Exploring the limits of hearing aid candidacy for children with unilateral hearing loss

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Conflicts of Interest

- NIH/NIDCD - Grants
- Boys Town National Research Hospital - Salary
- British Columbia Early Hearing Program – Paid consultant
- Oticon – Research grants
- Oberkotter Foundation – Scientific Advisory Board

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Special Thanks!

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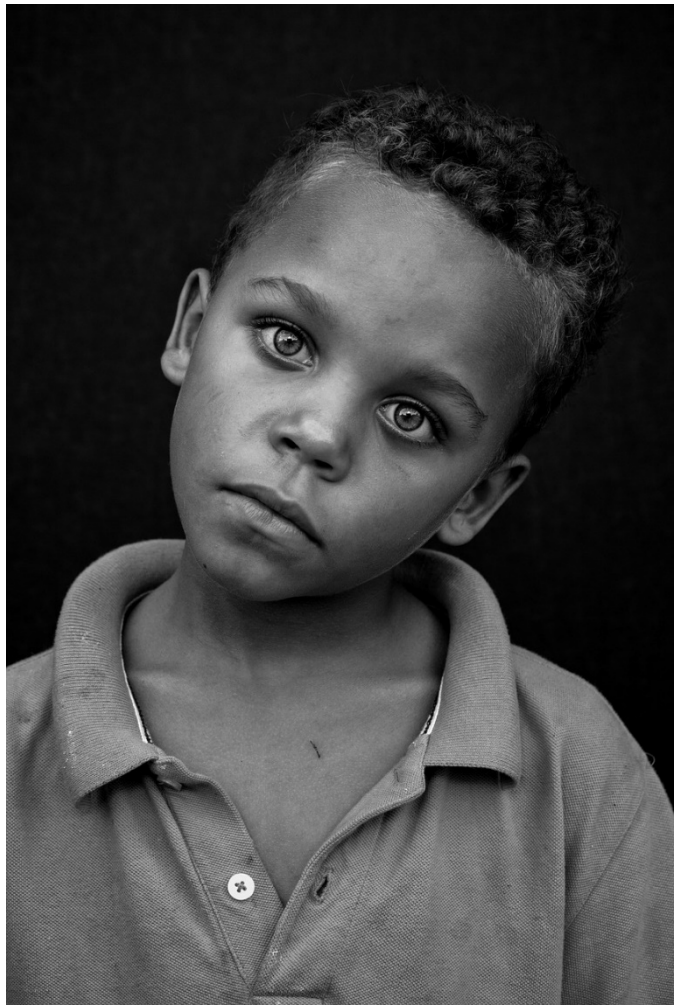
What is unilateral hearing loss?

One ear with typical hearing levels



One ear with reduced hearing levels

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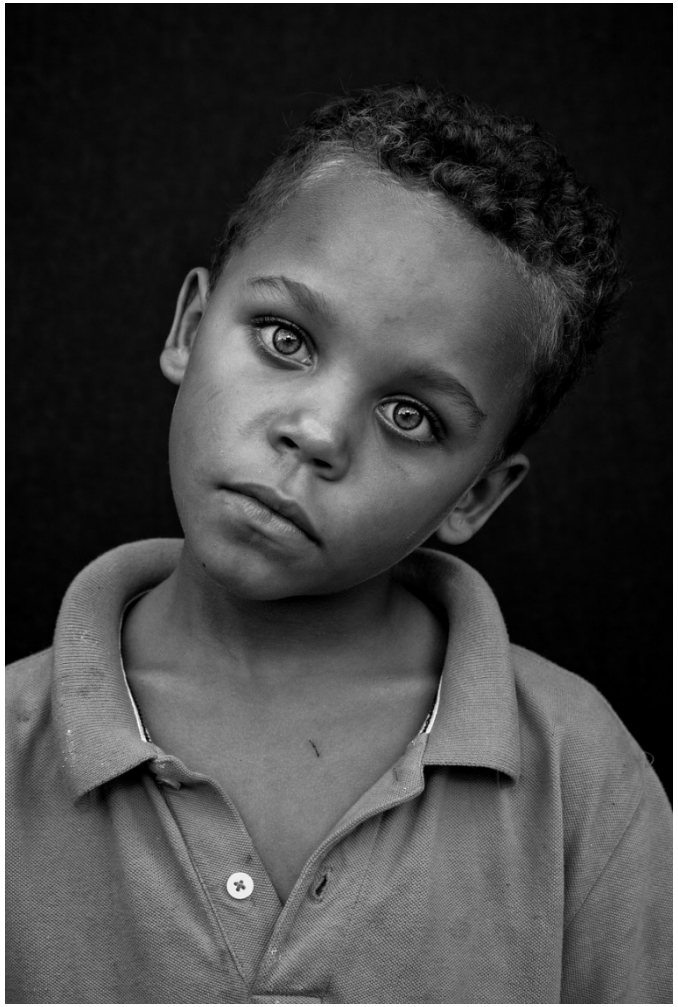
Isn’t one ear enough?

Binaural hearing = two ears

Interaural timing and level differences

Binaural summation

Segregation of sound sources



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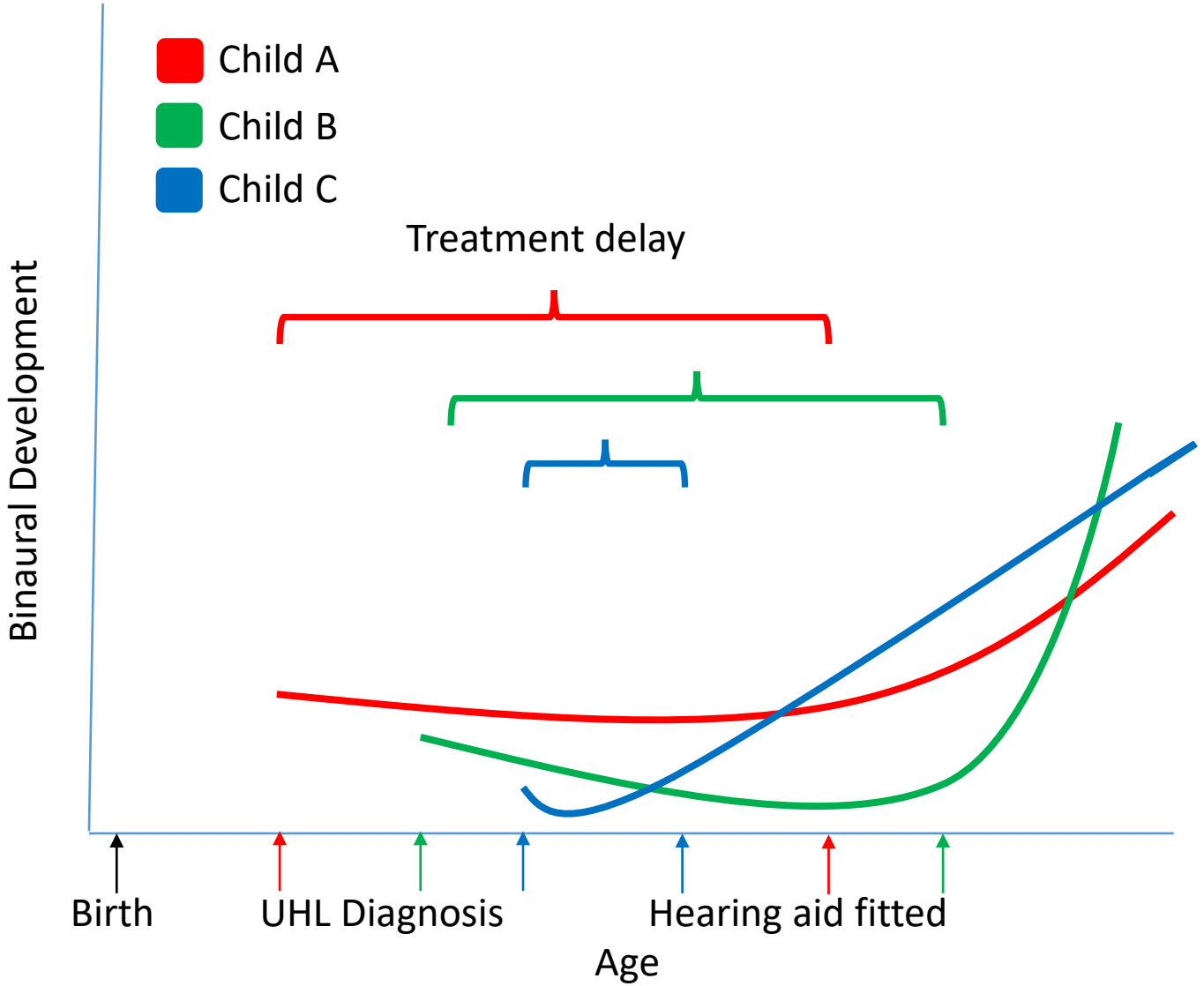
Effects of UHL mixed

