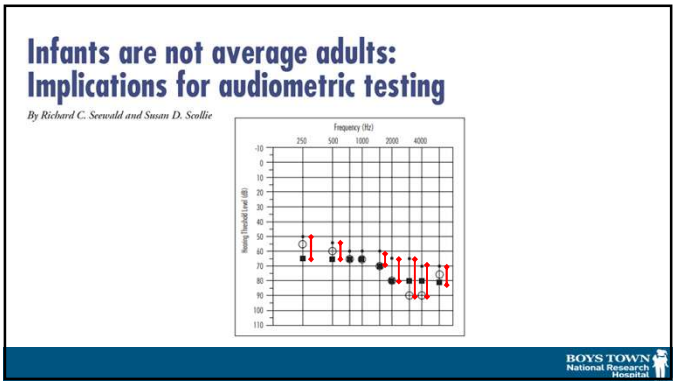

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Ear canal acoustics

- Assessment
- Hearing aid fitting

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Hearing aid candidacy

- Audibility

How does ear canal acoustics influence diagnostic assessment?

How does the hearing loss impact audibility?

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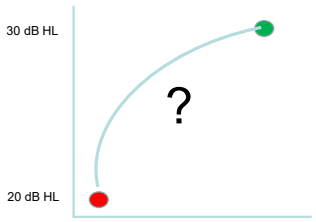
Fit children with mild bilateral hearing loss?



Clinical equipoise

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

To fit or not to fit?

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Is mild bilateral hearing loss a developmental risk?

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

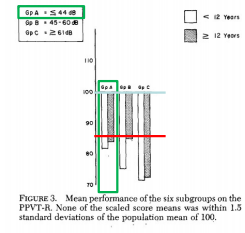

FIGURE 3. Mean performance of the six subgroups on the FPVT-R. None of the scaled score means was within 1.5 standard deviations of the population mean of 100.

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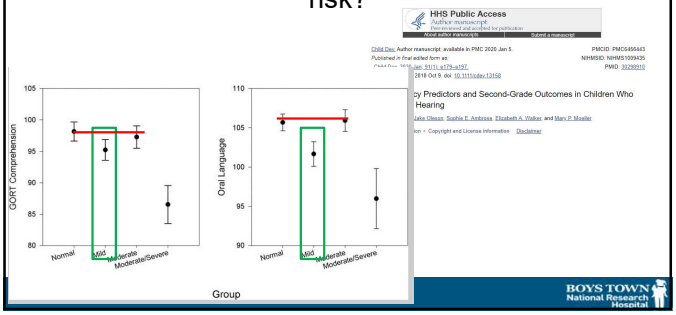
Is mild bilateral hearing loss a developmental risk?



HHS Public Access

Author manuscript

Predictors and Second-Grade Outcomes in Children Who Hearing

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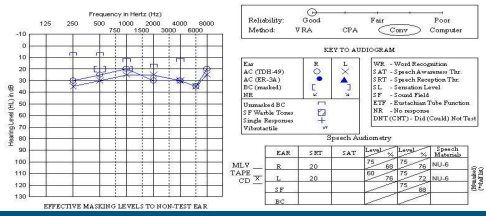
Hearing aid candidacy

- Audiogram method



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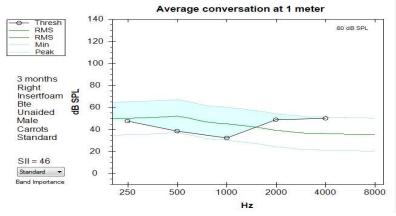
Hearing aid candidacy

- Audibility method – 3 month-old



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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

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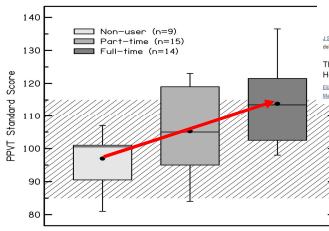
Does amplification help children with mild bilateral hearing loss?



