Advanced Considerations for Pediatric Hearing Aid Fitting

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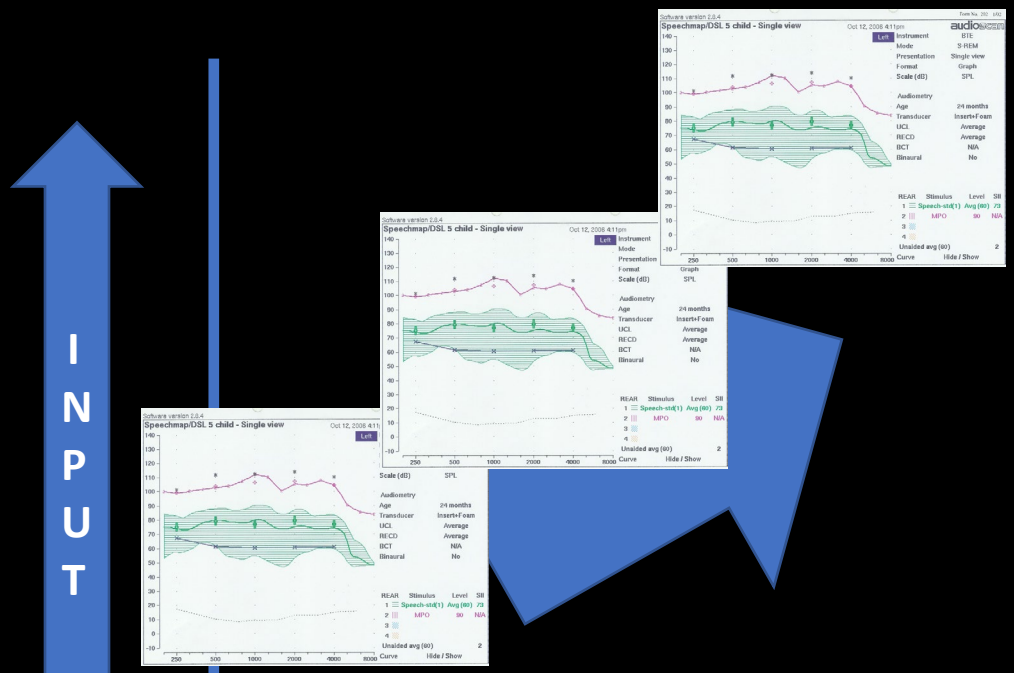
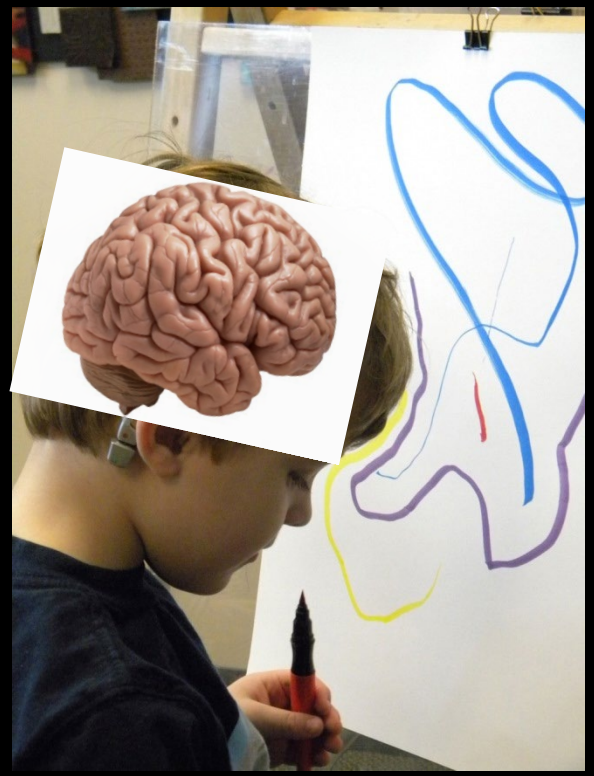
Acknowledgements / Conflicts of Interest

- NIH/NIDCD
- Boys Town National Research Hospital
- British Columbia Early Hearing Program

Goals with kids? Auditory development

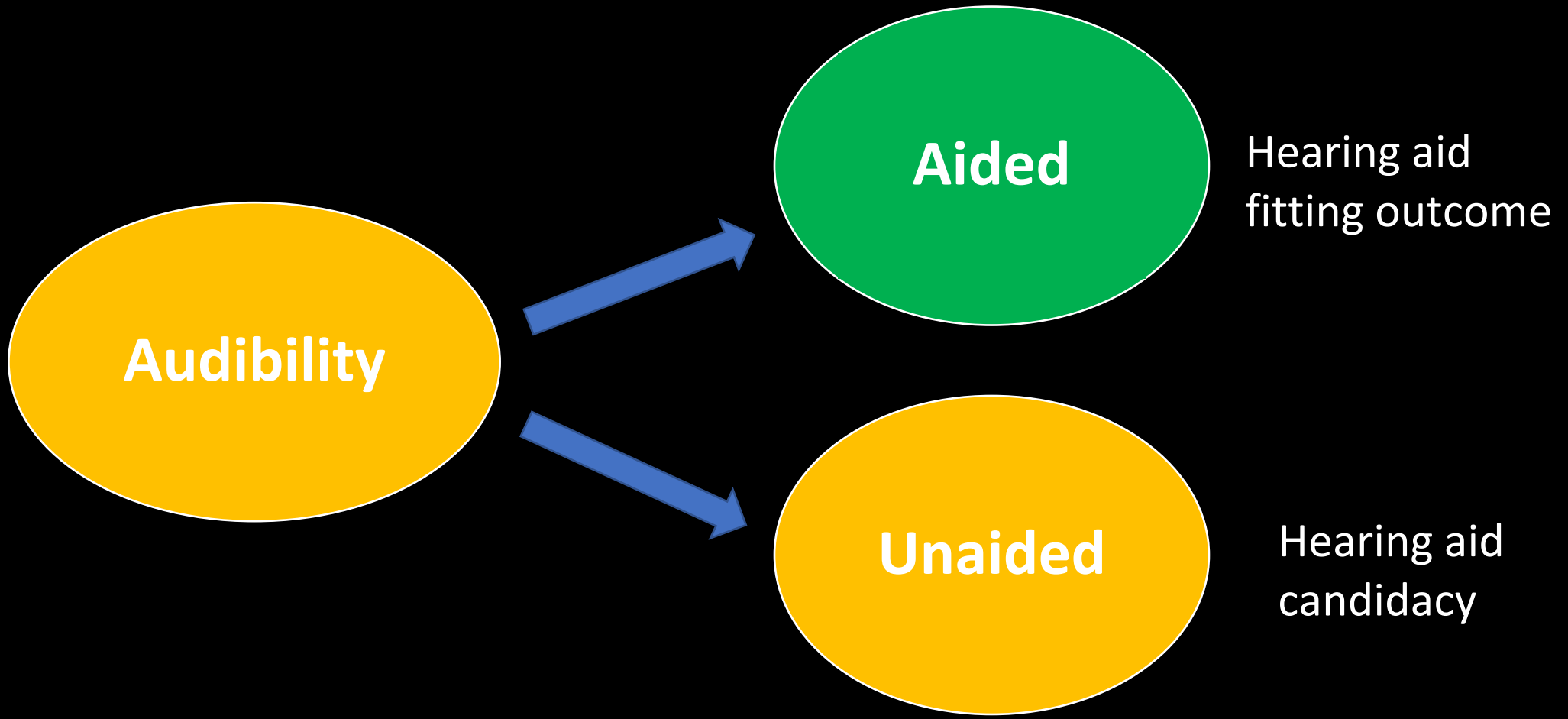




Audibility

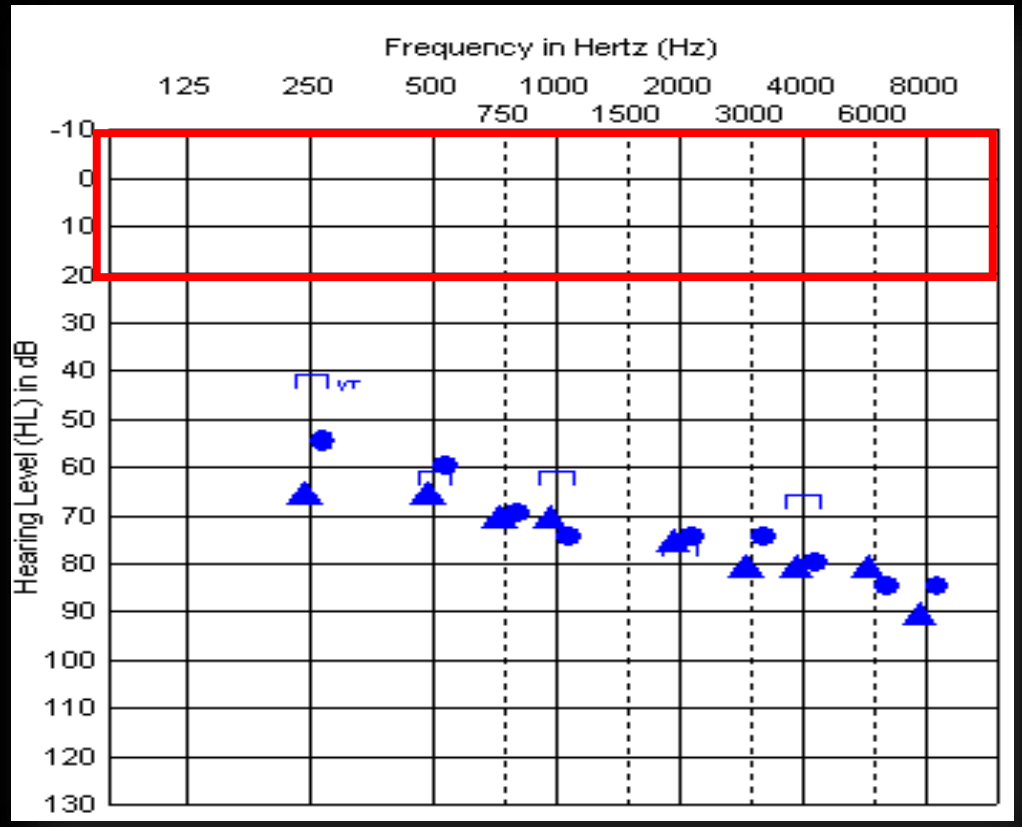
- How well we can hear a specific sound
- Children can only develop what they hear
- Determined by:
  - Hearing thresholds
  - **Level** and **location**
  - Noise
  - Device (if present)