UHL < children with typical hearing

- Kiese-Himmel 2002
- Sedey et al. 2002
- Peckham & Sheridan 1976
- Borg et al. 2002
- Lieu 2015

UHL = children with typical hearing

- Klee & Davis-Dansky 1986
- Cozad 1977



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UHL and academic challenges

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Table 2

Standardized scores on cognitive, achievement, and oral language tests in 104 children with unilateral hearing loss (UHL) compared with 91 siblings with normal hearing (NH). Standard scores range from 40 to 160 by age and grade, with mean = 100 and SD = 15.

Lieu, 2015

Outcome scores	UHL Mean (SD)	NH Mean (SD)	P value
Cognitive			
Verbal sum IQ	100.9 (16.3)	105.5 (14.6)	0.040
Performance sum IQ	99.8 (14.4)	102.6 (14.5)	0.168
Full scale IQ	100.5 (15.2)	104.5 (14.3)	0.052
Achievement			
Reading	101.1 (15.3)	102.7 (15.4)	0.470
Math	96.6 (15.9)	99.2 (16.6)	0.251
Writing	101.5 (14.8)	103.5 (16.2)	0.368
Oral language			
Listening comprehension	91.7 (10.9)	96.7 (14.2)	0.007
Oral expression	92.7 (15.8)	100.1 (18.5)	0.003
Oral composite	90.6 (13.0)	98.0 (15.7)	0.0004

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Audiological Interventions for UHL

Mild - severe UHL

- Binaural hearing
- Hearing aid

Severe – Profound UHL

- Cochlear implant*

OR

- Rerouting of sound to better ear
  - Contralateral routing of sound (CROS)
    - Bone conduction
    - Air conduction

*Some restrictions may apply

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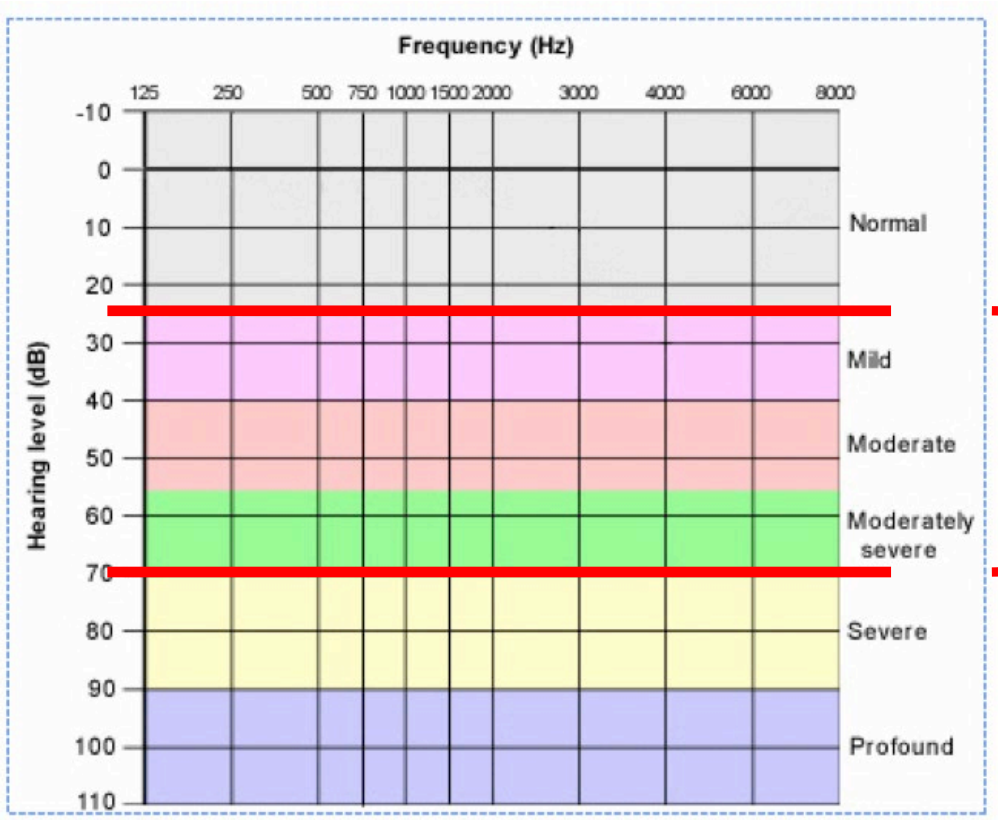
What level of UHL for hearing aids?



Limited evidence for benefit

Range of UHL hearing aid candidacy

Potential for crossover or binaural interference
Cochlear implant candidacy range*

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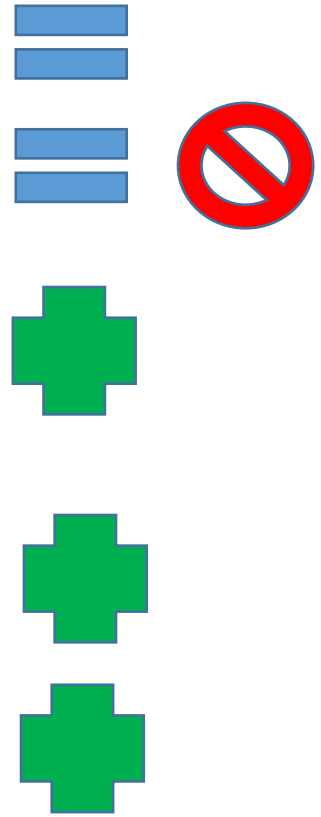
Challenges with hearing aids and UHL

- Limited research

Table 4. Outcomes for Nonsurgical Intervention.

Study	Amplification	Objective Outcome	Functional Outcome
Briggs et al, 2011[10]	Conventional HA	No significant change in average SNR-50 score on BKB-SIN	Average improvement on CHILD-child of 1.25; average improvement on CHILD-parent of 1.18; no significant change in average improvement on SIFTER
Johnstone et al, 2010[15]	Conventional HA	Sound localization with HA significantly worse in older children and significantly better in younger children; negative correlation between age of first fitting and bilateral benefit ($r = -0.671$, $P < .05$)	N/A
Kenworthy et al, 1990[16]	FM/CROS	Mean BKB scores were 97% unaided, 90% with FM system, and 48% for CROS in the MD setting; no significant difference between unaided and FM system; CROS significantly reduced performance Mean BKB scores were 32% unaided, 93% with the FM system, and 93% for CROS in the MI setting; both FM system and CROS significantly improved performance, but there was no significant difference between FM system and CROS Mean BKB scores were 93% unaided, 90% with the FM system, and 85% for CROS in the MS/ON setting; no significant differences in performance were seen	N/A
Priwin et al, 2007[19]	Conventional HA	Significantly improved speech recognition in noise with 0 SNR; in SNR of +4 and +6 dB, there were no significant improvements; no improvement in sound localization	No significant improvement in MAIS
Updike, 1994[20]	Conventional HA/FM/CROS	Mean unaided word recognition scores were 75.6 and 39 in quiet and noise, respectively; mean scores with HA were 53.5 and 29 in quiet and noise, respectively; mean scores with CROS were 69.3 and 32 in quiet and noise, respectively; mean scores with FM were 90.7 and 87.3 in quiet and noise, respectively	N/A

Abbreviations: BKB, Banford-Kowal-Bench sentences; CHILD, Children's Home Inventory for Listening Difficulties; CROS, contralateral routing of signals; FM, frequency modulation; HA, hearing aid; MAIS, Meaningful Auditory Integration Scale; MD, monaural direct; MI, monaural indirect; MS/ON, midline signal/omnidirectional noise; N/A, not applicable; SIFTER, Screening Instrument For Targeting Educational Risk; SNR-50, signal to noise ratio corresponding to 50% correct key word identification.