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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

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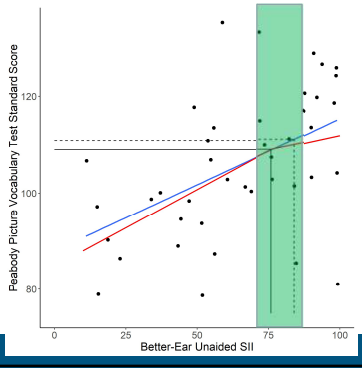

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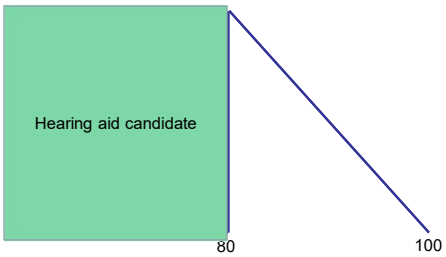
Unaided SII Criterion



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Unaided SII Criterion

PTA-based criterion

- Did not reflect effects of ear-canal acoustics
- Not based on language outcomes data
- Not easy to quantify impact of hearing on audibility

Unaided SII criterion

- Reflects effects of ear-canal acoustics on thresholds
- Based on language outcomes data
- Quantifies impact of hearing on audibility

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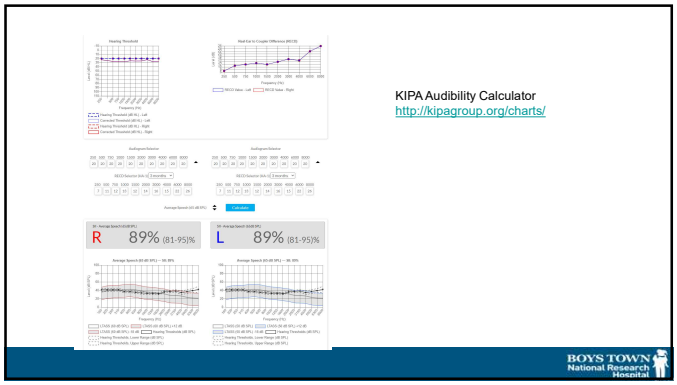

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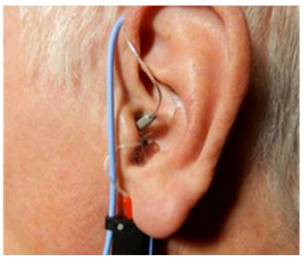
What is hearing aid verification?



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Which prescription for children?

- NAL-NL2/3
  - Loudness-based prescription
  - Most common adult prescription in our clinic
- DSL 5- Child
  - Audibility-based prescription
  - Only pediatric prescription

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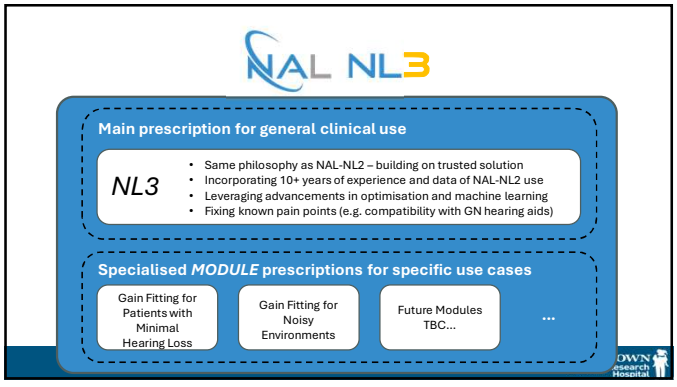

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Hearing aid verification outcomes

- Speech audibility
  - Unaided and aided SII
- RMS error
  - Fit-to-target
- Audible bandwidth
  - Maximum audible output frequency (MAOF)

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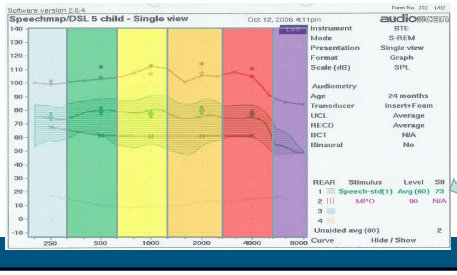
Aided Audibility