Audibility

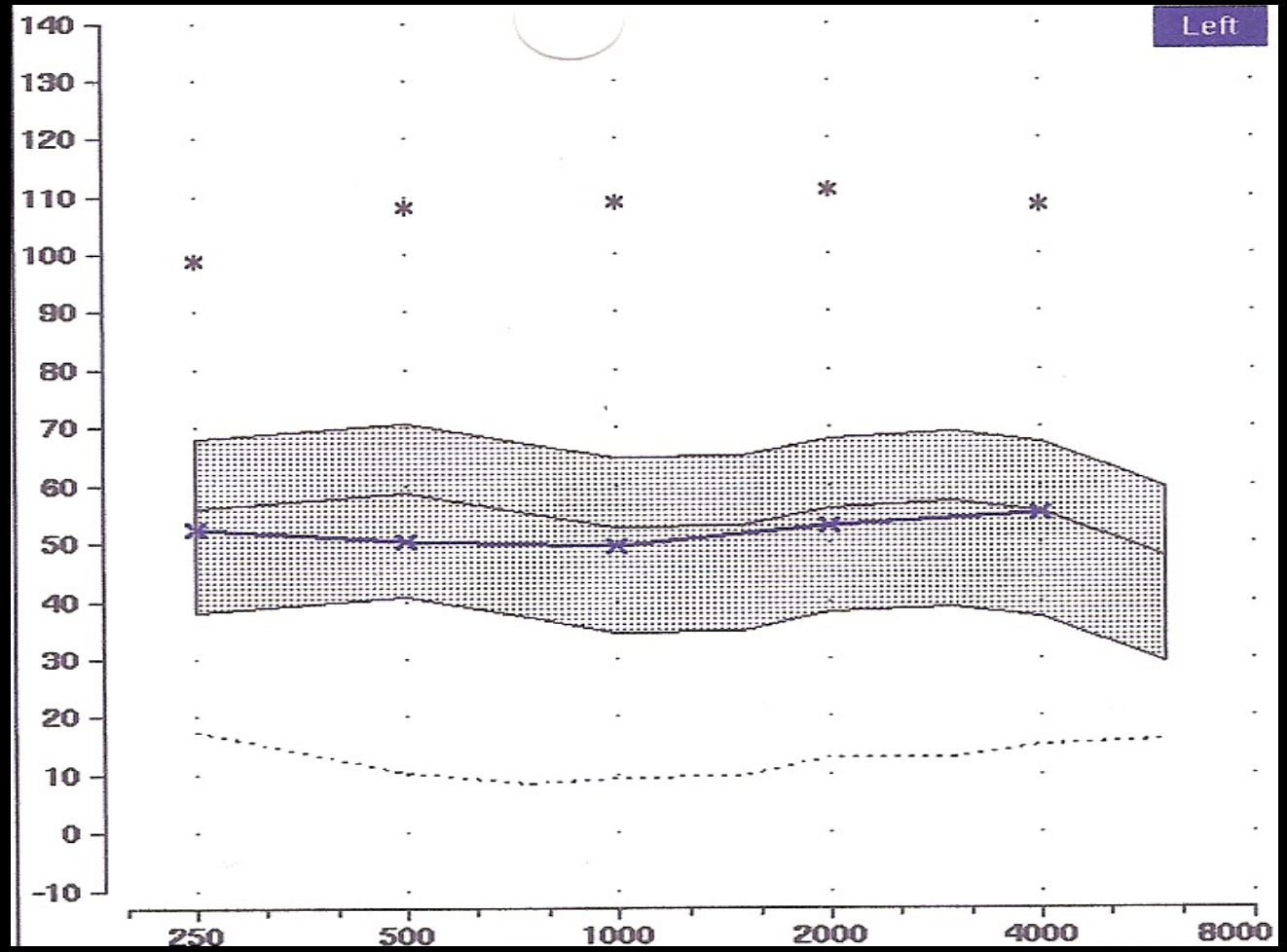

Audibility
Aided
Unaided
Hearing aid fitting outcome
Hearing aid candidacy

Hearing Thresholds

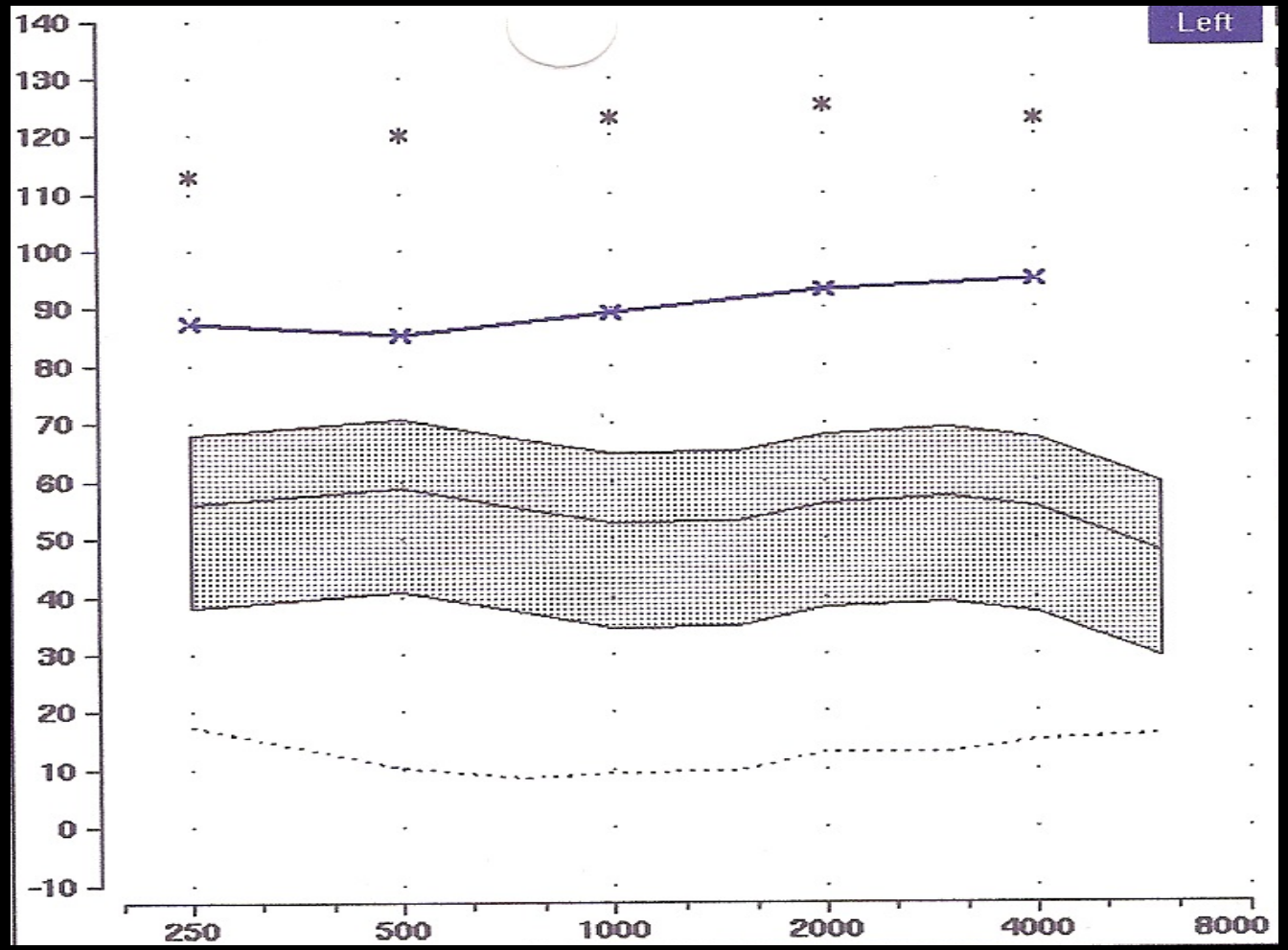
- Hearing loss results in loss of audibility for speech and other important sounds.
- Greater hearing loss = more limited audibility



Audibility with Mild Hearing Loss



Audibility with Severe Hearing Loss



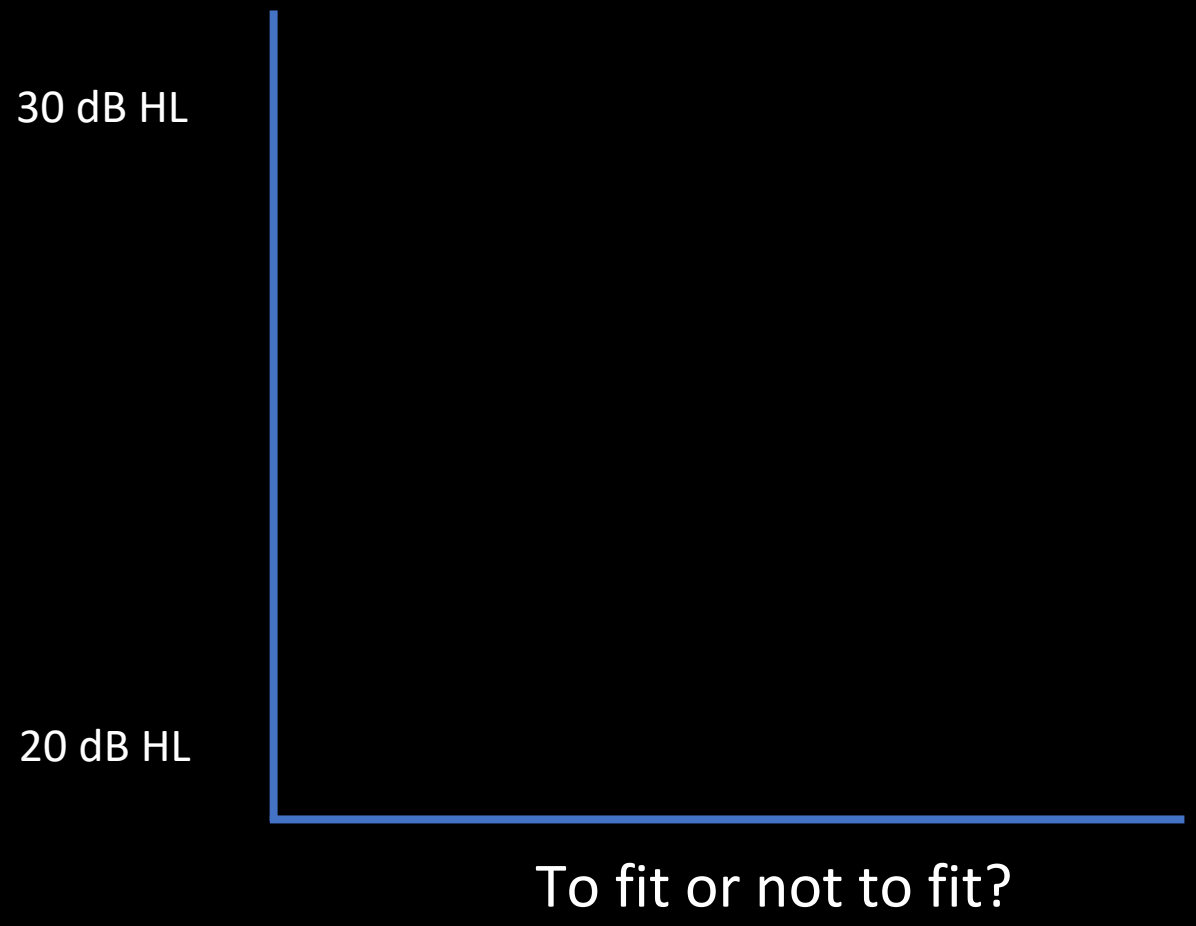
Hearing aid candidacy

- Audibility

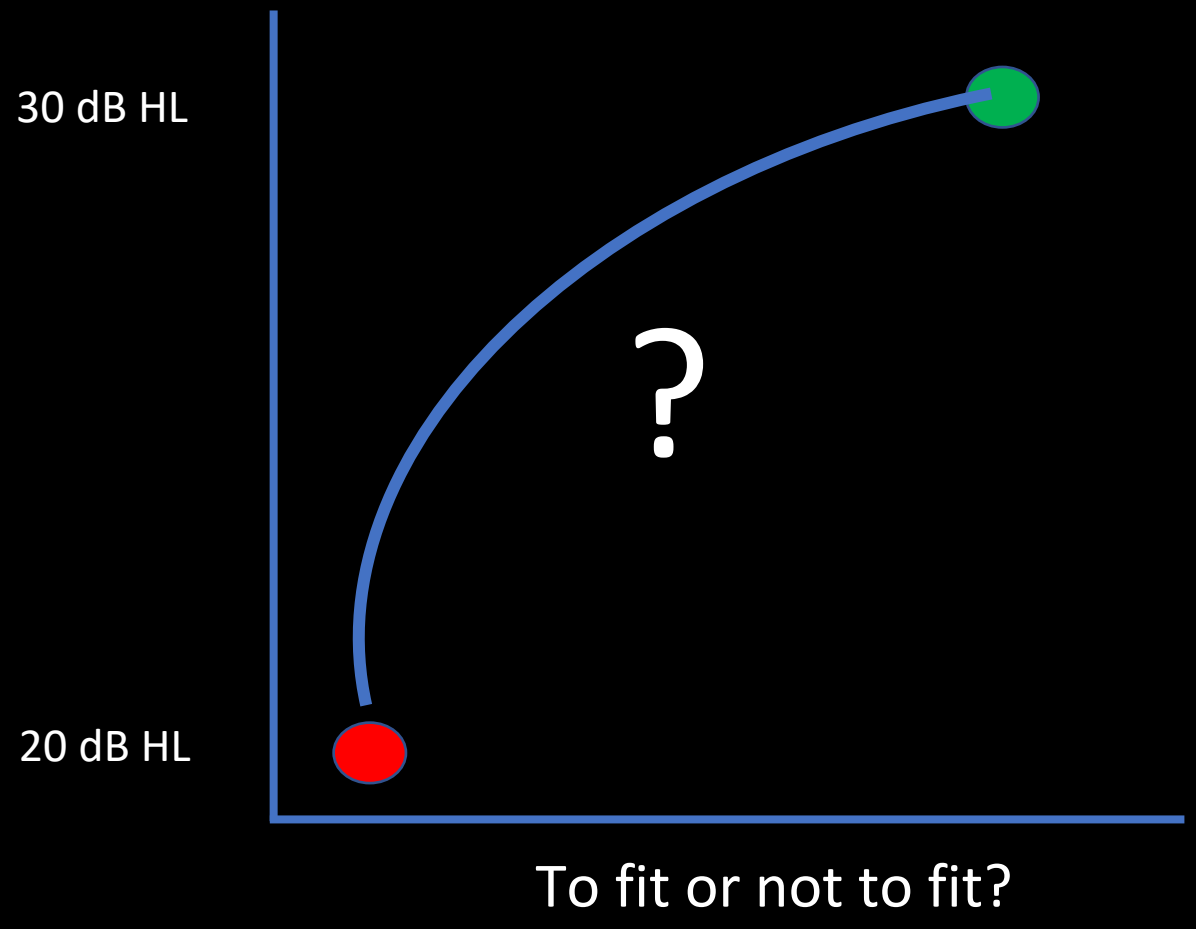
  How does ear canal acoustics influence diagnostic assessment?

  How does the hearing loss impact audibility?

Fit children with mild bilateral hearing loss?



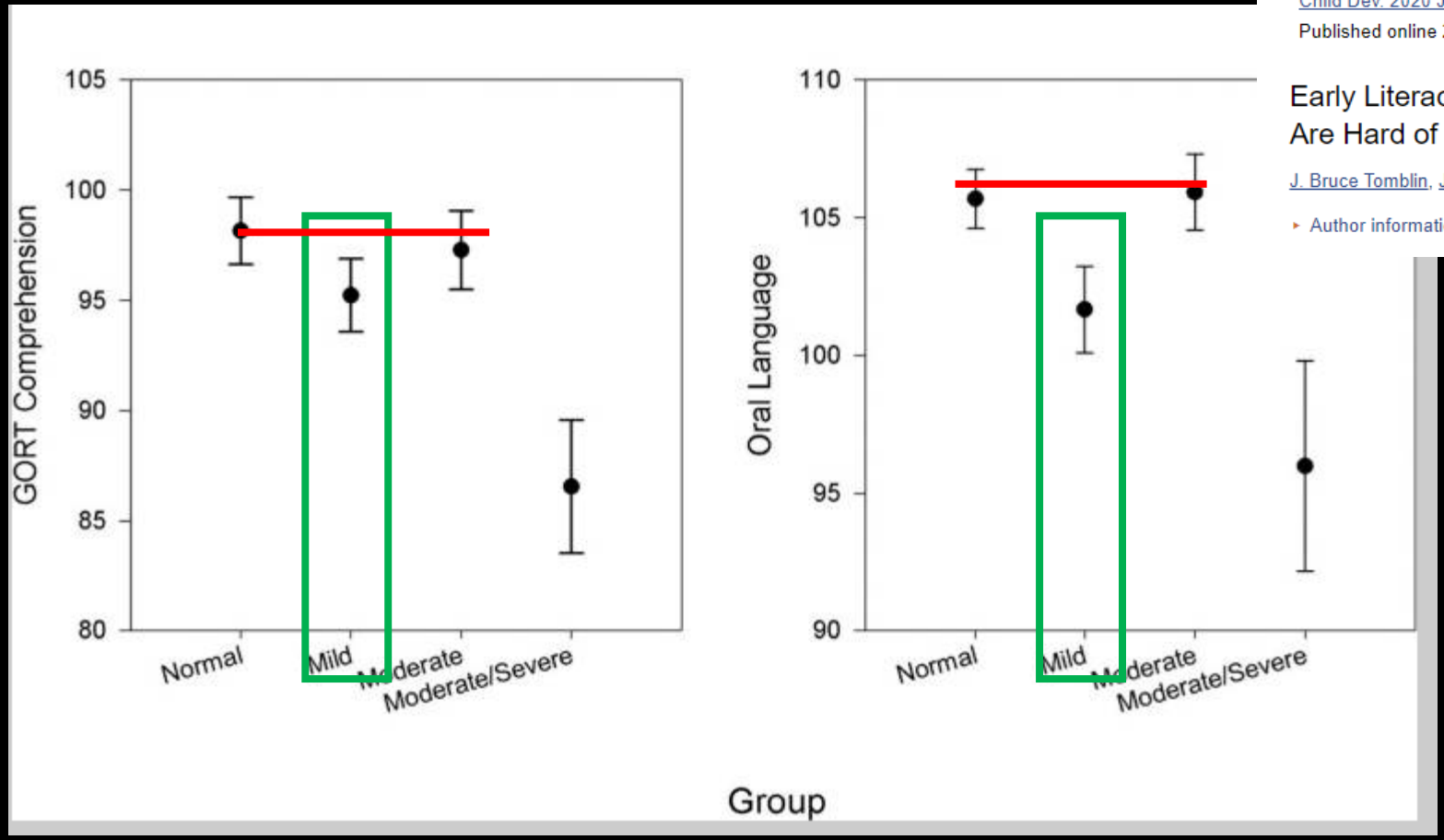
Fit children with mild bilateral hearing loss?



Clinical equipoise

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

Is mild bilateral hearing loss a developmental risk?