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Challenges with hearing aids and UHL

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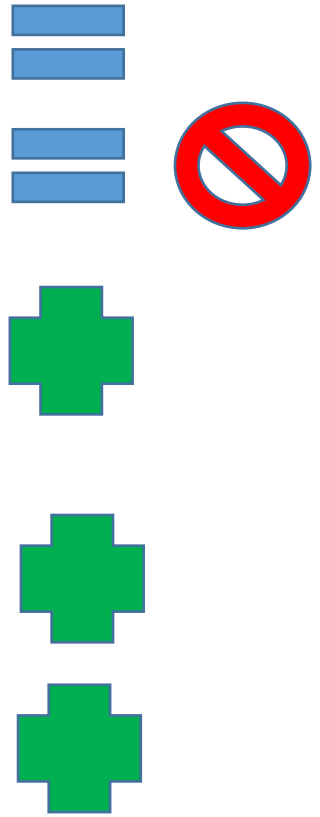

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Challenges with hearing aids and UHL

- Testing aided benefit?
  - Mask good ear?
  - Spatialize speech and noise?
- Make clinical decisions early
  - Tools?

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

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

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Ear canal acoustics

- Assessment

- Hearing aid fitting

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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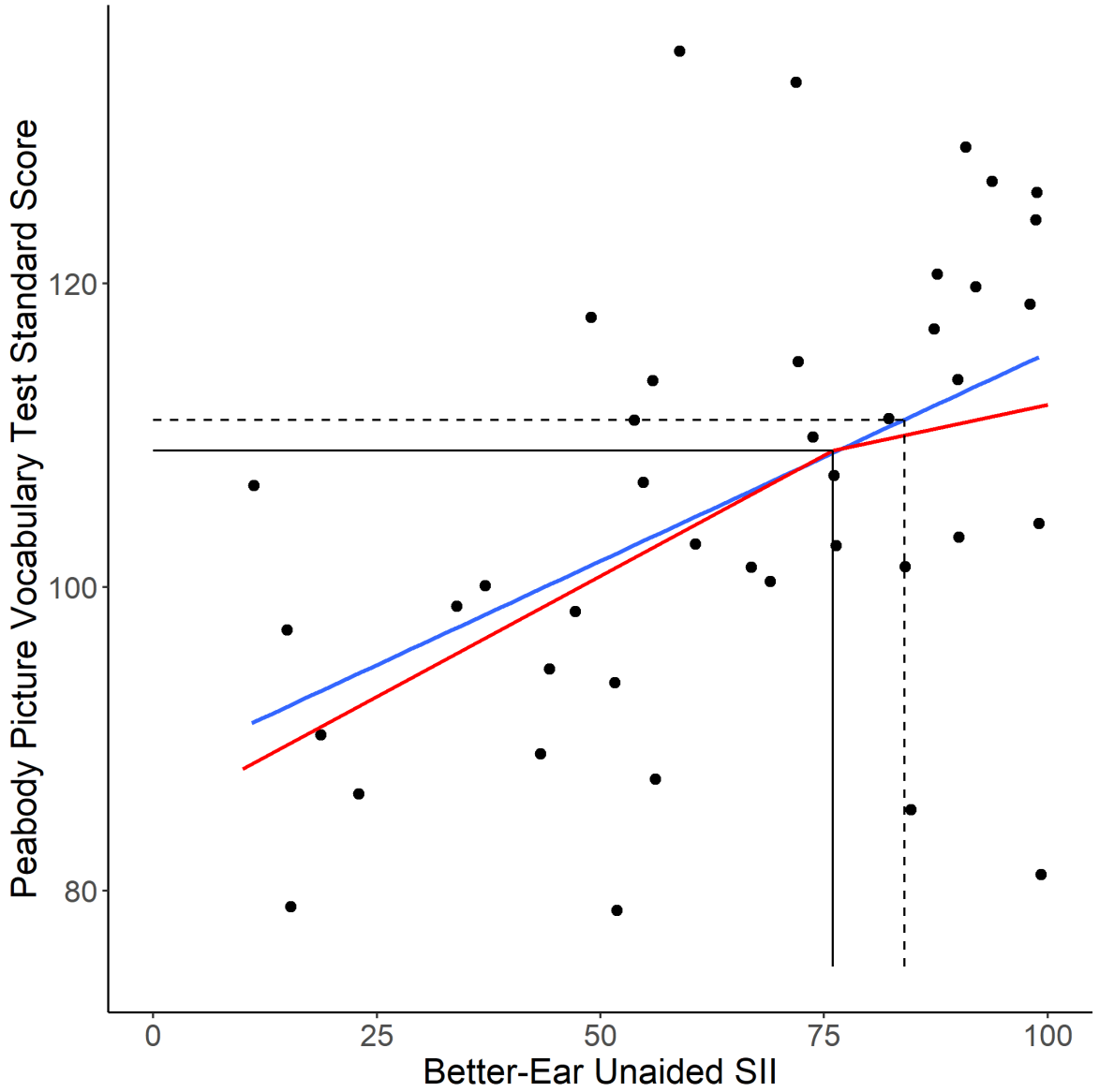
Receptive Vocabulary

Linear

Piecewise



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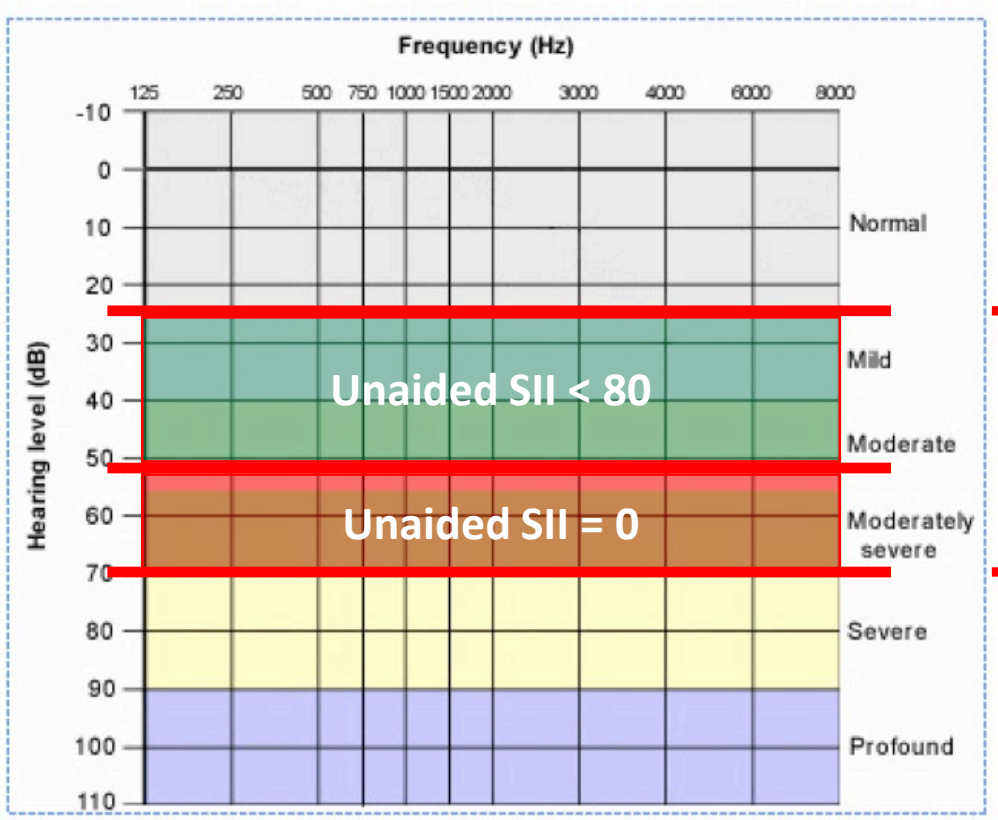
What about children with UHL?