For each band – Audibility x FIW = weighted audibility

SII = Sum of weighted audibility of all frequency bands

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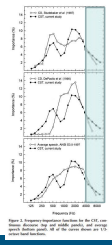
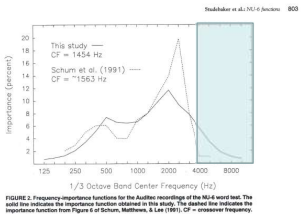
SII band importance and bandwidth

Sentences



Words



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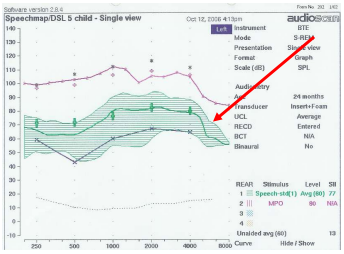
Audible bandwidth



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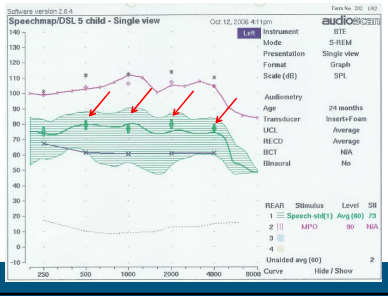
Target vs. Actual (RMS error)



Fitting data compared to DSL targets

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

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Better match to targets → better audibility

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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[a], Elizabeth A. Walker[b], Meredith Spratford[c], Marc Brennan[d] and Ryan W. McCreery[c]

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

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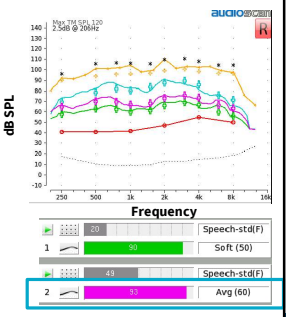
N = 307 children with hearing aids
Age = 5 months – 11.5 years

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)



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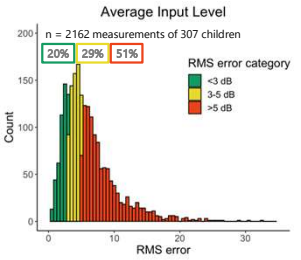

Half of hearing aid fittings had large error

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

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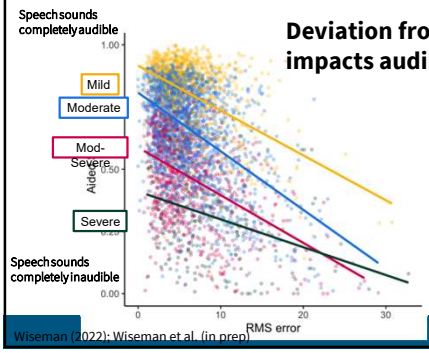

Deviation from target negatively impacts audibility

Fitting error (RMS error)

Audibility (aided SII)

.02 decrease in aided SII for every 1 dB increase in RMS error

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

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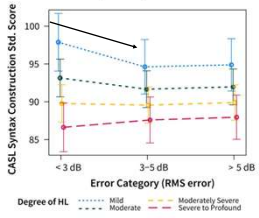
Lower RMS error criterion has advantages for language outcomes, esp. for milder HL



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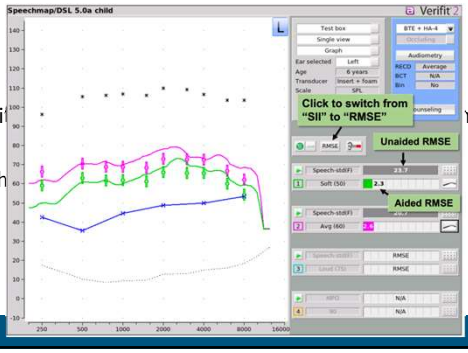
Veri…ments

Fit h…



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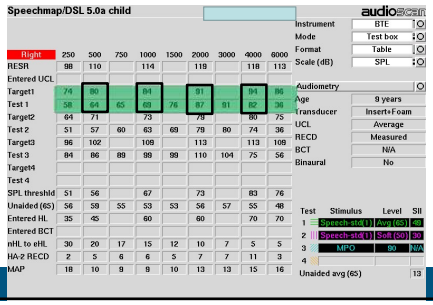
How can you measure RMS error?