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PMCID: PMC6456443
NIHMSID: NIHMS1009435
PMID: 30298910

Early Literacy Predictors and Second-Grade Outcomes in Children Who Are Hard of Hearing

J. Bruce Tomblin, Jake Oleson, Sophie E. Ambrose, Elizabeth A. Walker, and Mary P. Moeller

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

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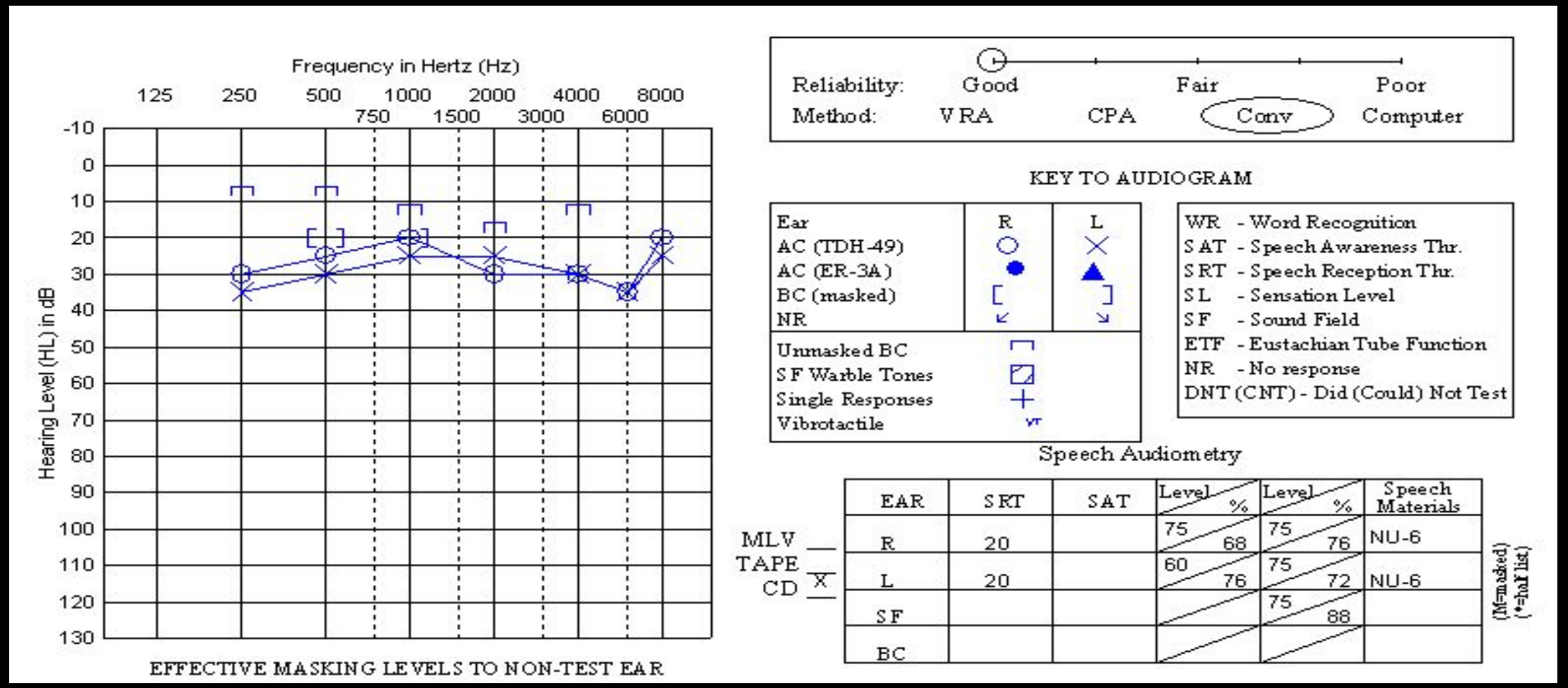
Eaton-Peabody Laboratory, Massachusetts Eye and Ear Infirmary, 243 Charles Street, Boston, Massachusetts 02114, Department of Otolaryngology, Massachusetts Eye and Ear Infirmary, 243 Charles Street, Boston, Massachusetts 02114, and Department of Otology and Laryngology, Harvard Medical School, Speech 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

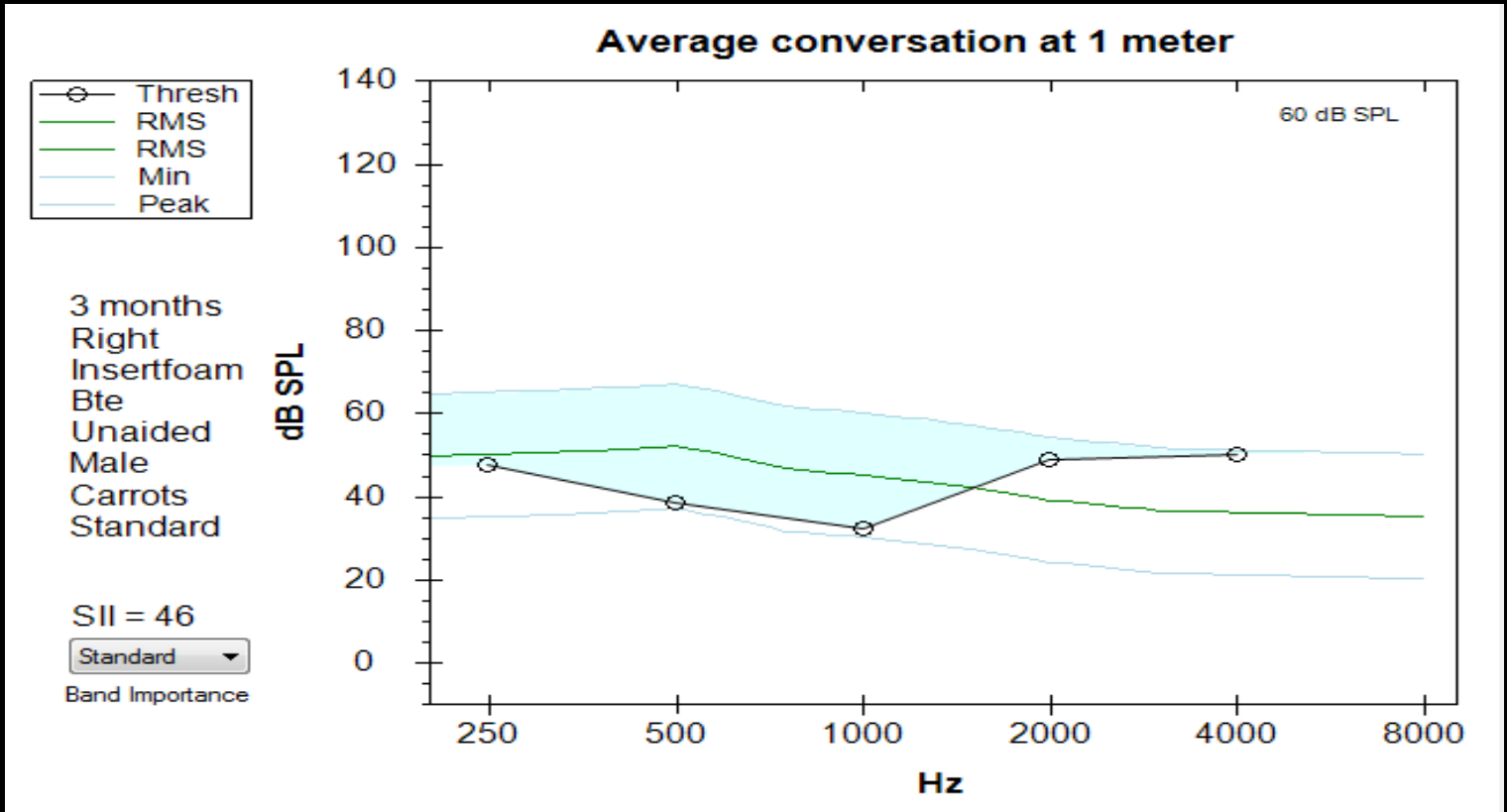
Hearing aid candidacy

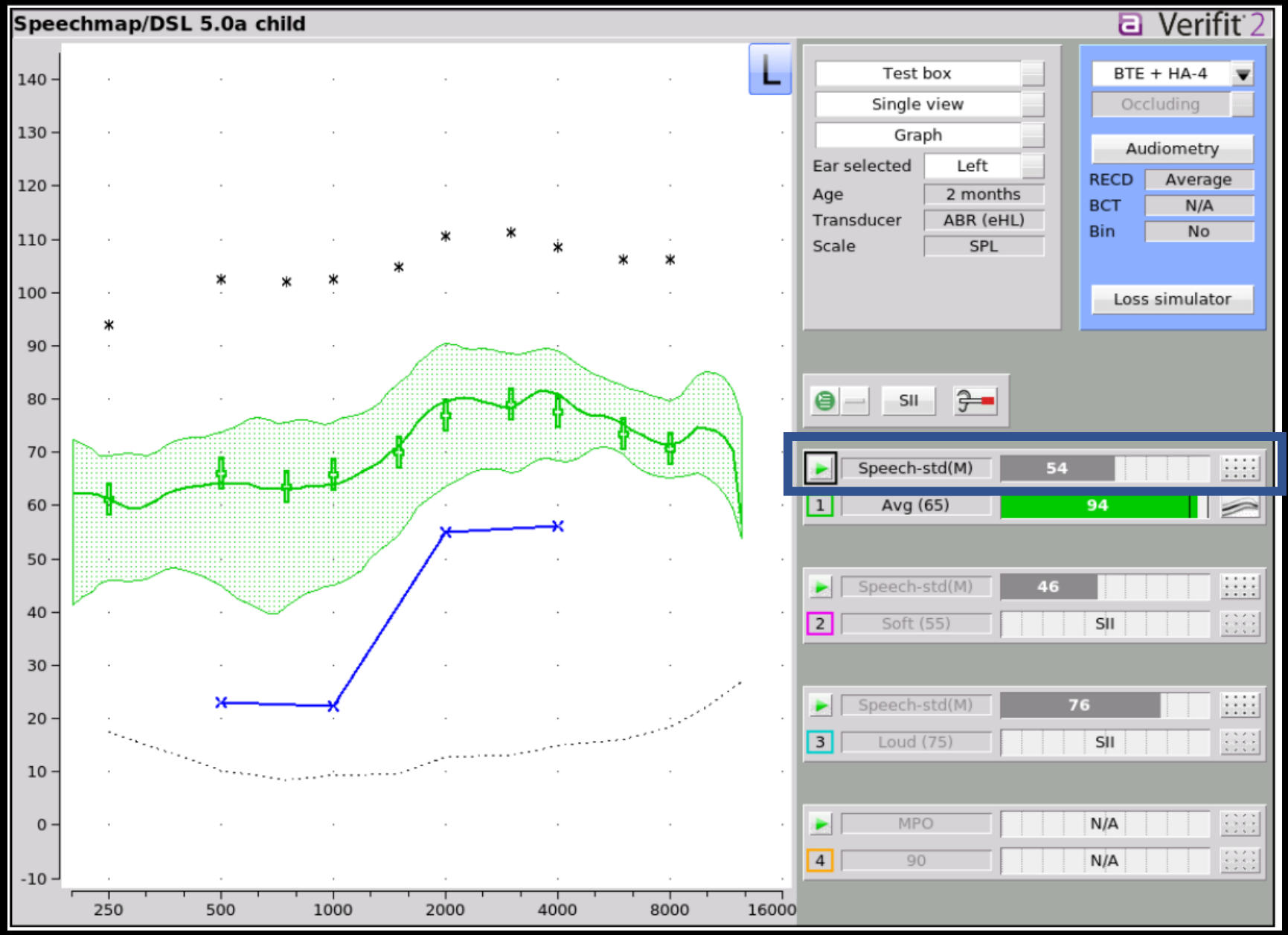
- Audiogram method



Hearing aid candidacy

- Audibility method – 3 month-old




Speechmap/DSL 5.0a child
Verifit 2
L
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
250
500
1000
2000
4000
8000
16000
Test box
Single view
Graph
Ear selected
Left
Age
2 months
Transducer
ABR (eHL)
Scale
SPL
BTE + HA-4
Occluding
Audiometry
RECD
Average
BCT
N/A
Bin
No
Loss simulator
SII
Speech-std(M)
54
1
Avg (65)
94
Speech-std(M)
46
2
Soft (55)
SII
Speech-std(M)
76
3
Loud (75)
SII
MPO
N/A
4
90
N/A

Why do thresholds change?

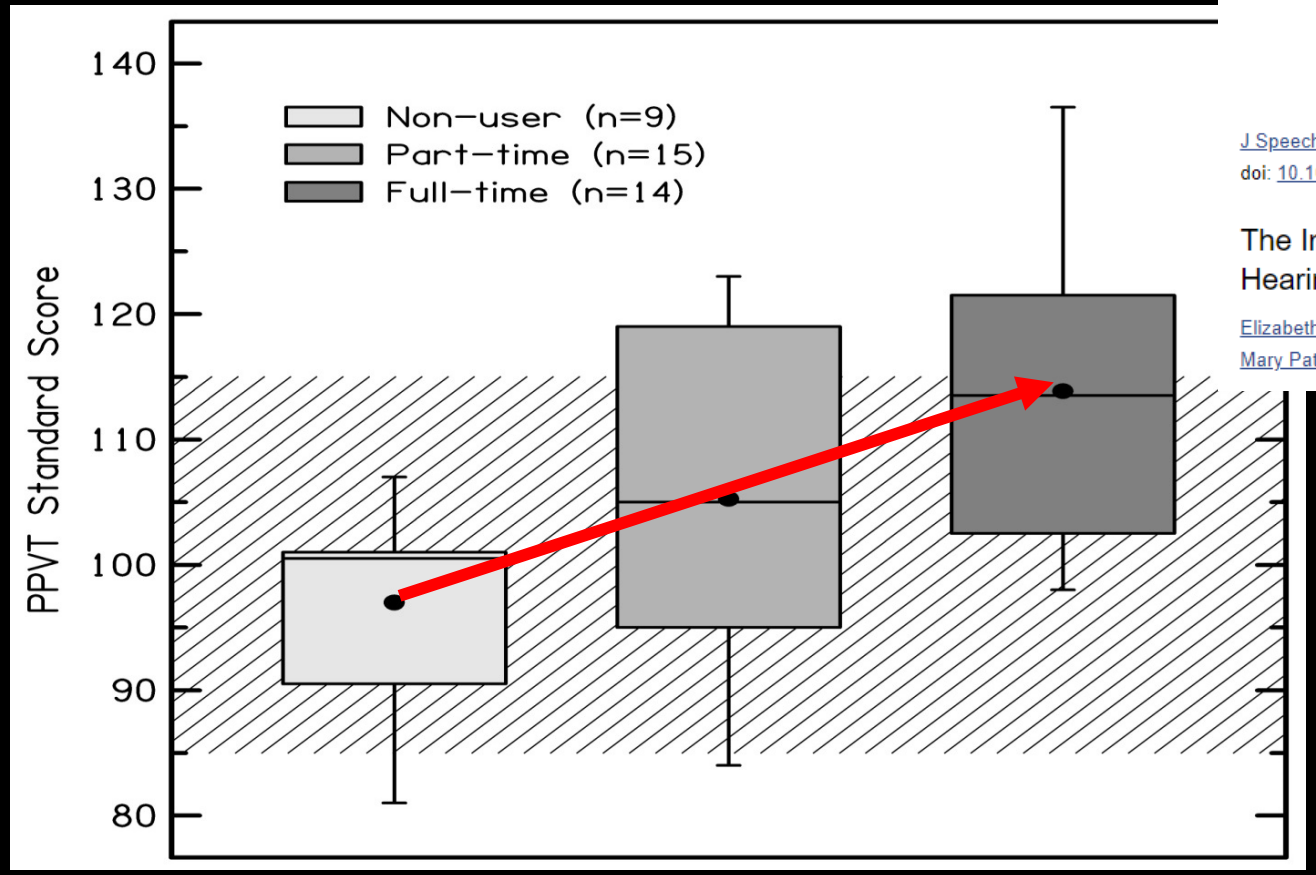
We know the RECD affects hearing aid measurements, but how do they affect thresholds??

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

Does amplification help children with mild bilateral hearing loss?