- If unaided SII < or = 80, child may be a candidate for amplification?

- If unaided SII ~ 0, what's the potential for aided benefit?
  - Based on children with bilateral hearing loss
    - Well-fitted hearing aids led to an SII > 50 in ~ 95% of cases

Unaided SII?



Limited evidence for benefit

Range of UHL hearing aid candidacy

Potential for crossover or binaural interference

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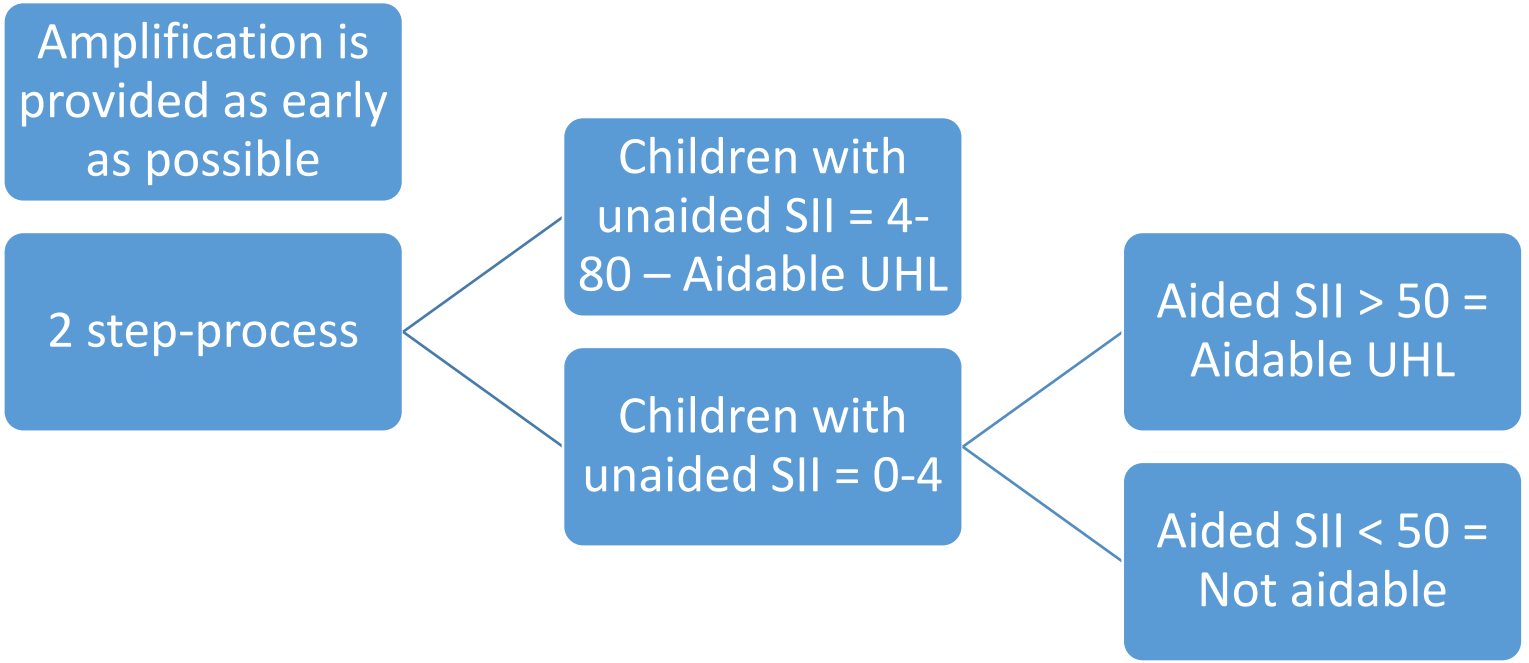
Audibility-based UHL Criterion



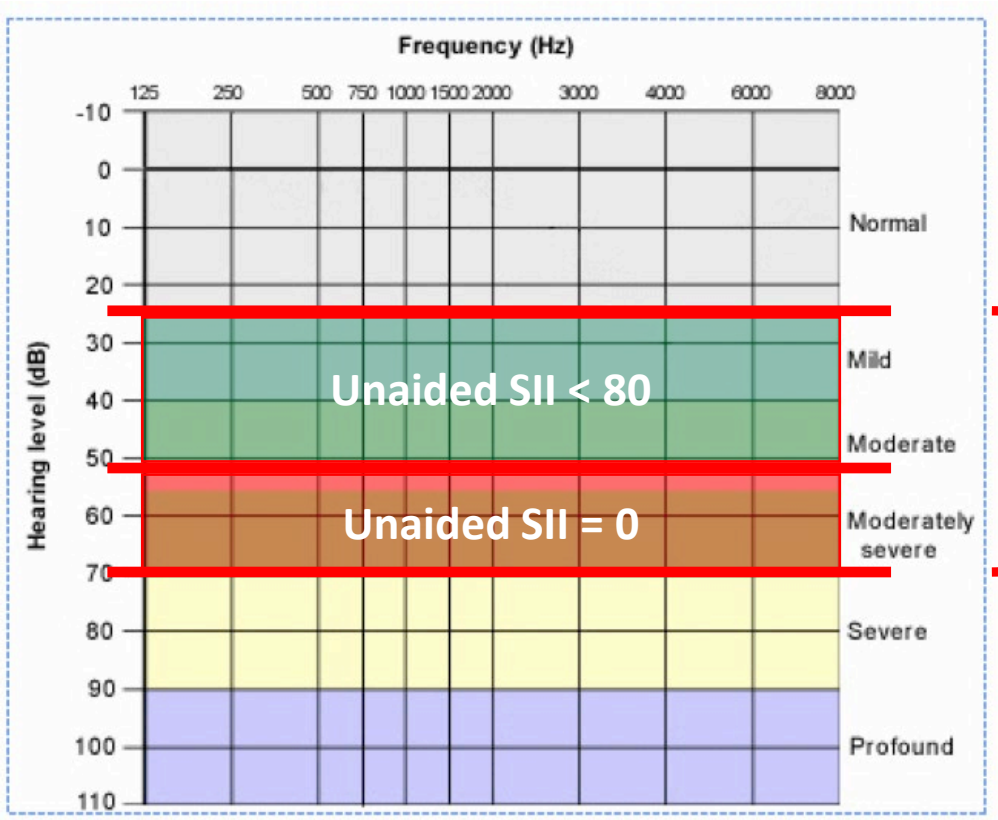
UHL Hearing Aid Candidacy

Translation of PTA < 70 dB HL to SII

- Unaided SII = 0 at 55 dB HL
- Look at simulated aided when unaided = 0

No empirical data to support this approach

Unaided SII?