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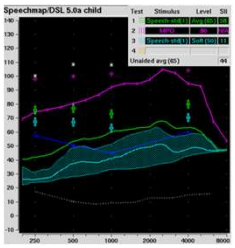
When we can't match target?

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



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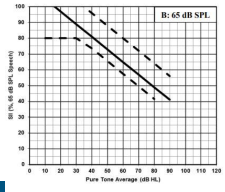
Children: How muchaudibility?

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



Bagatto et al.
2015
www.dslio.com

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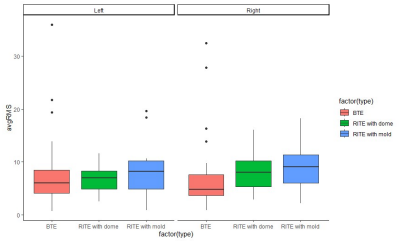
RMS error for average by coupling



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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

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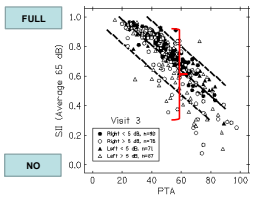
Variation in Audibilty (SII)



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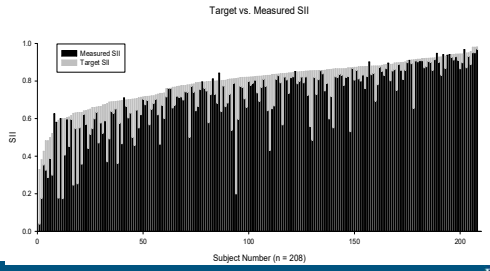
Can we assume all children have well-fit hearing aids?



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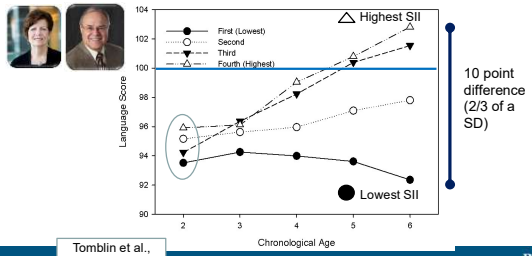
Language scores as a function of audibility



Tomblin et al., 2015

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Real ear or Simulated?

- Real-ear measurements
  - Hearing aid output is measured in the ear with a probe microphone
- Real-ear-to-coupler-difference (RECD)
  - Probe microphone measurement is applied to hearing aid measurements in the coupler

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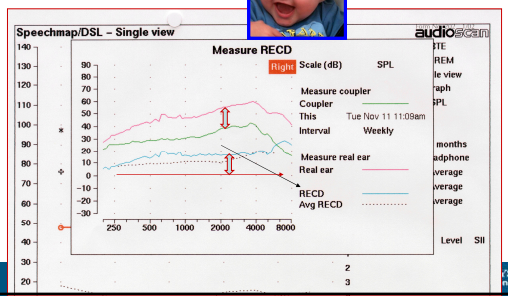
RECD in Infants



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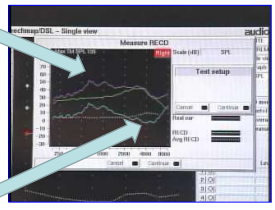
What affects RECD?

- Noise
- Abnormal TM
  - Perforation
  - PE Tube
- Middle ear effusion
- Ear canal size
- Probe tube insertion depth



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RECD: Average vs. Measured

- Patient's RECD always the preferred method.
- Age-related averages available
- If patient's RECD differs from averages
  - PE tube /Perforation
  - Stenosis/small ear canal
  - Noise ?