ASHAWIRE JSLHR JOURNAL OF SPEECH, LANGUAGE, AND HEARING RESEARCH
RELATED TOPICS | FOR AUTHORS | SUBSCRIBE

J Speech Lang Hear Res. 2015 Oct; 58(5): 1611–1625. PMCID: PMC4686313
doi: 10.1044/2015_JSLHR-H-15-0043 PMID: 26151927

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

Elizabeth A. Walker,[a] Lenore Holte,[a] Ryan W. McCreery,[b] Meredith Spratford,[b] Thomas Page,[c] and Mary Pat Moeller[d]

OPEN

Amount of Hearing Aid Use Impacts Neural Oscillatory Dynamics Underlying Verbal Working Memory Processing for Children With Hearing Loss

Elizabeth Heinrichs-Graham,[1,2] Elizabeth A. Walker,[3] Jacob A. Eastman,[1,2]
Michaela R. Frenzel,[1,2] and Ryan W. McCreery[4]

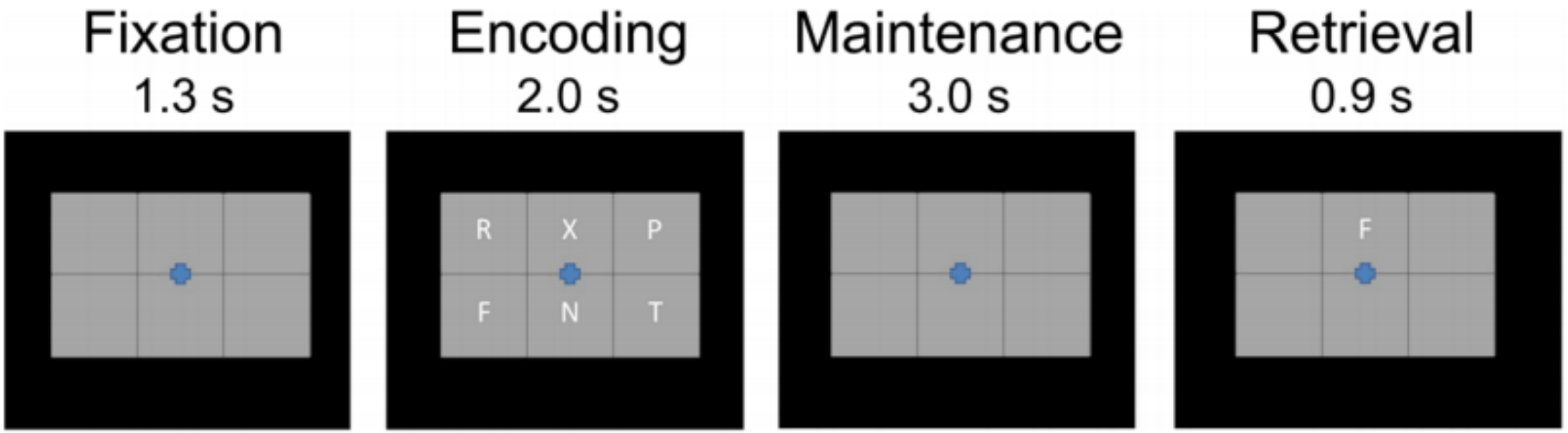
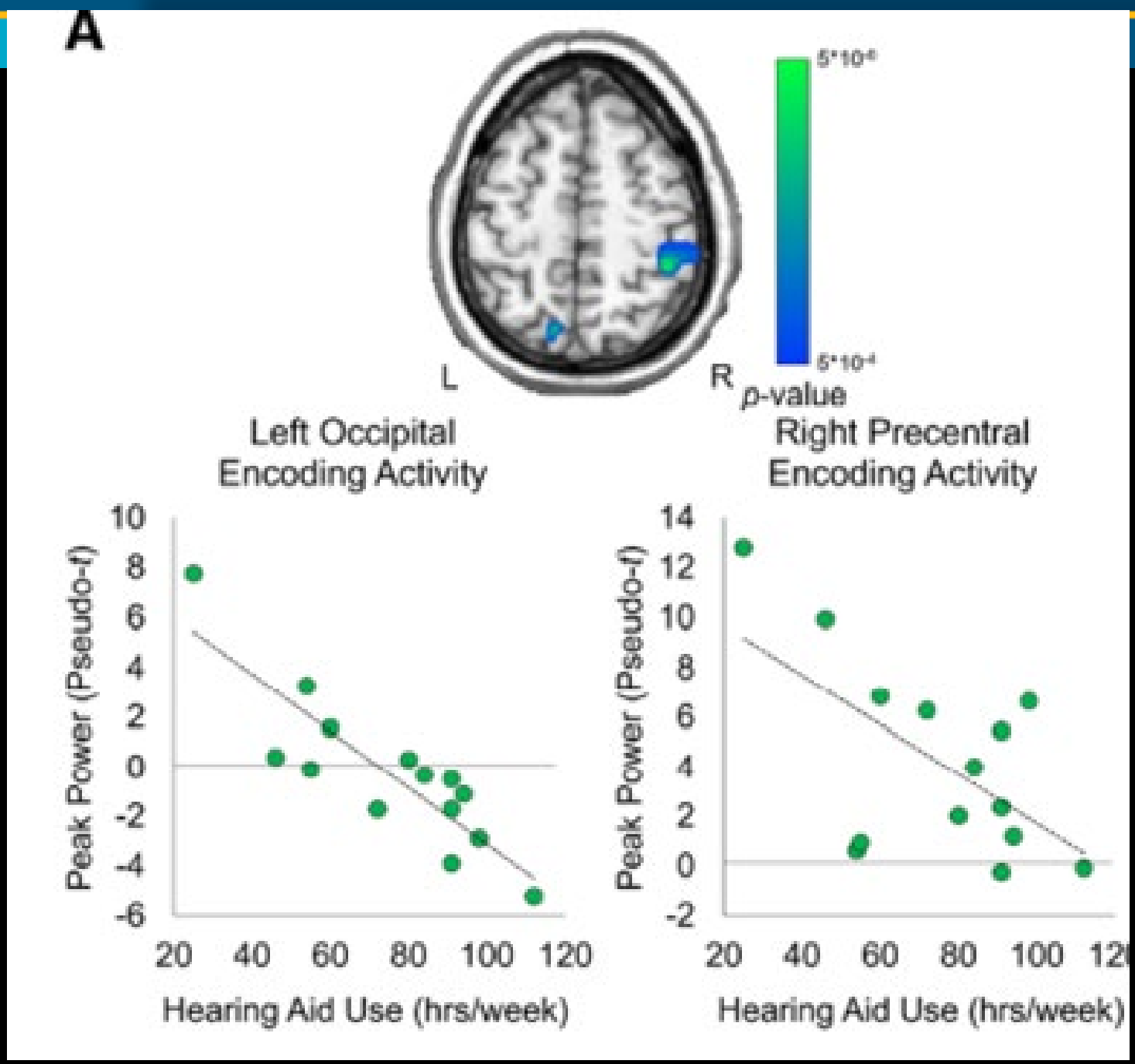
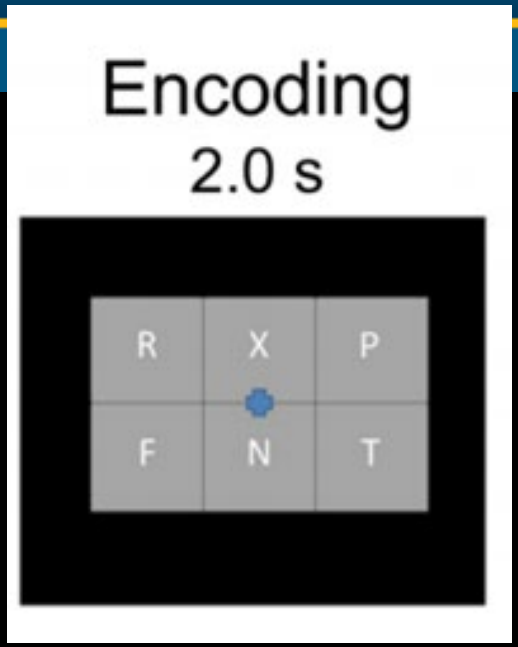
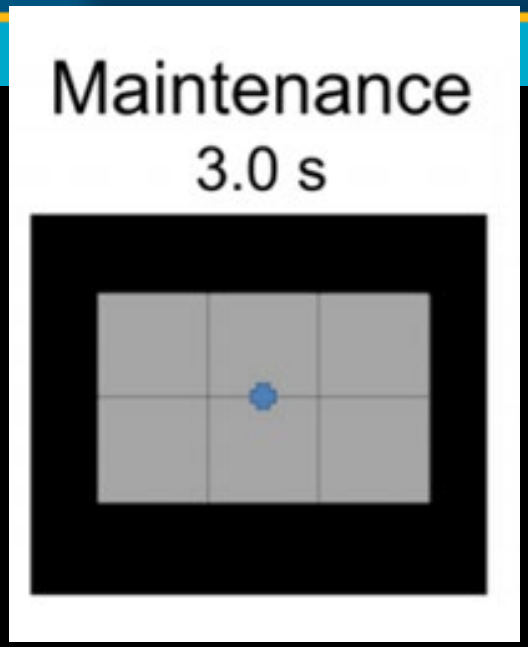


Fig. 1. Task paradigm. After a baseline period, participants were presented with six letter stimuli (encoding phase). After 2.0s, the letter stimuli disappeared (i.e., maintenance), and then 3.0s later a probe stimulus appeared (i.e., retrieval). Participants were asked to respond via button press whether the probe letter was one of the prior encoding stimuli.

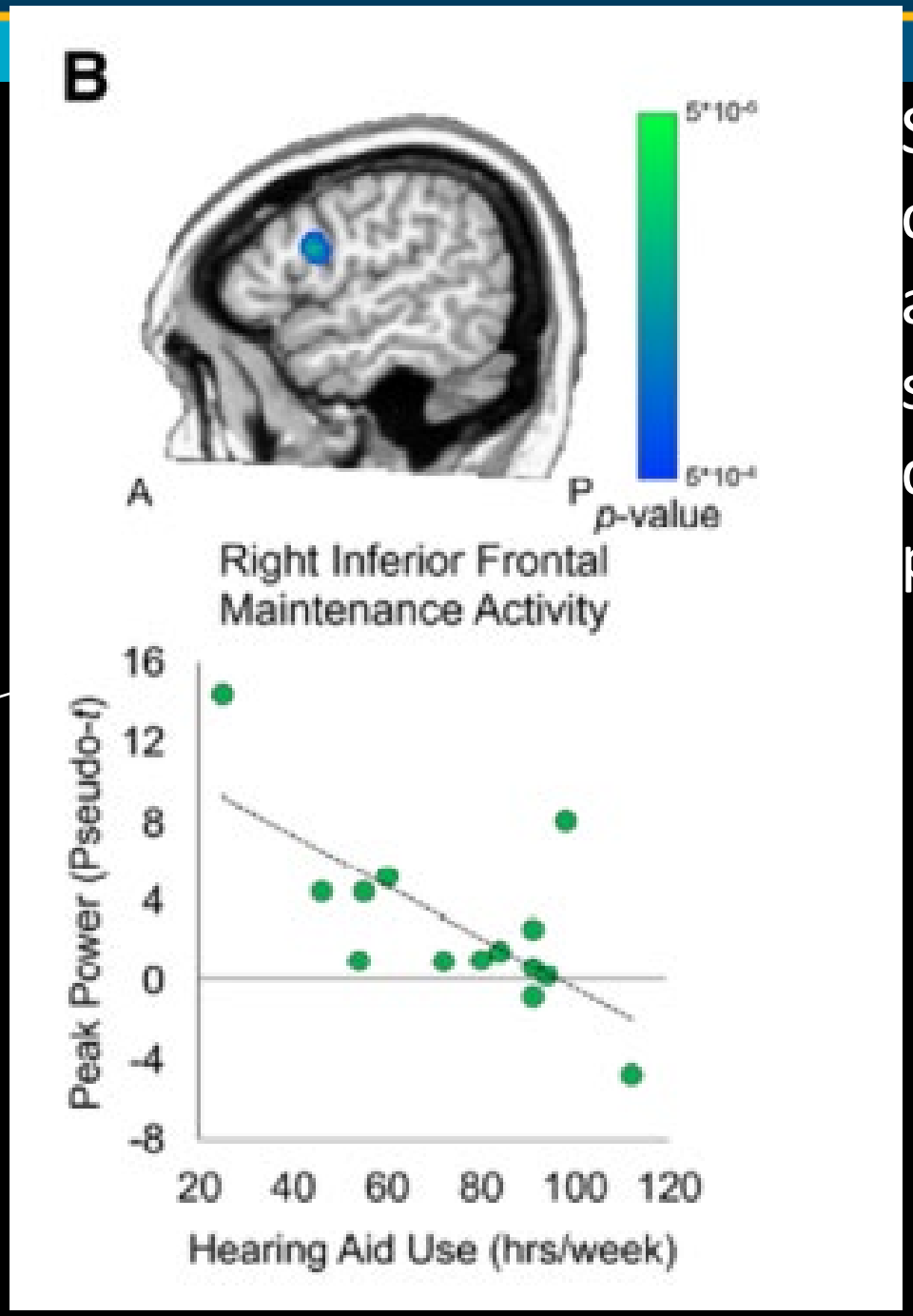




Significant negative correlation between hours of hearing aid use and encoding activity. More activity indicates less efficiency in rehearsal.



Less normalized neural activity



Significant negative correlation between activity in the right side of the brain during maintenance phase.

More normalized neural activity

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.

Finding Appropriate Solutions to Treat Reduced Audibility in Kids

2020

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

2021

Validate clinical tools in complex listening conditions in the laboratory

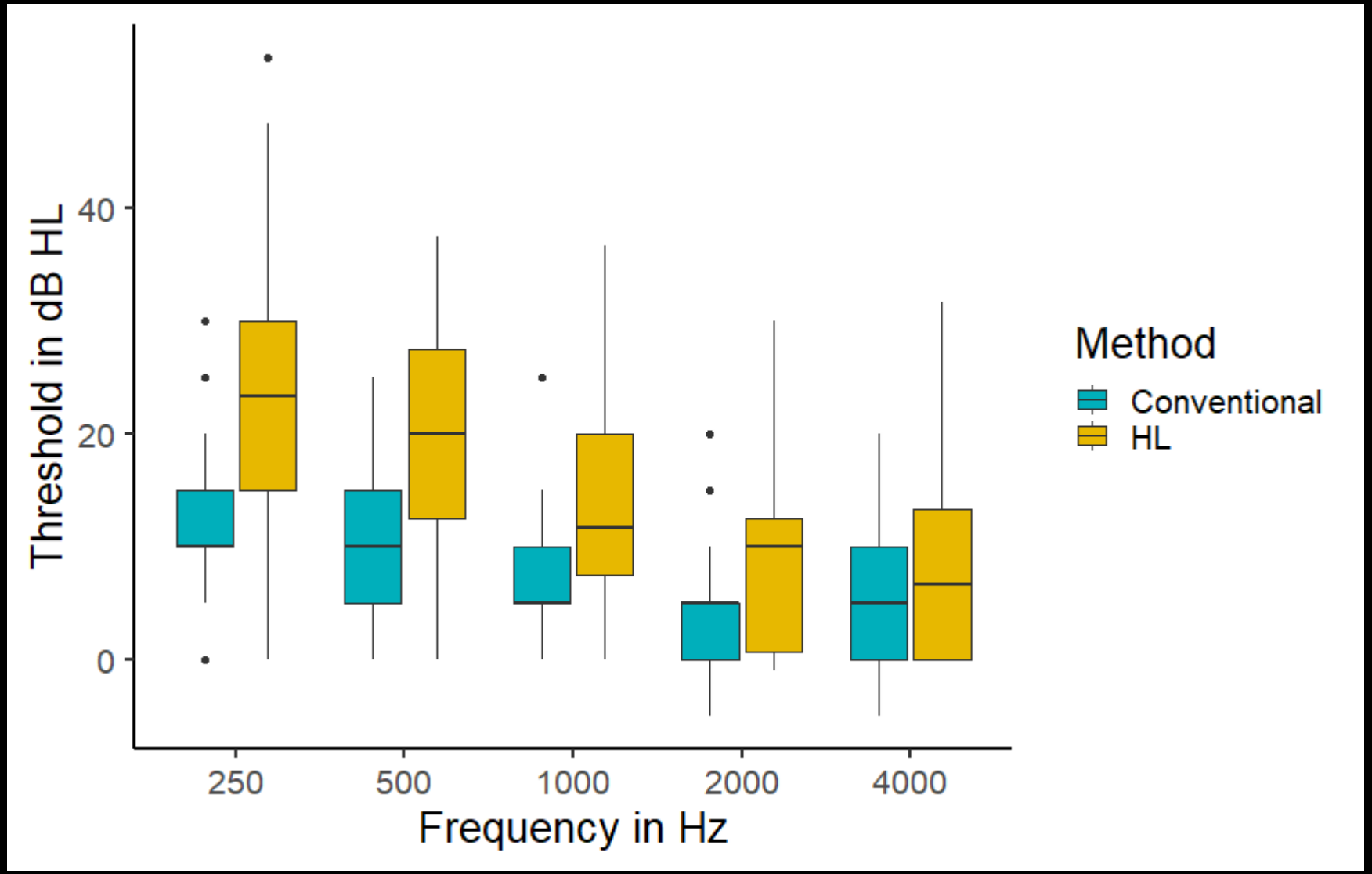
2022

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

How could we solve this calibration problem?