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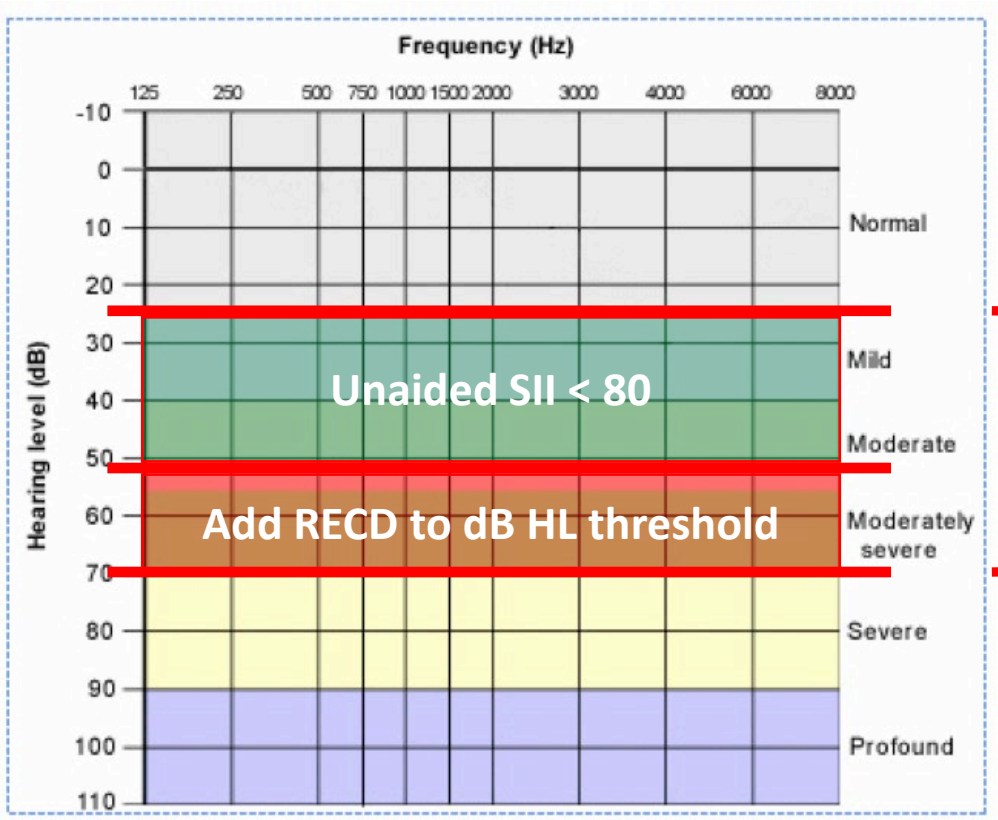
Ear-canal adjusted dB HL?



Limited evidence for benefit

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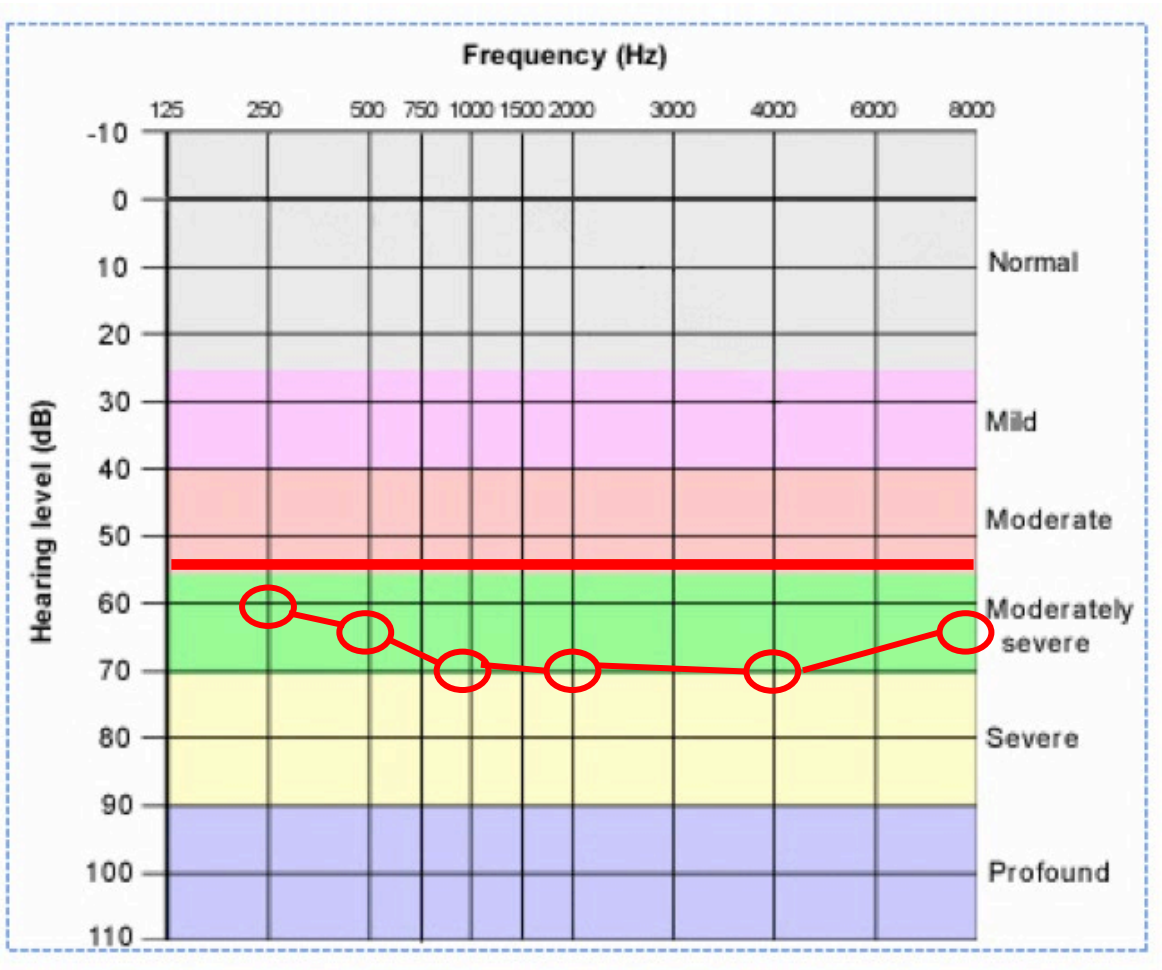
Ear-canal adjusted dB HL

18 month-old
Unaided SII = 0
Aided SII = 40



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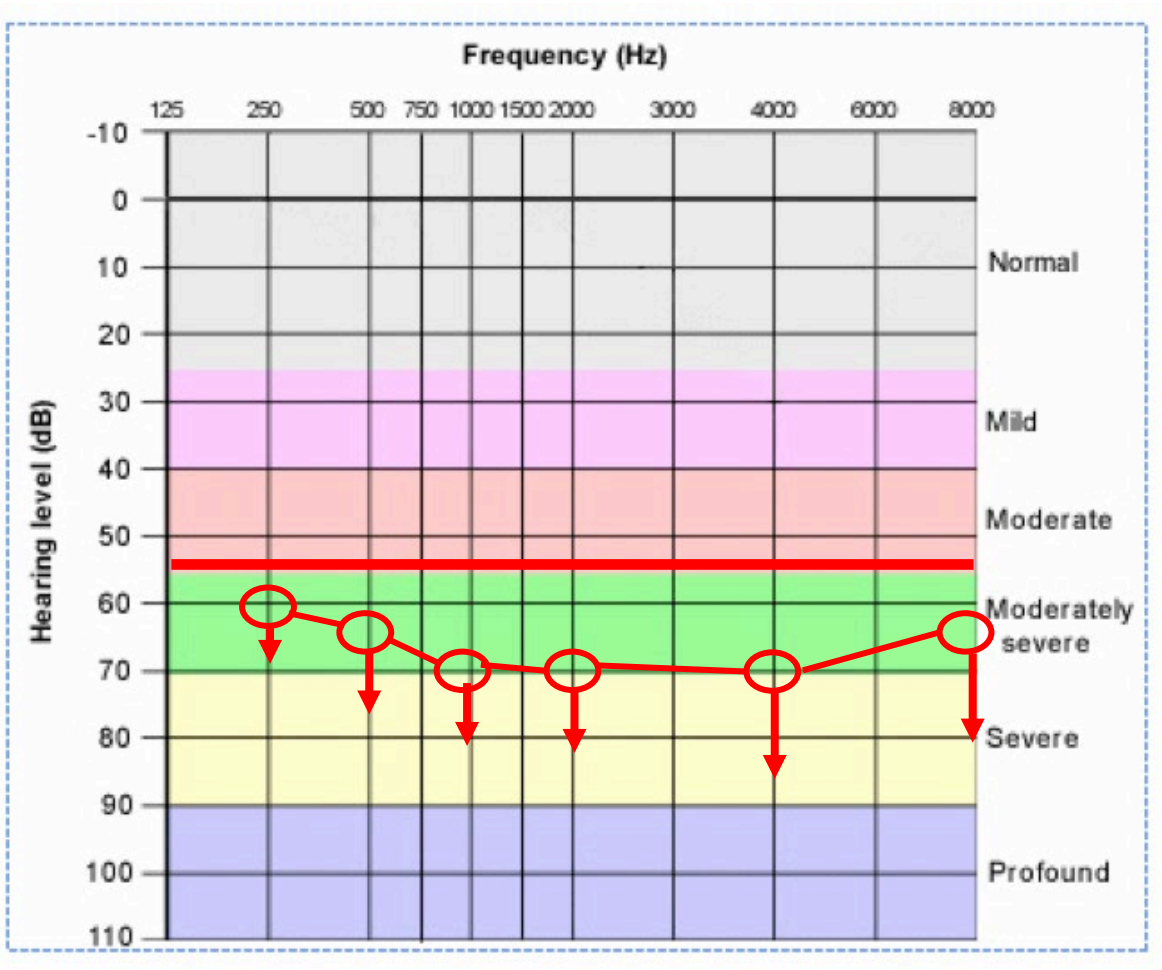