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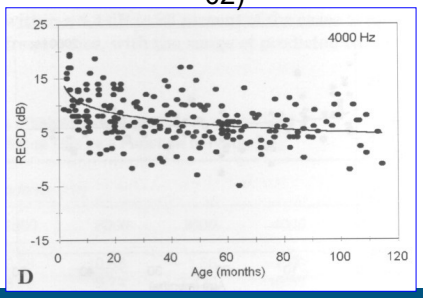
Age Related Averages (Bagatto et al, '02)



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What If I Just Can't?

- Use age-related averages if
  - Lack of cooperation (by baby)
  - Cerumen or drainage

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Both Ears?

- Tharpe et al. (2001) / Munro et al.
  - Between-ear RECDs modestly correlated
  - Generally reasonable to measure only one ear
- Look for obvious physical differences
  - Unilateral P.E. tube
  - Unilateral middle ear dysfunction
  - Ear canal anomalies

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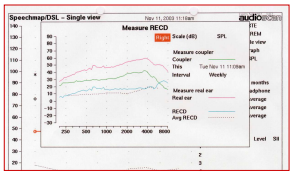
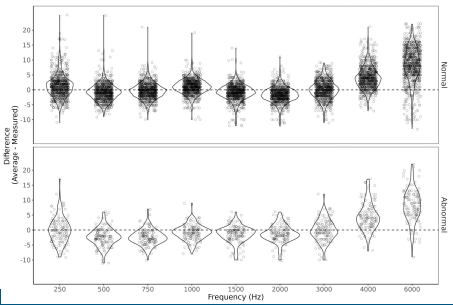
Can we use immittance to predict RECD?



McCreery et al. 2023/2024

64



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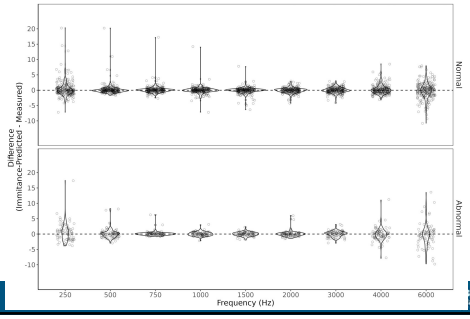


66

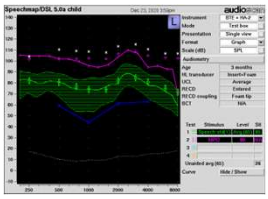
Changes related to middle ear status

- 3 months (ABR – normal middle ear)
- 8 months (post PE tube placement)
- 16 months (tubes extruded)

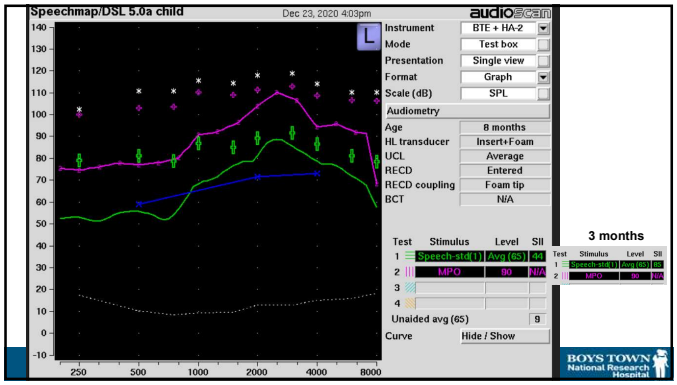
67

Initial fitting at 3 months

- Low RMSe
- Aided SII = 85
- Audible bandwidth > 6000 Hz



68



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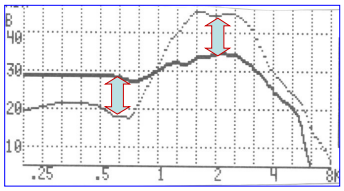
RECD in ear with Tympanostomy tube