- Calibrate to the ear canal like we do for OAE using a similar probe
- Measure sound level in the ear canal
  - Calibration
  - Self-generated noise during assessment

dB HL vs. FASTRAK experimental dB HL



Lang Speech Hear Serv Sch. 2020 Jan; 51(1): 55–67.
Published online 2020 Jan 8. doi: 10.1044/2019_LSHSS-OCHL-19-0021
PMCID: PMC7251589
PMID: 31913801

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

Ryan W. McCreery,[a] Elizabeth A. Walker,[b] Derek J. Stiles,[c] Meredith Spratford,[a] Jacob J. Oleson,[d] and Dawna E. Lewis[a]

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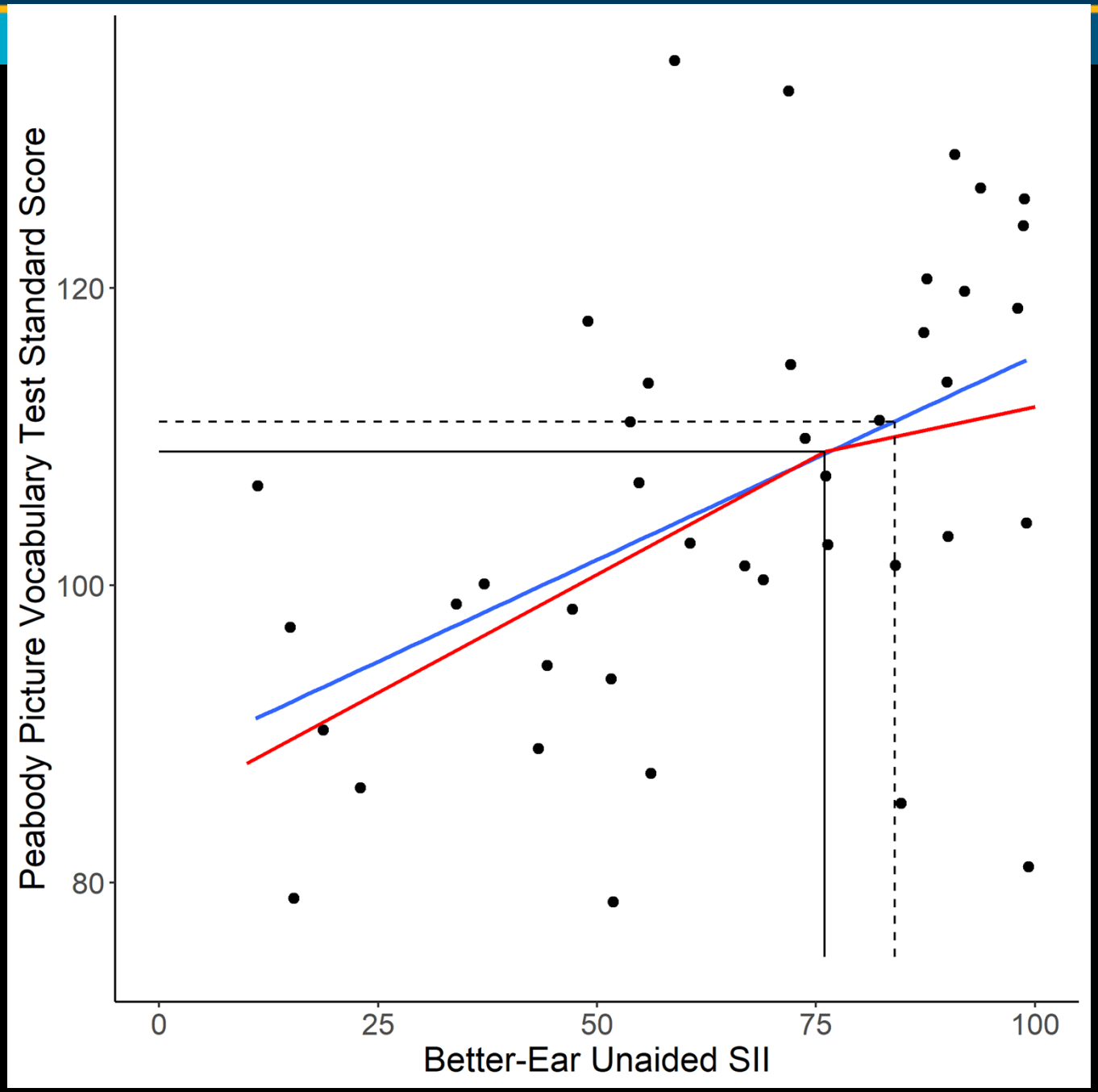

Peabody Picture Vocabulary Test Standard Score
120
100
80
0
25
50
75
100
Better-Ear Unaided SII