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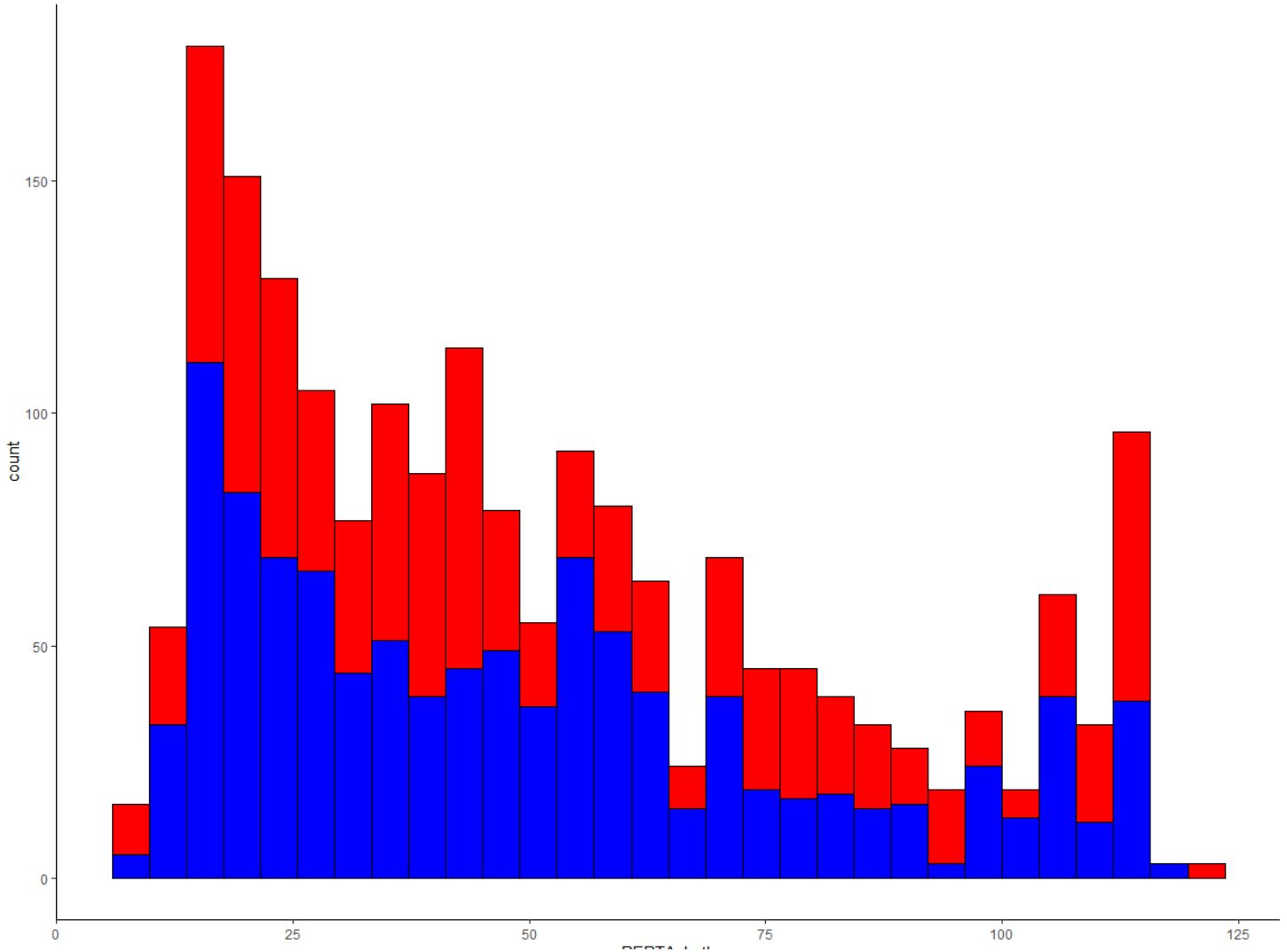
How does this align with clinical practice?

- Retrospective analysis of 263 children with UHL who were fitted with hearing aids at Boys Town National Research Hospital
  - Better-ear pure-tone average (BEPTA) = 9.9 dB HL (- 5 to 15 dB HL)
  - Poorer-ear pure-tone average (PEPTA) = 50.5 dB HL (6.3 to 115 dB HL)



Poorer-ear PTA

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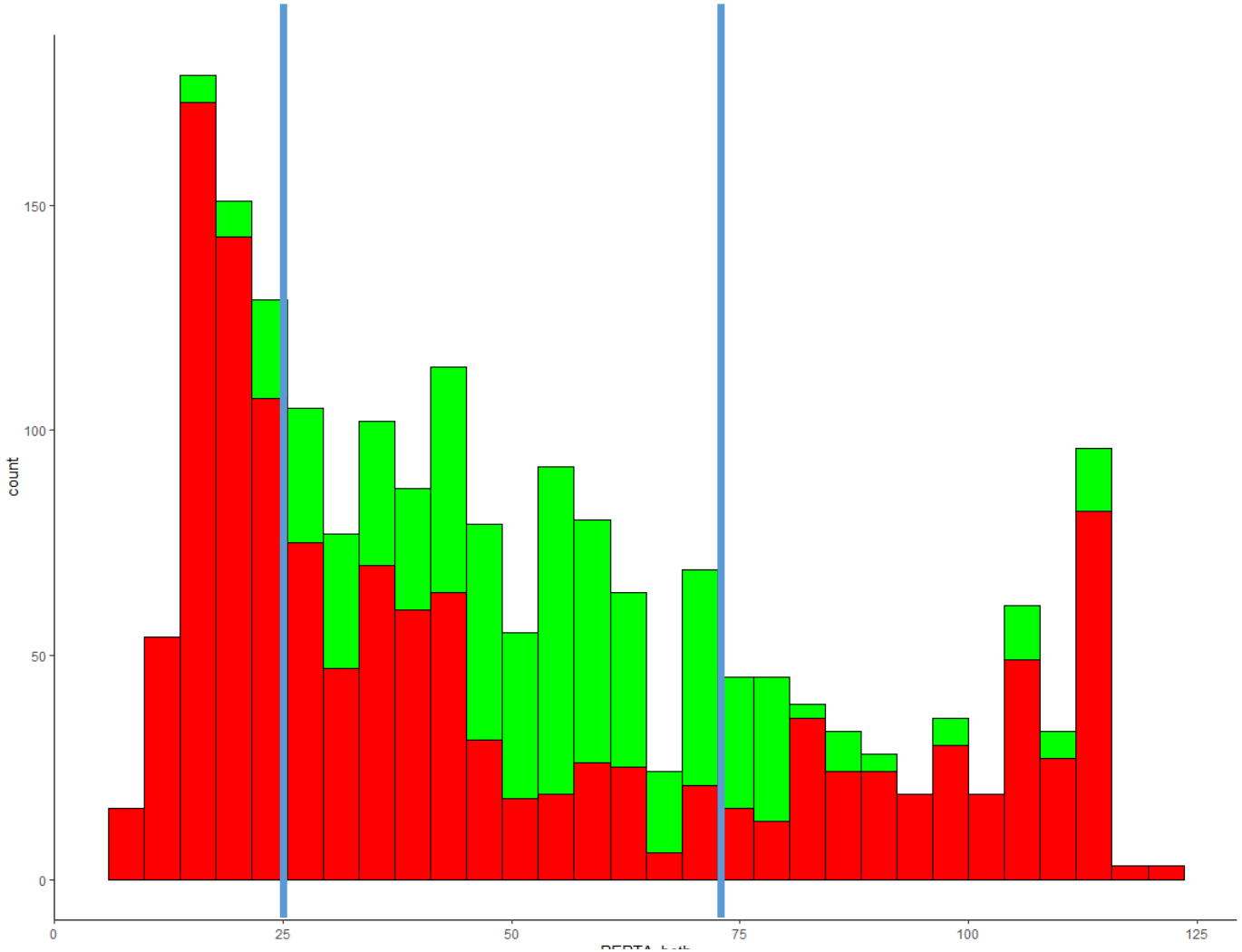
PTA 25- 70