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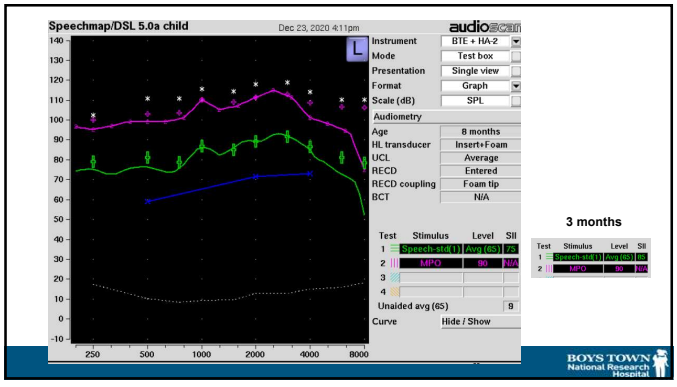
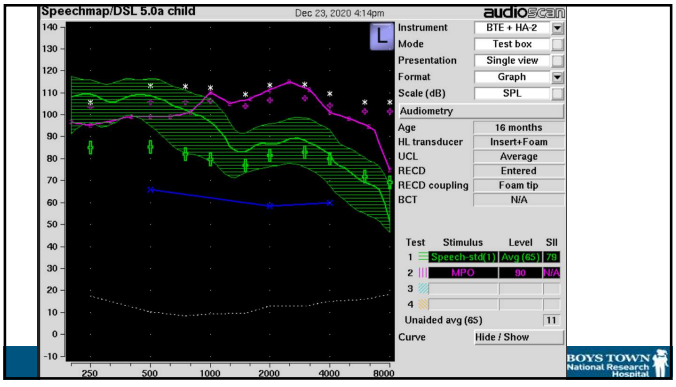
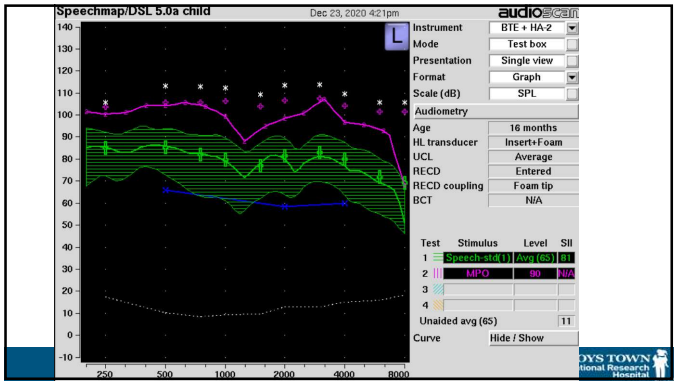


71



72



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Well-fitted hearing aids

Audiologist's role

- Use verification and pediatric prescription
- Measure the RECD or do in-situ (> 5 years) verification
- Do not rely on functional gain / aided sound field
- Make new earmolds and hearing aids frequently
  - Every 3-6 months under 3 years

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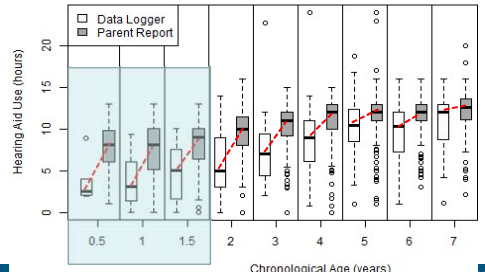
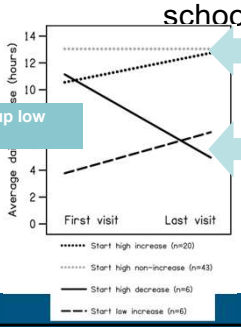
Hearing aid use



Walker et al., in review

75

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)

Walker et al., 2019

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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!