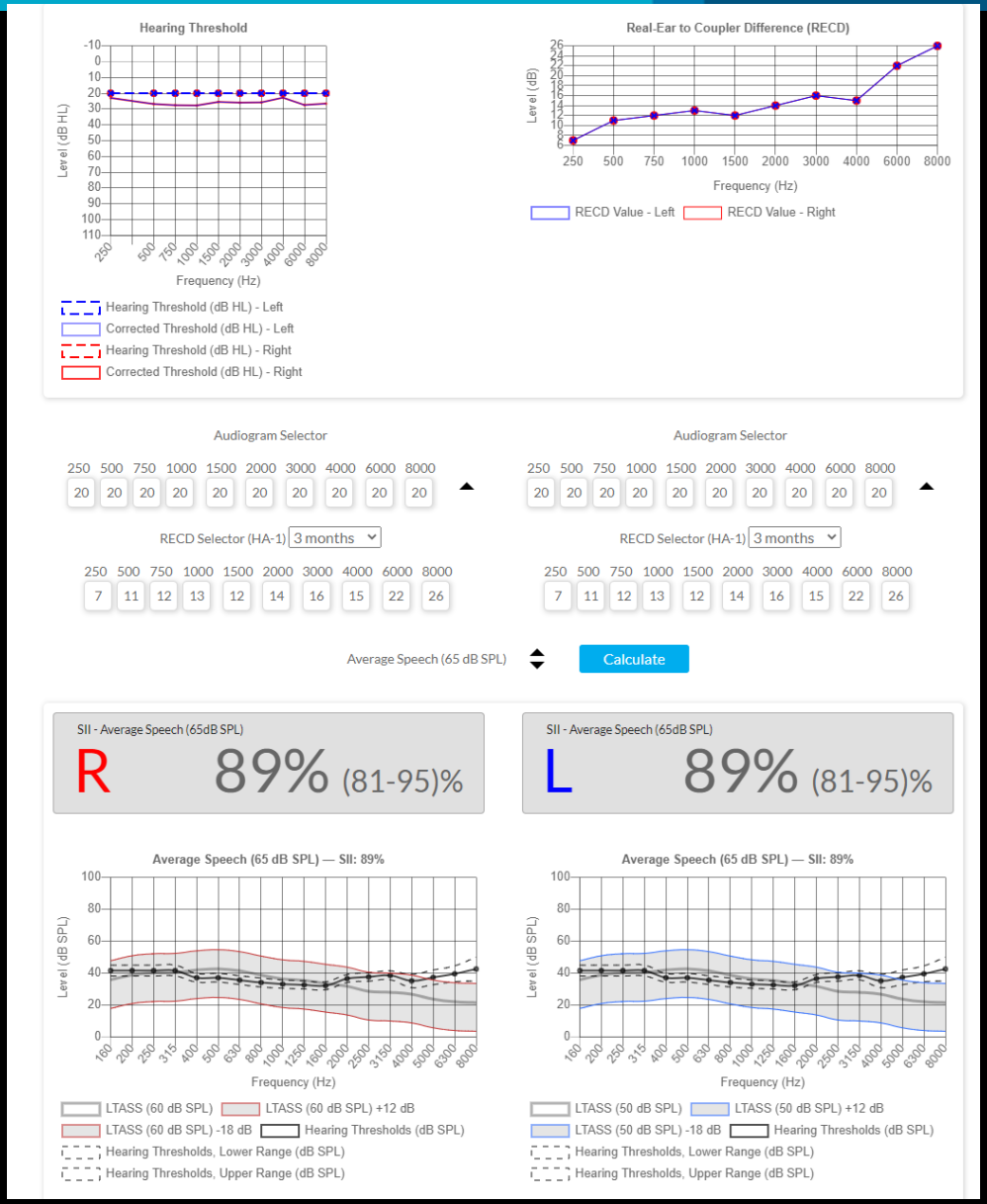
Unaided SII Criterion

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

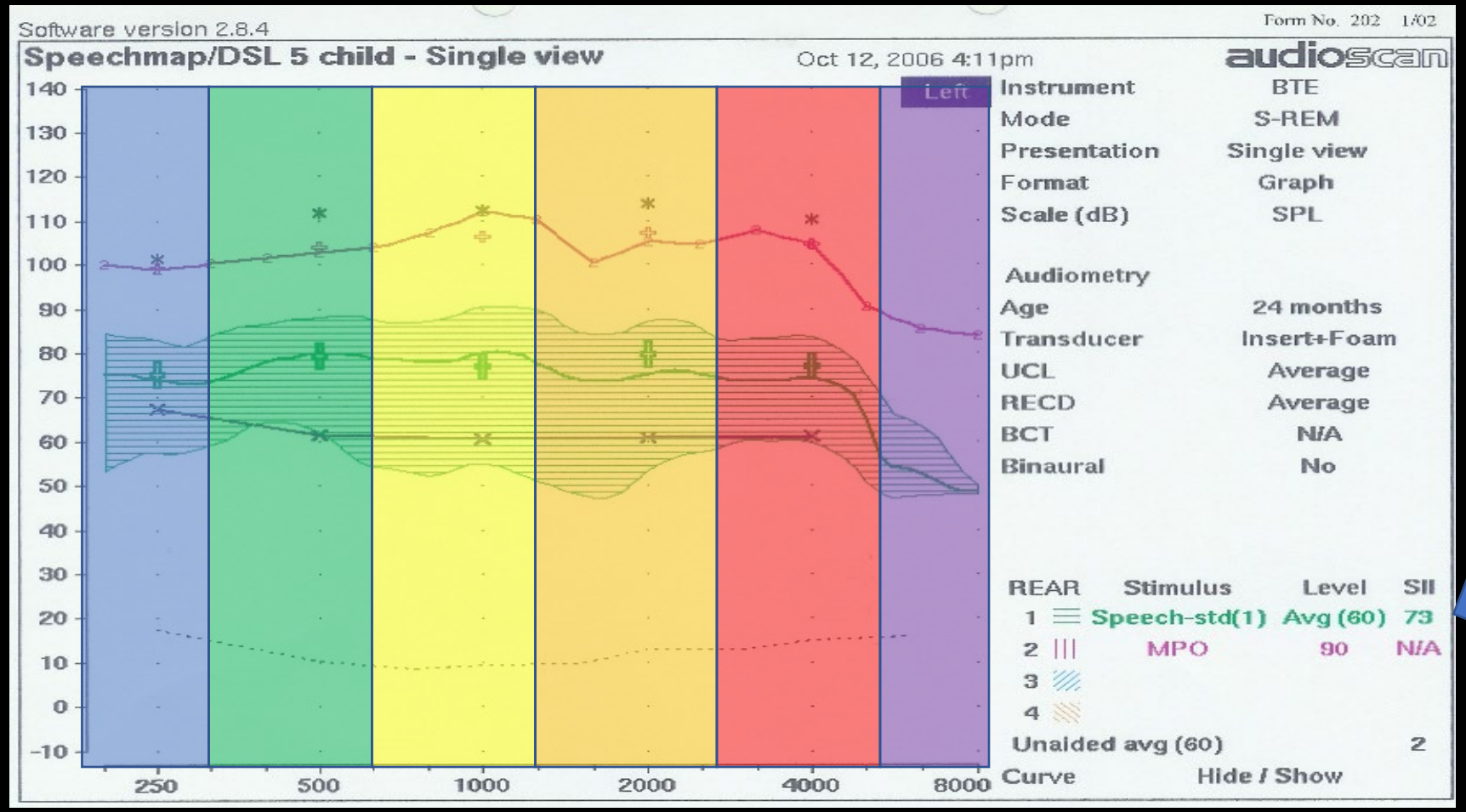
Unaided SII criterion

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



KIPA Audibility Calculator
http://kipagroup.org/charts/

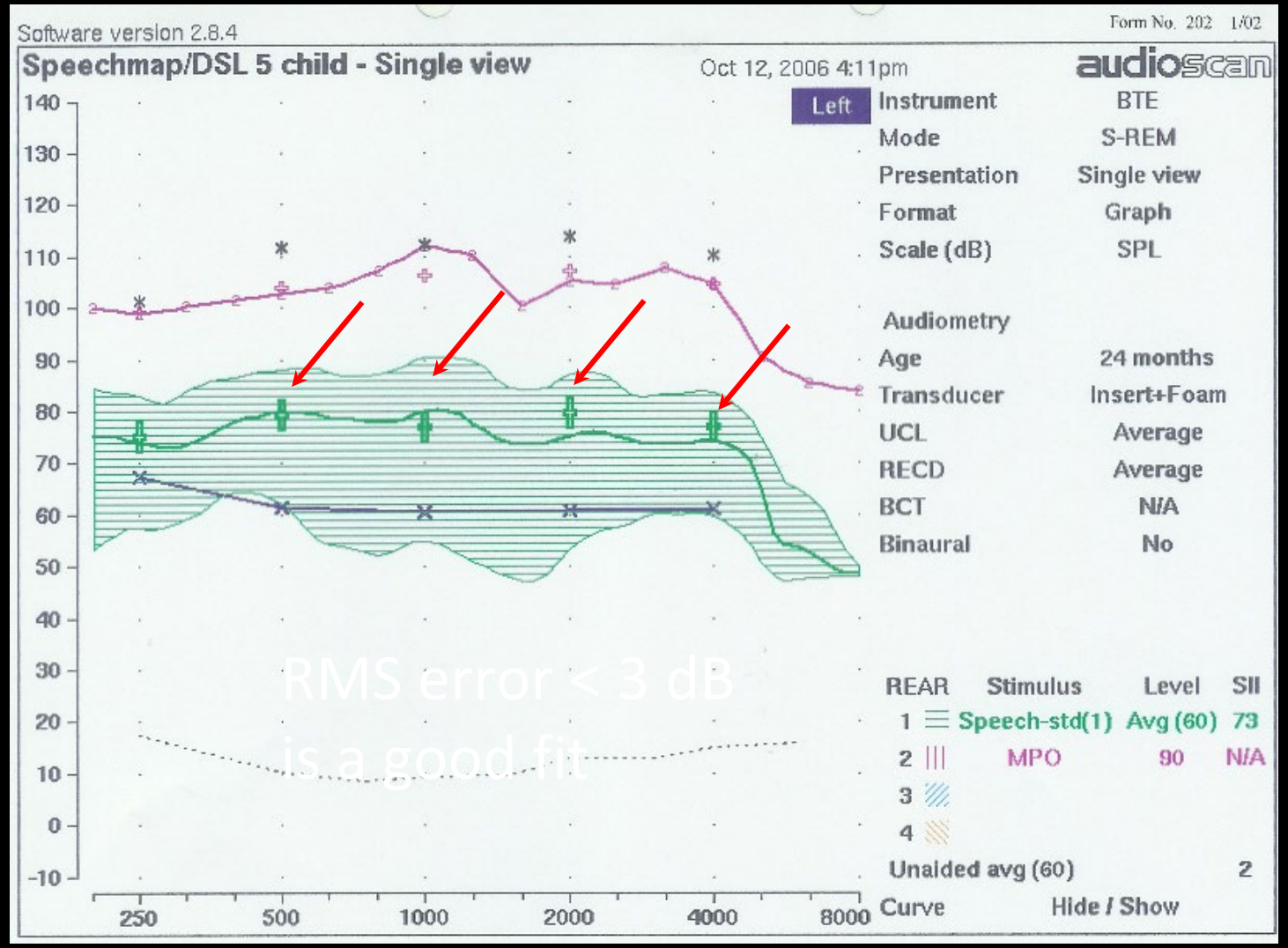
SPL-o-gram SII Snapshot



For each band – Audibility x FIW = weighted audibility

SII = Sum of weighted audibility of all frequency bands

Target vs. Actual (RMS error)

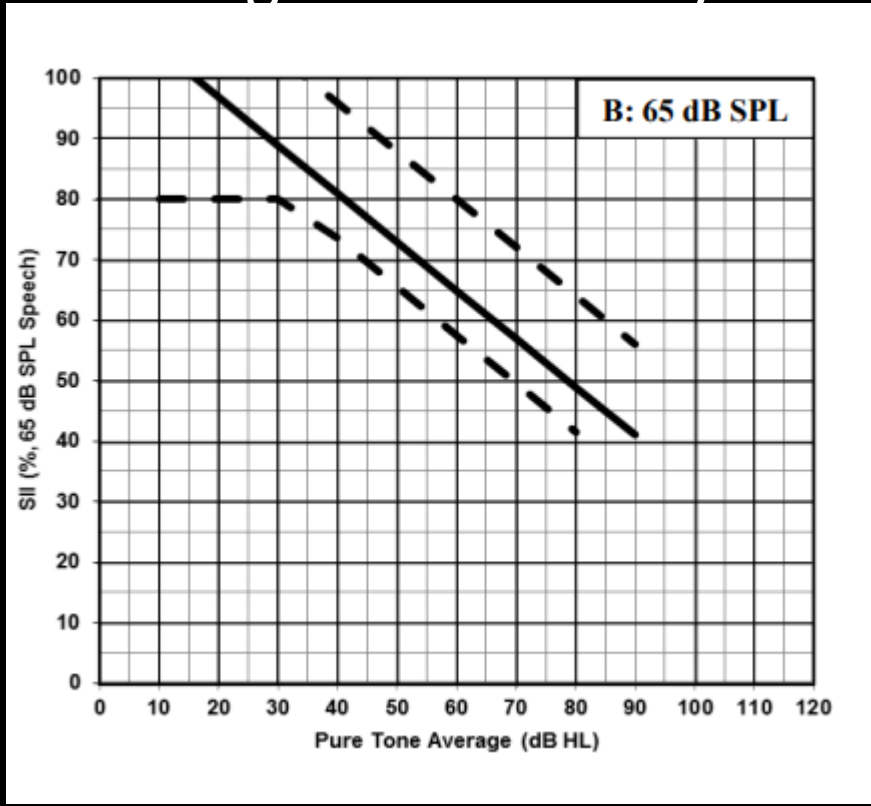


Fitting data compared to DSL targets

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

Children: How can I tell if there's enough audibility?

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



Bagatto et al. 2015
www.dslio.com

Real Ear to Coupler Difference

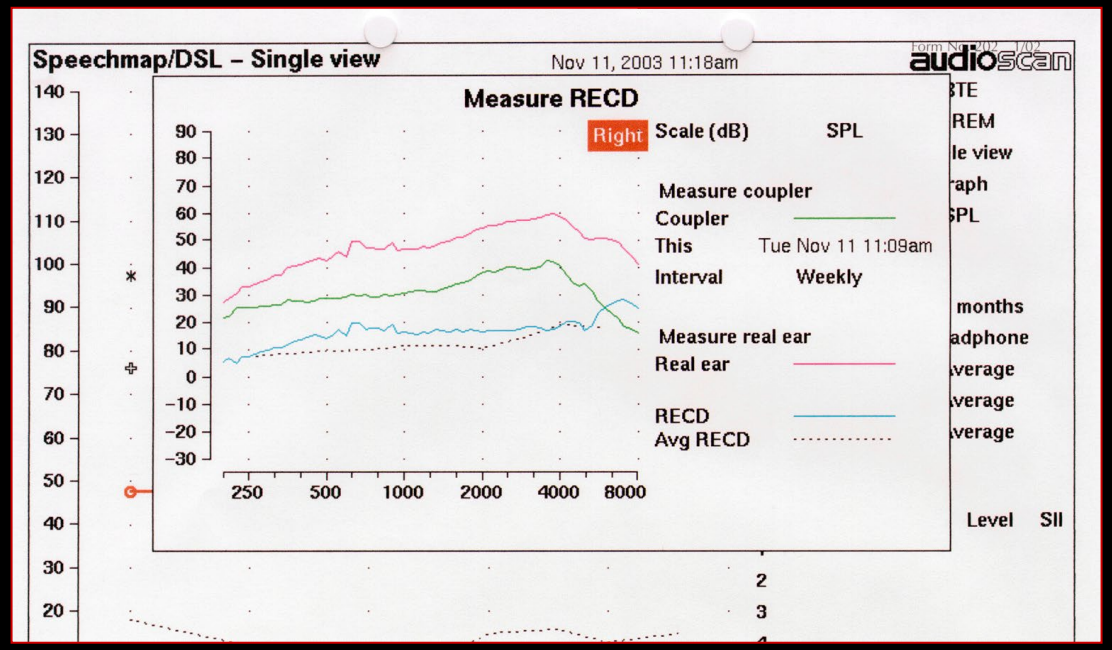
- Infant ear does not approximate adult ear
  - Greater SPL for same input compared to adult

- RECD is applied to:
  - Threshold (Inserts + ABR)
  - Targets for gain and output

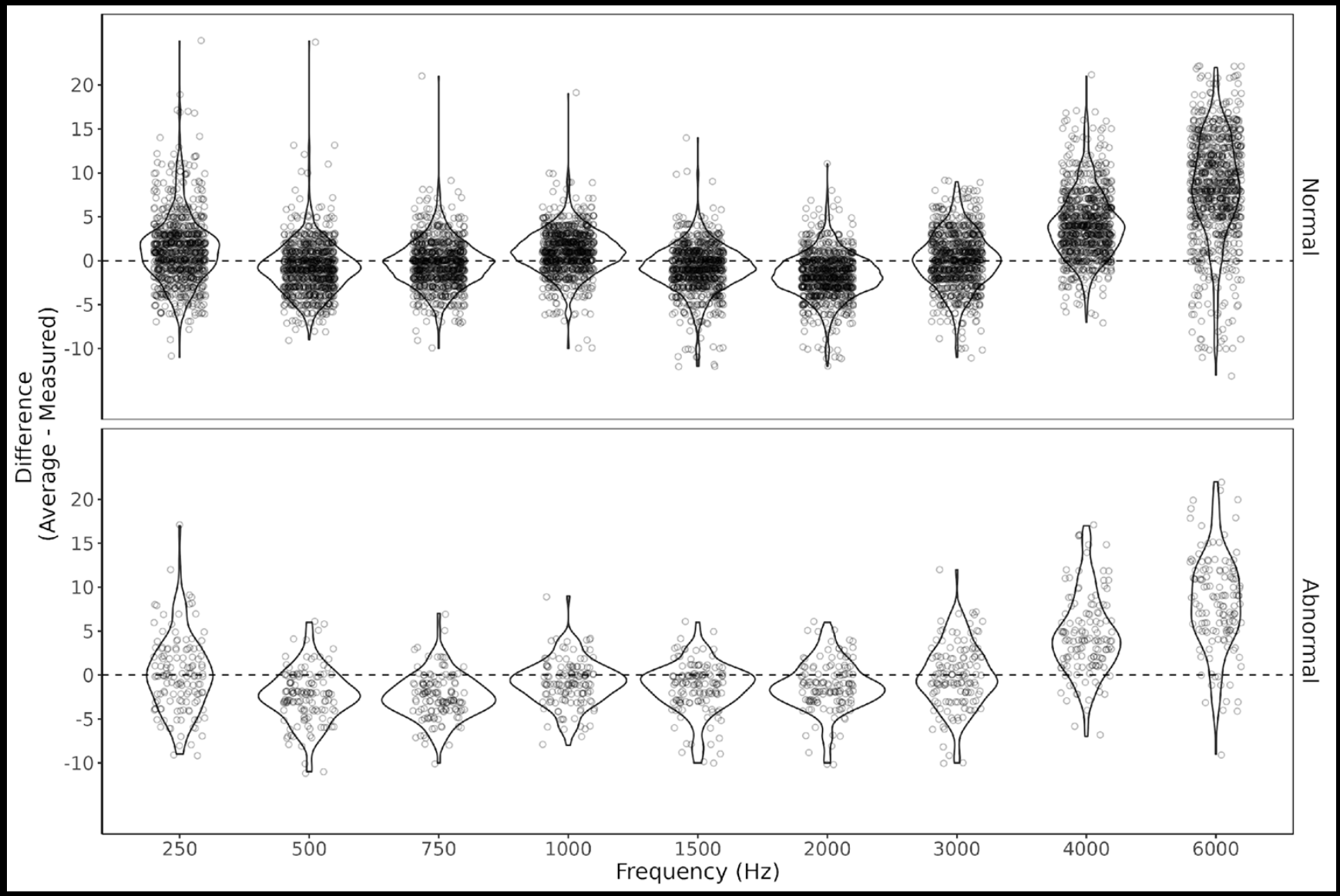
What If I Can’t measure RECD?

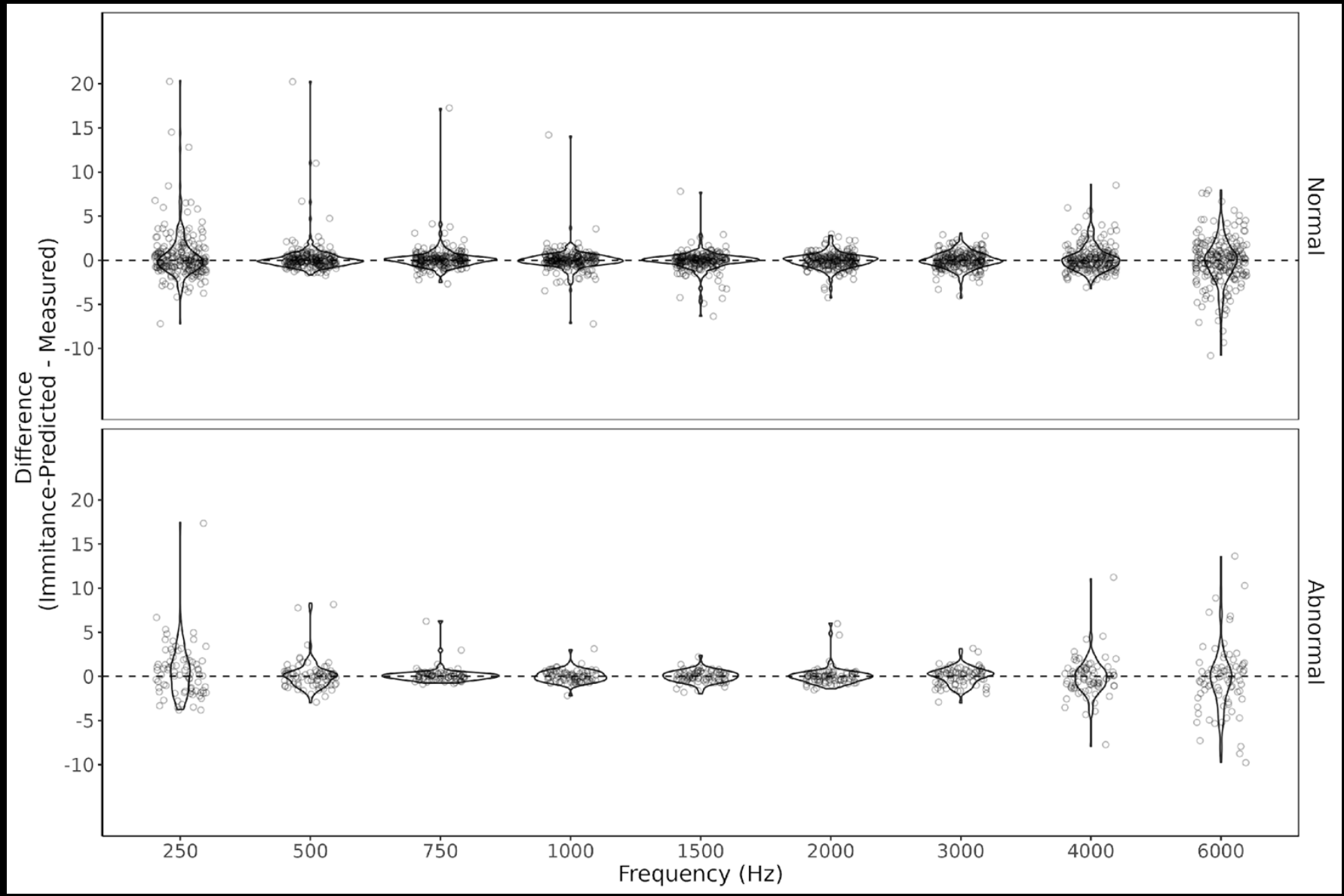
- Use age-related averages if
  - Lack of cooperation?
  - Cerumen?
  - Middle ear dysfunction?