Poorer-ear PTA

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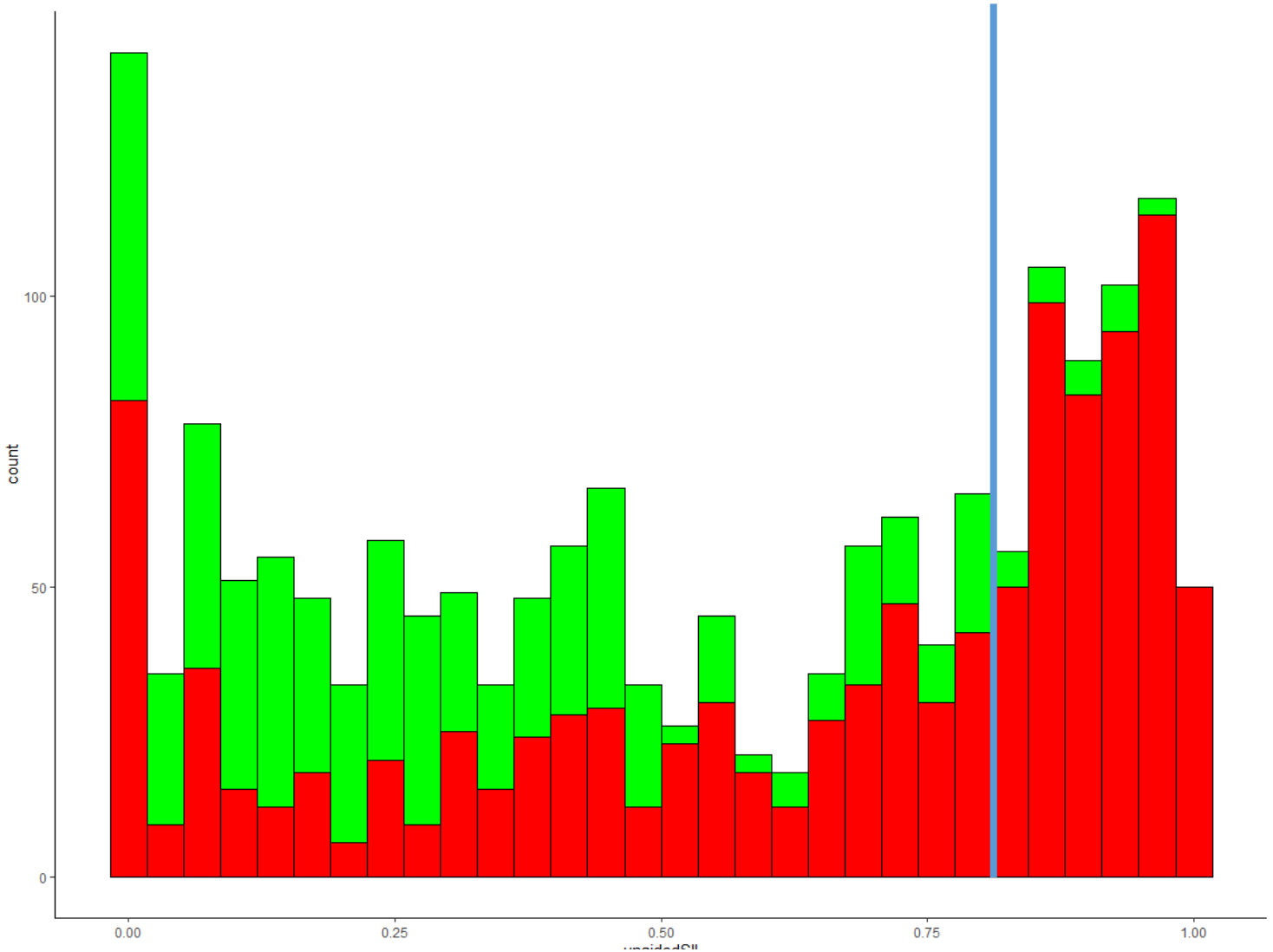
Unaided SII = 80



Unaided SII

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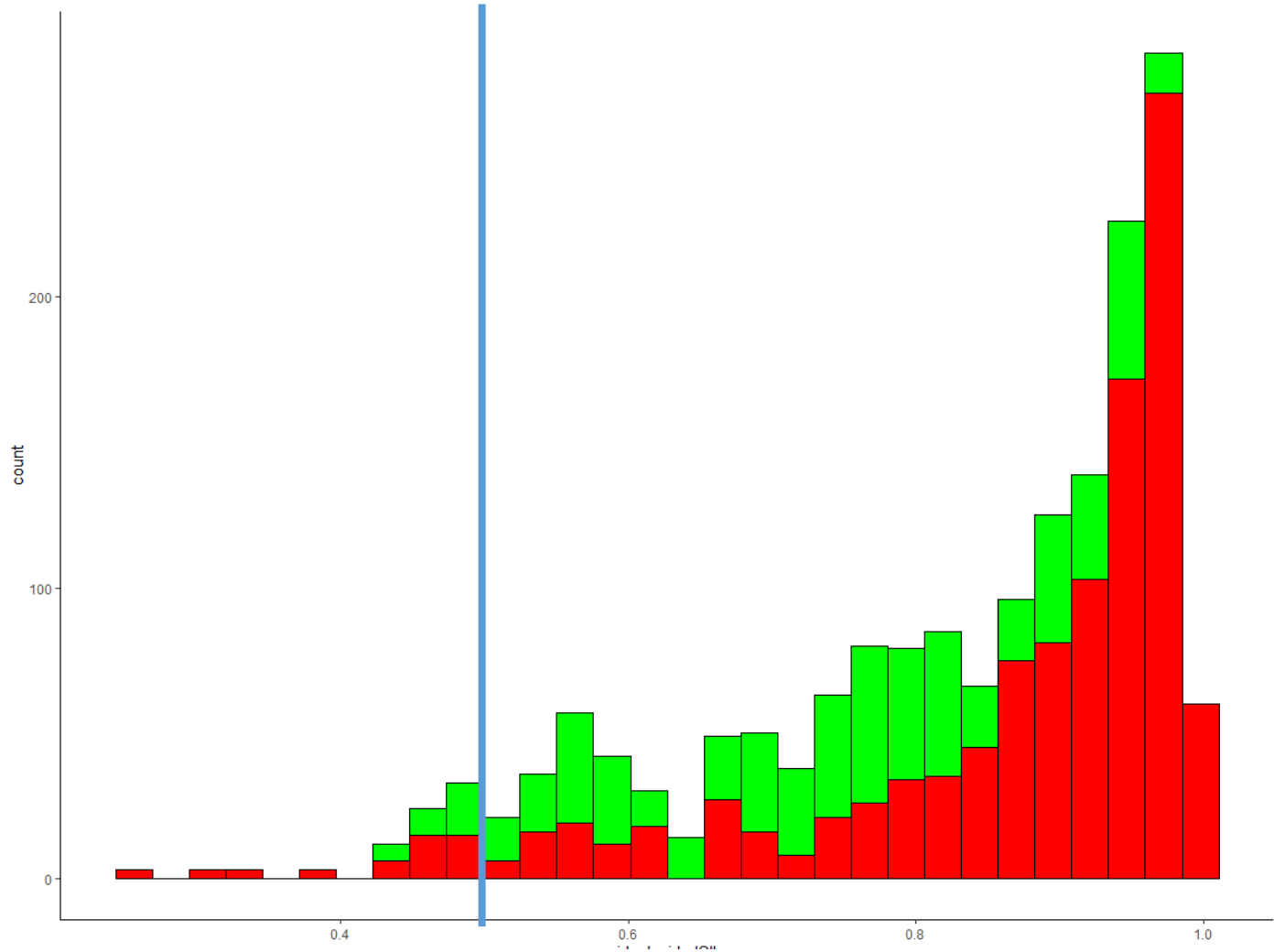
Aided SII = 50