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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

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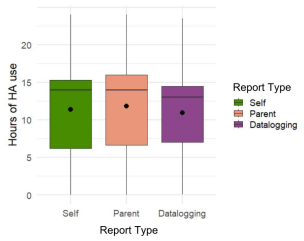
Type of report



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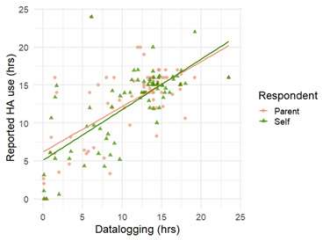
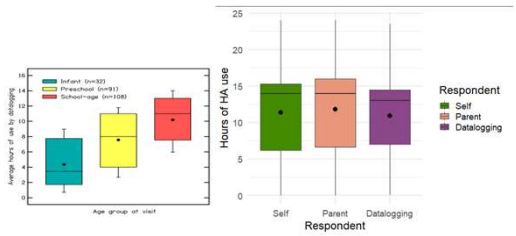
Association between self/parent report



80

How often do adolescents wear HAs?



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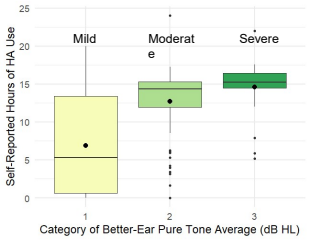
Self-report by degree of hearing loss



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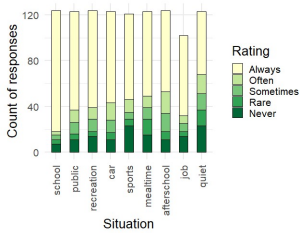
Situational hearing aid use



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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

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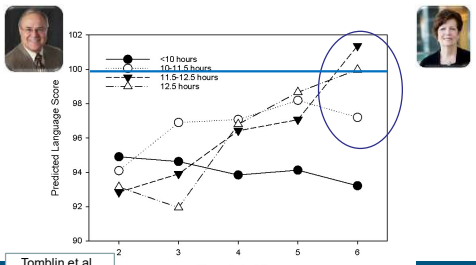
Language scores by daily HA use



Tomblin et al., 2015

85

Hearing aid use

- Average hours per day that hearing aids are worn.
  - Self-report
  - Parent-report
  - Data logging
- >10 hours / day is ideal
  - Quality time vs. quantity of time
- Data from Walker et al. 2025

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To refer or not to refer?

Wait and see with hearing aid?

Refer for cochlear implant candidacy evaluation

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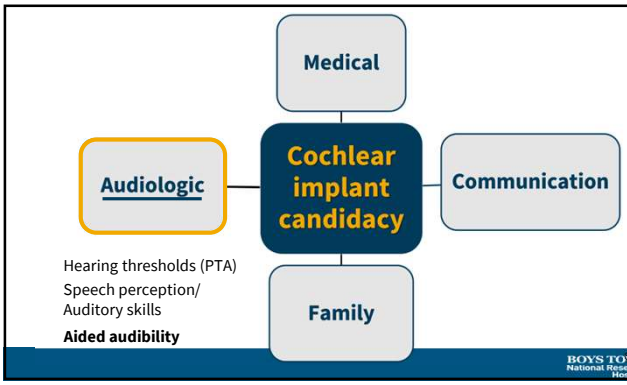

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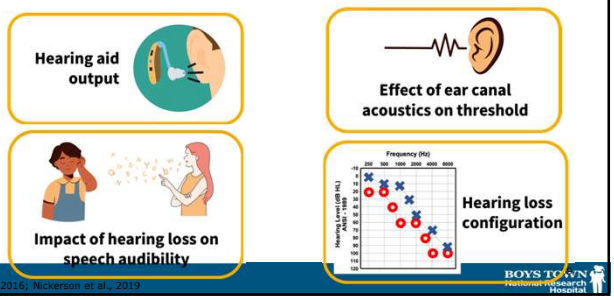
Using audibility adds to CI candidacy



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

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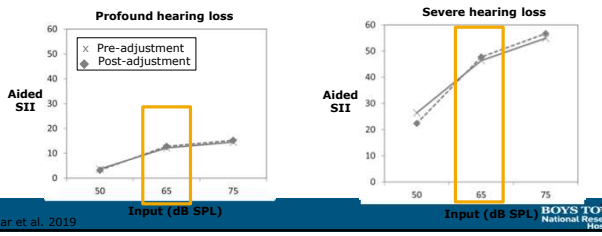
Hearing aid fitting outcome: audibility

How much audibility is enough?