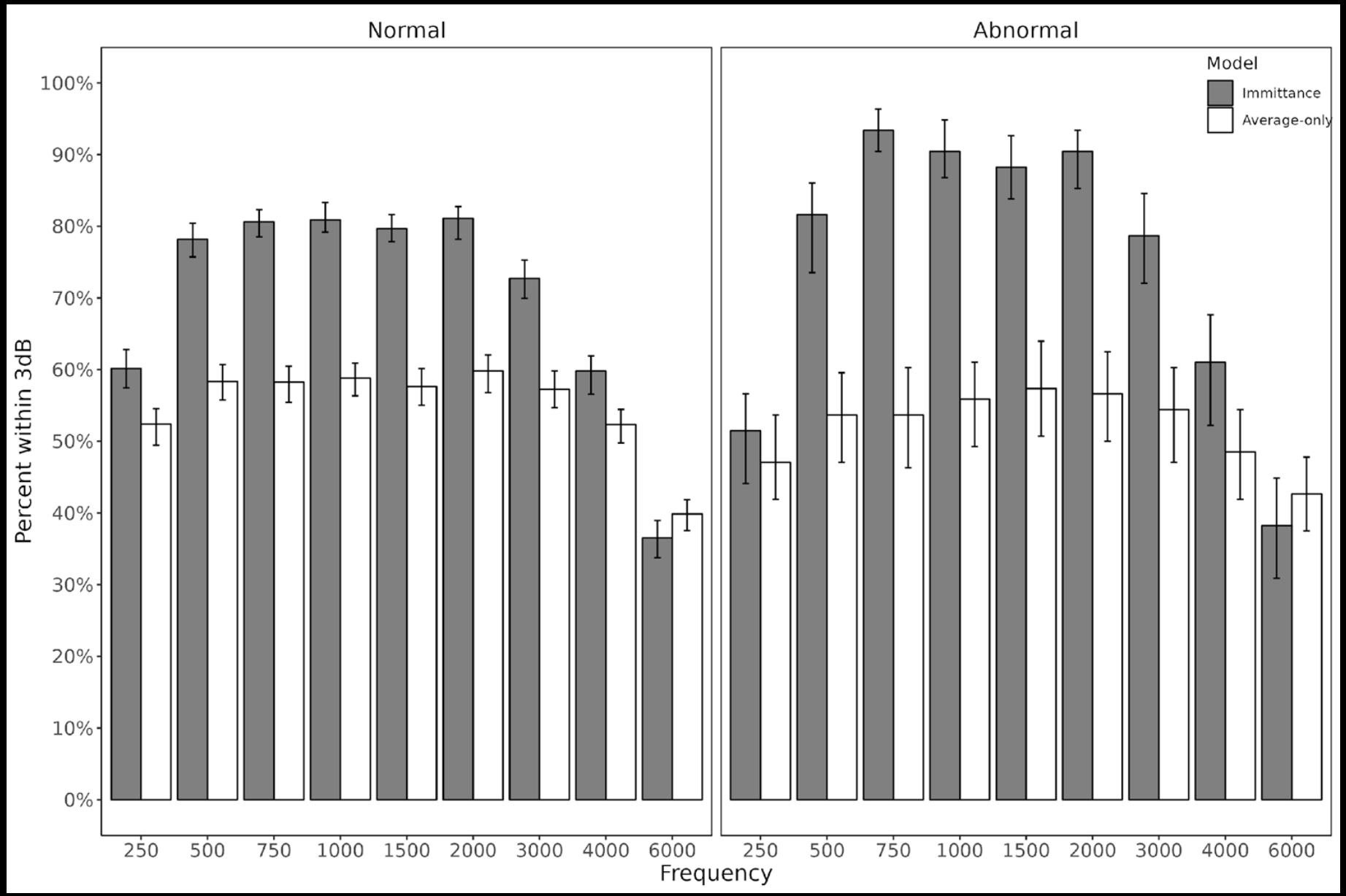
Can we use immittance to predict RECD?



McCreery et al. under review


Difference
(Average - Measured)
20
15
10
5
0
-5
-10
Normal
Abnormal
250
500
750
1000
1500
2000
3000
4000
6000
Frequency (Hz)

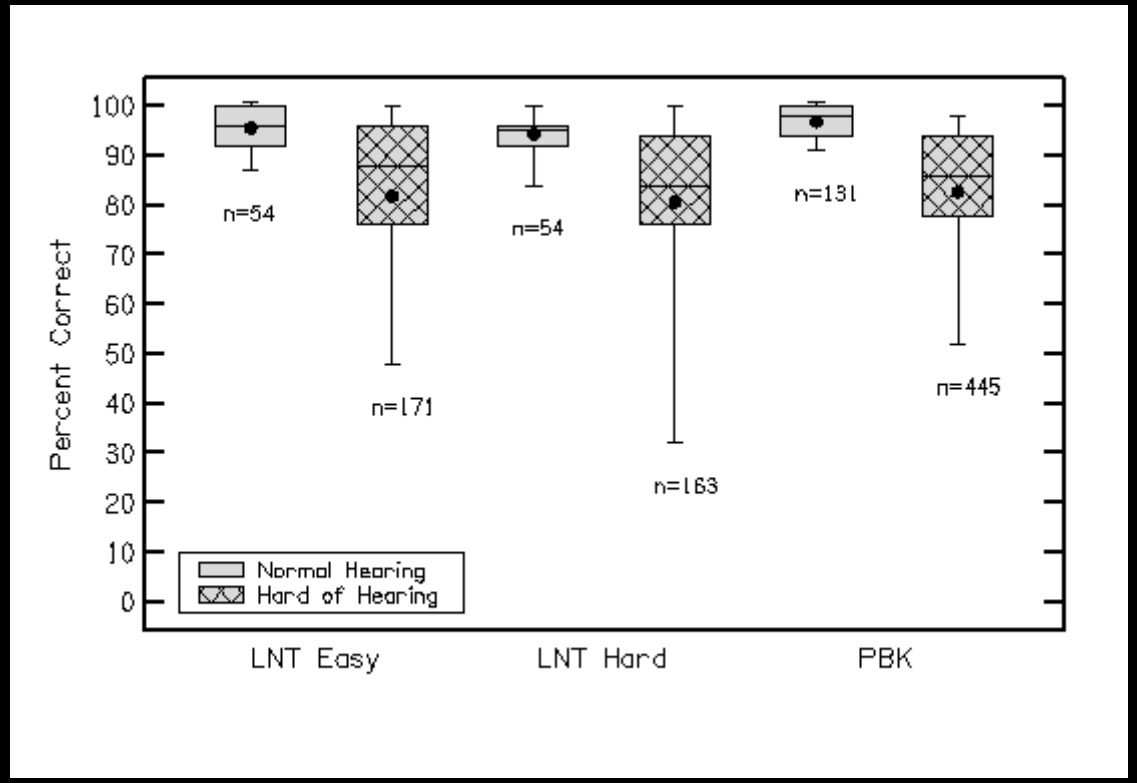

Difference
(Immitance-Predicted - Measured)
20
15
10
5
0
-5
-10
Normal
Abnormal
250
500
750
1000
1500
2000
3000
4000
6000
Frequency (Hz)


Normal
Abnormal
Model
Immittance
Average-only
Percent within 3dB
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
250
500
750
1000
1500
2000
3000
4000
6000
Frequency

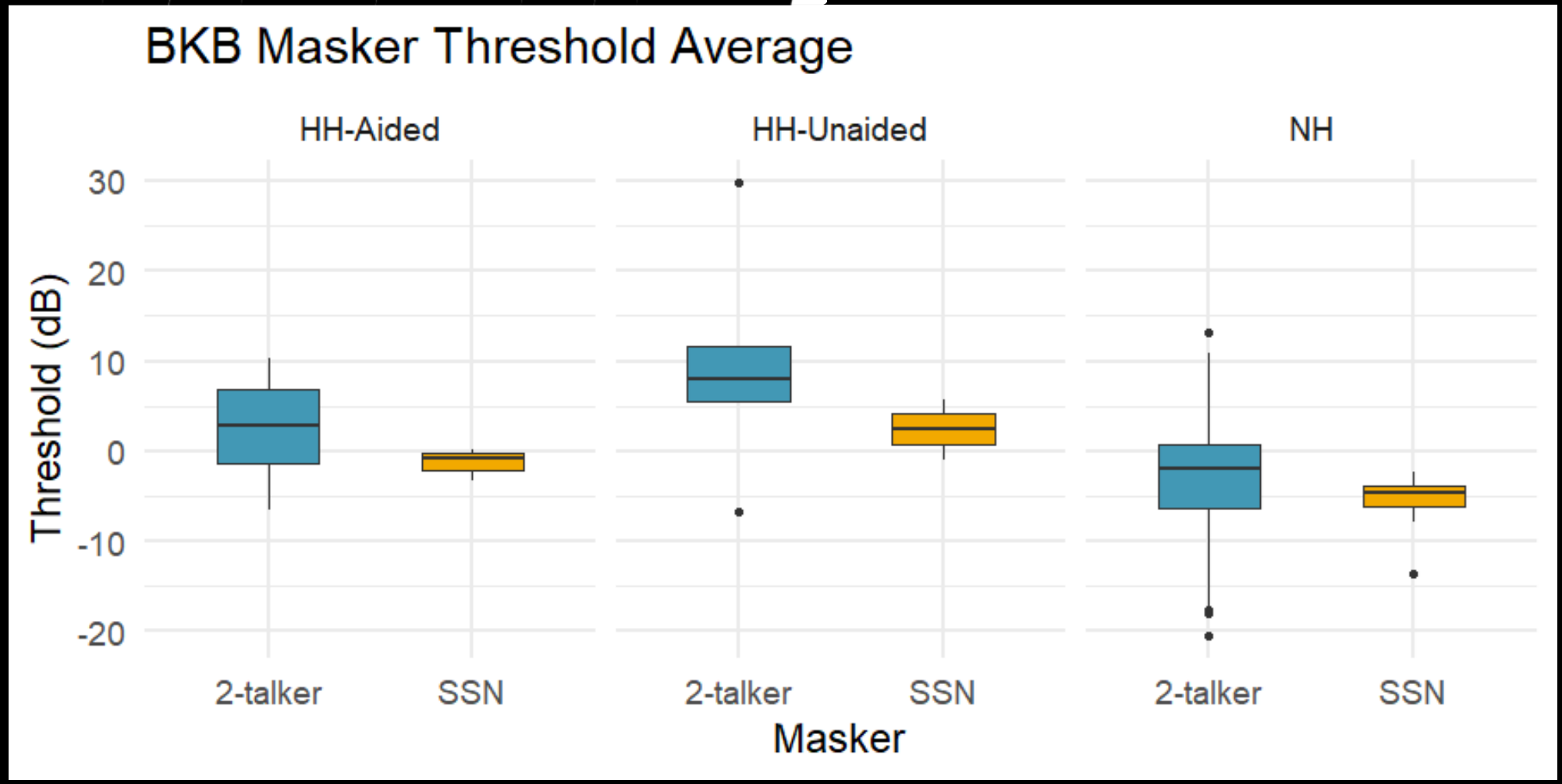
Next steps

- Develop model to allow clinicians to predict measured RECD/wRECD based on:
  - 226 Hz tympanometry
  - Wideband immittance

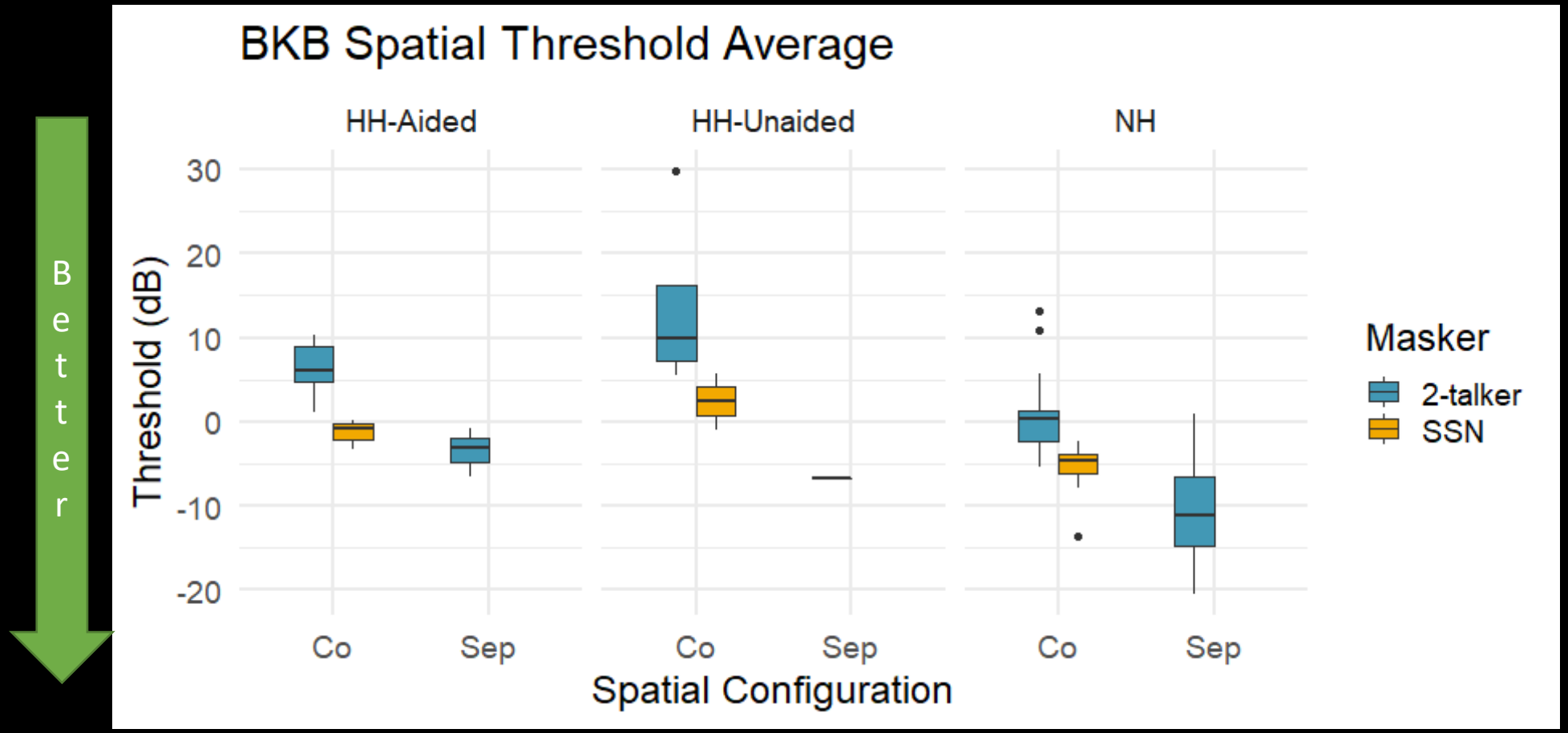
Performance on monosyllabic words in quiet