Quar et al. 2019

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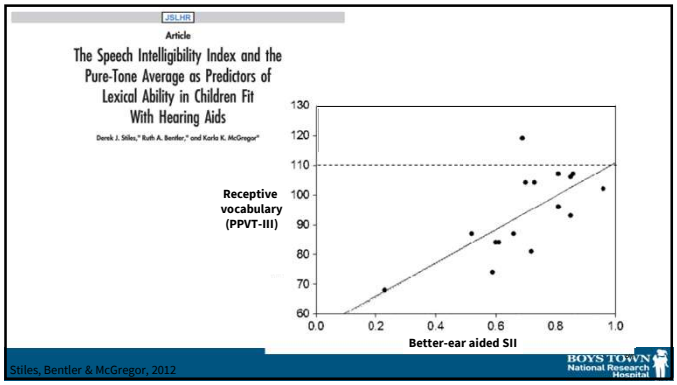
JSLHR
Article
The Speech Intelligibility Index and the Pure-Tone Average as Predictors of Lexical Ability in Children Fit With Hearing Aids
Derek J. Stiles,* Ruth A. Bentler,* and Karla K. McGregor*
Receptive vocabulary (PPVT-III)
130
120
110
100
90
80
70
60
0.0
0.2
0.4
0.6
0.8
1.0
Better-ear aided SII
Stiles, Bentler & McGregor, 2012
BOYS TOWN National Research Hospital

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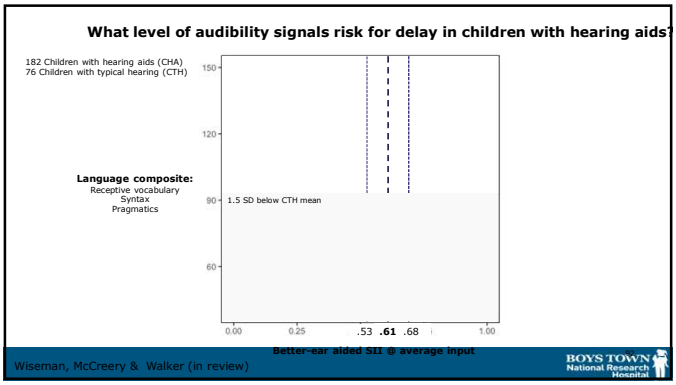
What level of audibility signals risk for delay in children with hearing aids?
182 Children with hearing aids (CHA)
76 Children with typical hearing (CTH)
Language composite:
Receptive vocabulary
Syntax
Pragmatics
150
120
90
60
1.5 SD below CTH mean
0.00
0.25
.53
.61
.68
1.00
Better-ear aided SII @ average input
Wiseman, McCreery & Walker (in review)
BOYS TOWN National Research Hospital

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ASHA
AJA
Tutorial
The Speech Intelligibility Index: Tutorial and Applications for Children Who Are Deaf and Hard of Hearing
Kathryn B. Wiseman,[a] Caitlin Sapp,[b] Derek Stiles,[c] Elizabeth A. Walker,[d] and Ryan W. McCreery[a]
[a]Center for Hearing Research, Boys Town National Research Hospital, Omaha, NE [b]Department of Audiology, University of North Carolina, Chapel Hill [c]Department of Otolaryngology and Communication Enhancement, Boston Children's Hospital, MA [d]Departm Communication Sciences and Disorders, University of Iowa, Iowa City
NEW!
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AUDIBILITY, PERCEPTION AND COGNITION LAB
Thank you!
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