FASTRAK



SSN = Speech-shaped noise

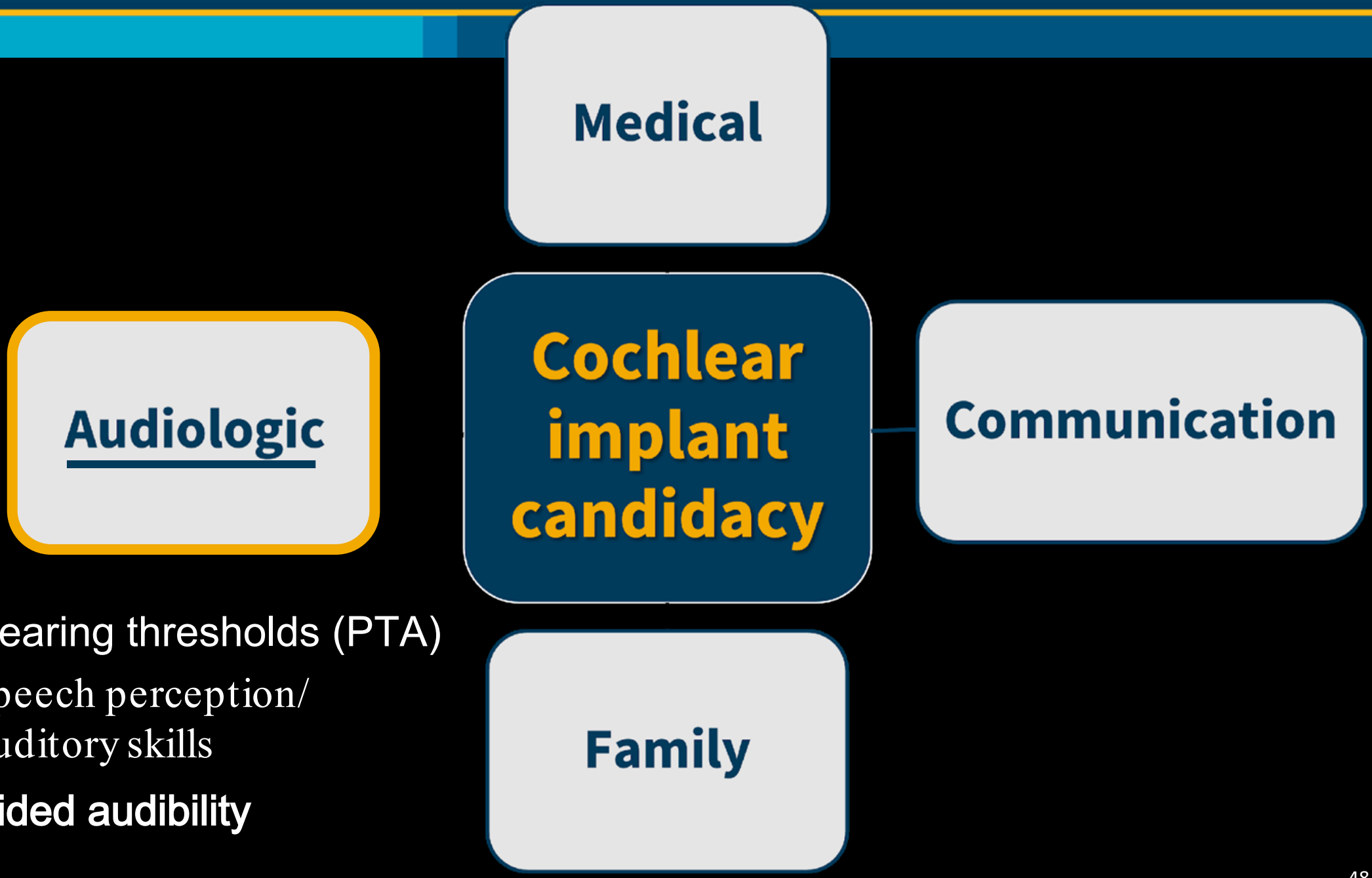


CO = Co-located
Sep = Separated

To refer or not to refer?

Wait and see with hearing aid?

Refer for cochlear implant candidacy evaluation



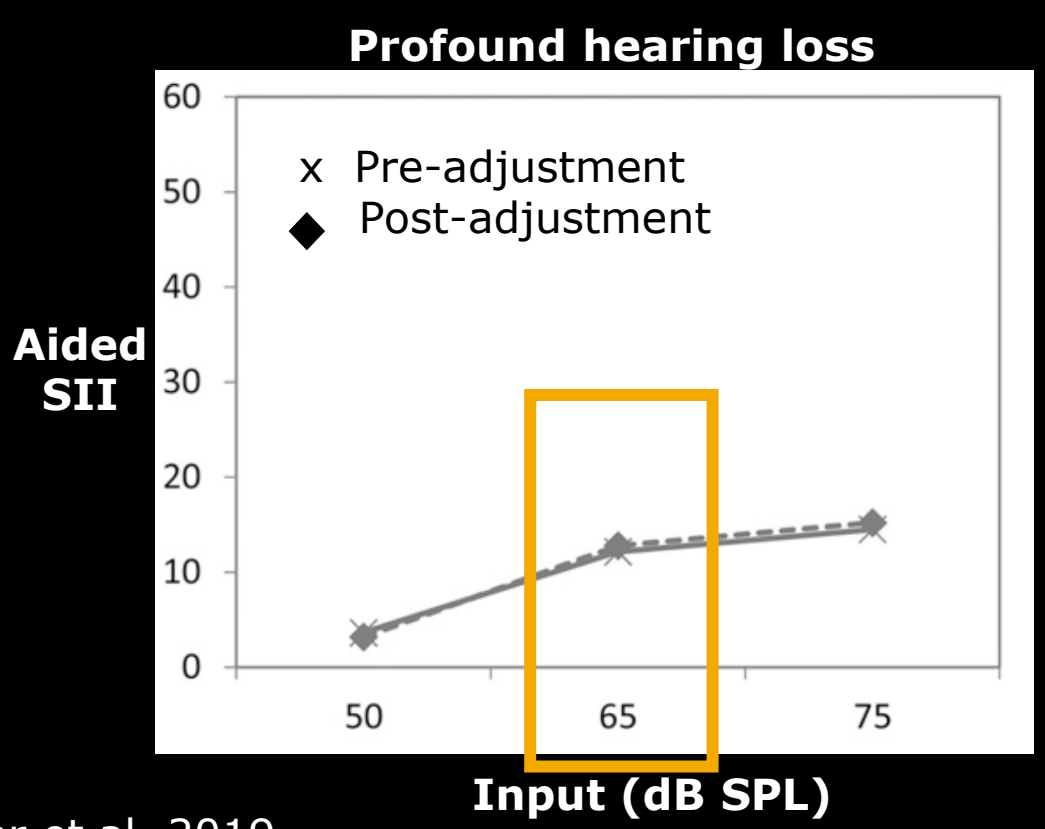
Hearing thresholds (PTA)

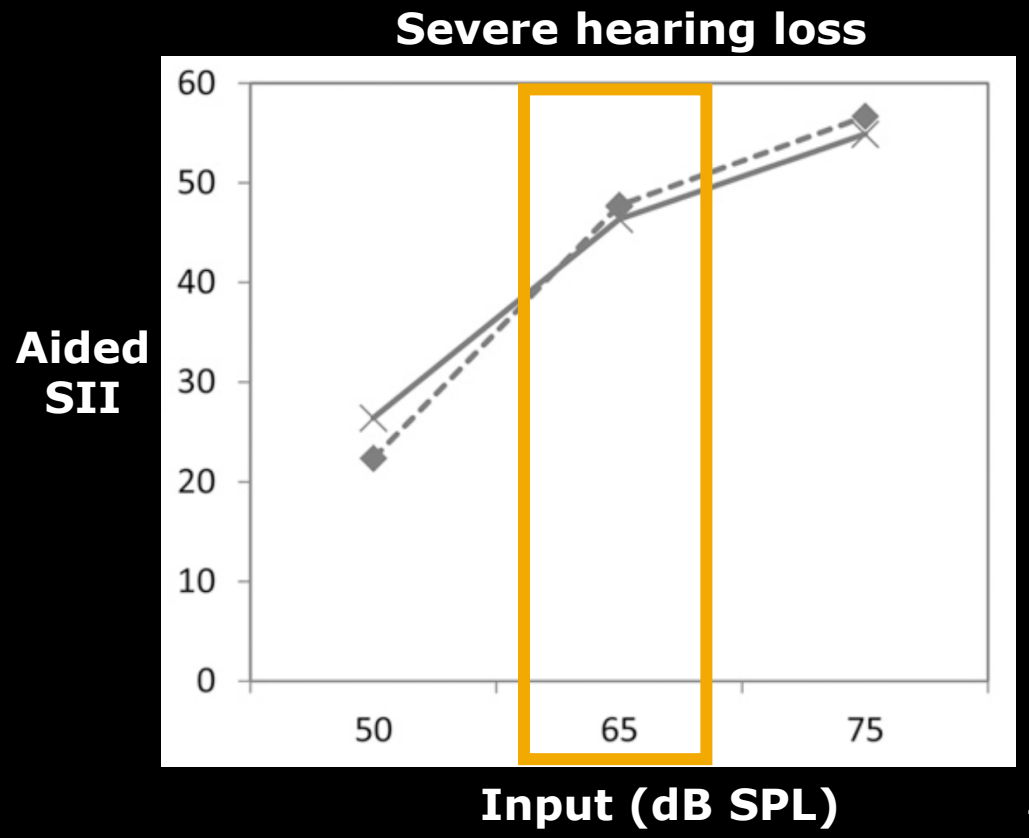
Speech perception/ Auditory skills

Aided audibility

Hearing aid fitting outcome: audibility

How much audibility is enough?



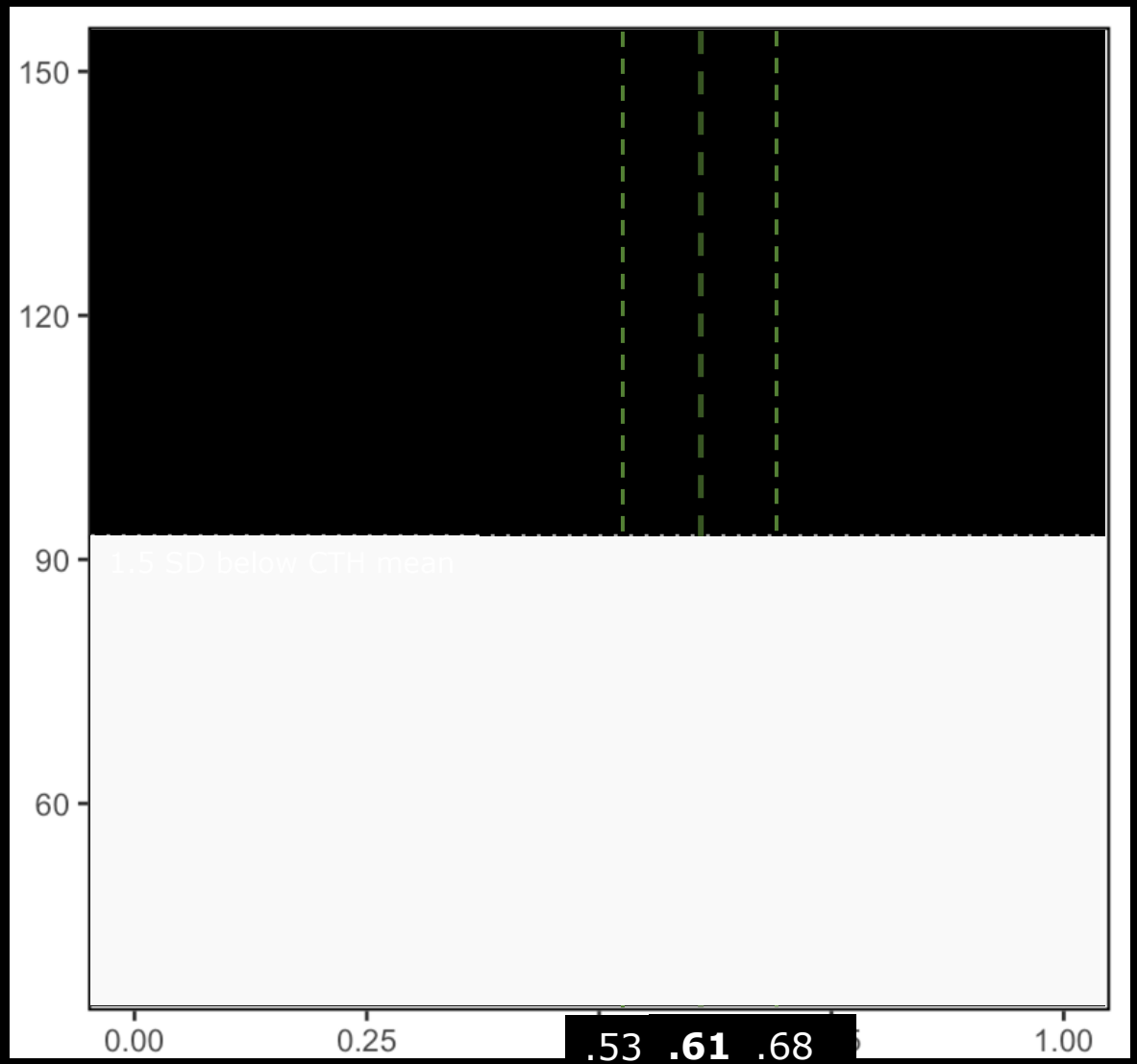


Quar et al. 2019

What level of audibility signals risk for delay in children with hearing aids?

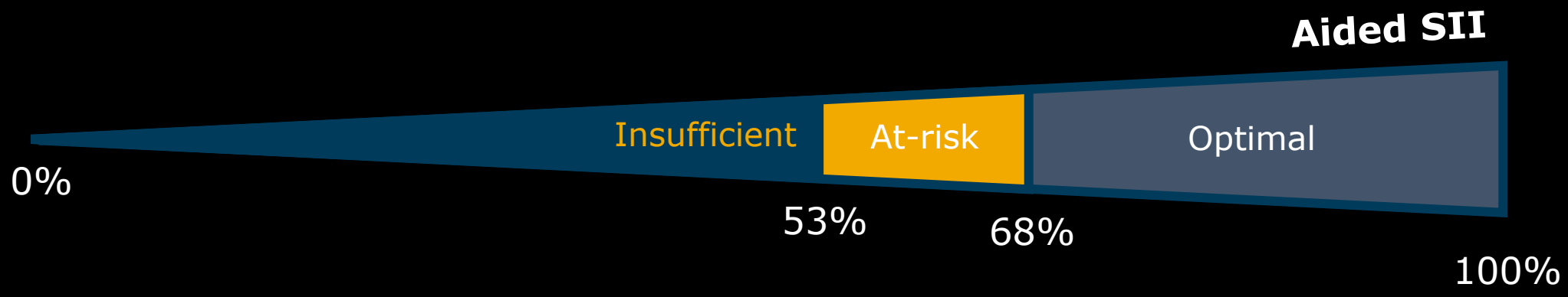
182 Children with hearing aids (CHA)
76 Children with typical hearing (CTH)

Language composite:
Receptive vocabulary
Syntax
Pragmatics



Wiseman, McCreery & Walker (in prep)

Audibility guidelines



Aligns with other estimates:

Stiles et al. (2012) - 65%

Tomblin et al. (2020) – 71%

Clinical Take-aways

1. Use unaided audibility to assist with candidacy decisions
2. Measure real-ear-to-coupler difference (RECD) when possible
3. Verify aided audibility within the normative range for prescription
4. Measure aided speech recognition at verification levels

Thank you!

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