Ideal Aided SII

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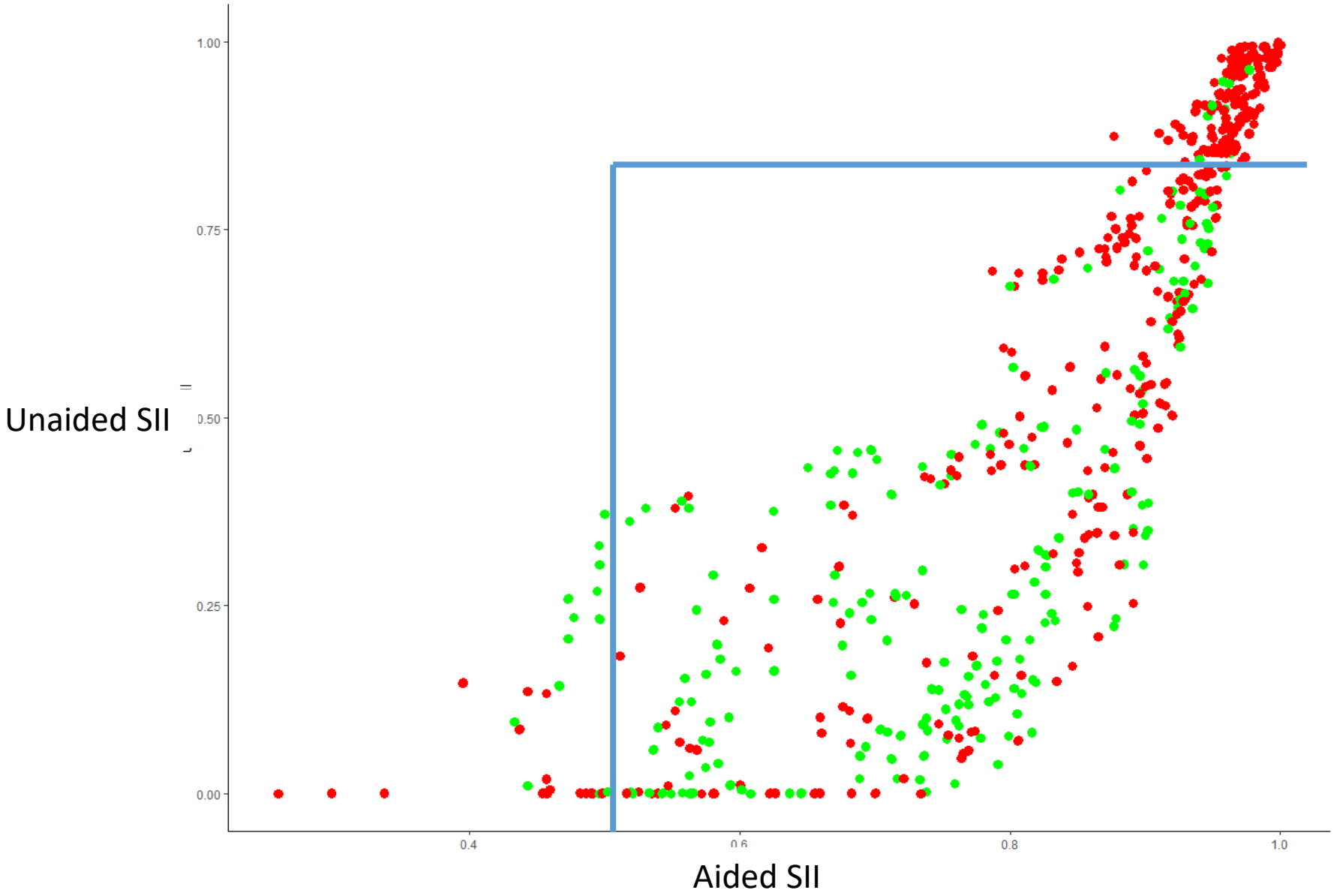

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Conclusions

- Hearing aid candidacy for children with UHL does not follow:
  - PTA
  - SII
- Future research should validate audibility-based approaches prospectively

Additional hearing aid candidacy factors

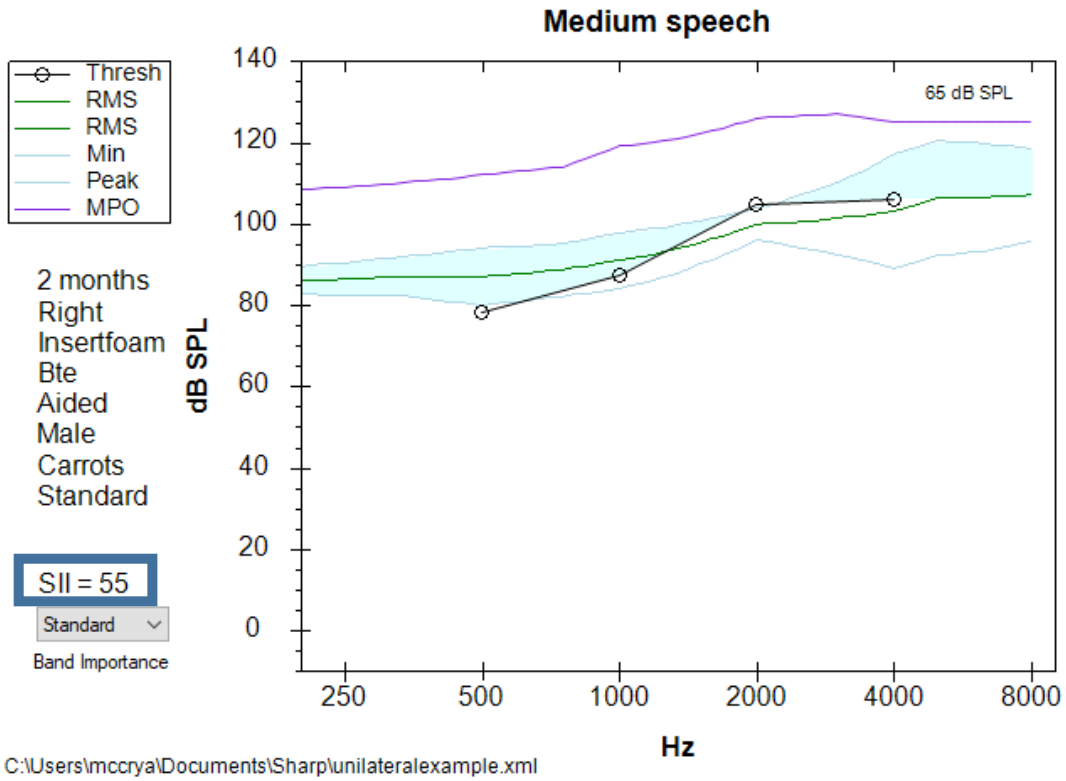
- Parental concern / perception of benefit
- Additional developmental or health concerns
- Evidence of limited benefit

Case Example

- 6 week old
- Family history of hearing loss
- ABR Results

Ear	500 Hz	1000 Hz	2000 Hz	4000 Hz
Right	65 dB eHL	75 dB eHL	85 dB eHL	85 dB eHL

Simulation of Aided SII



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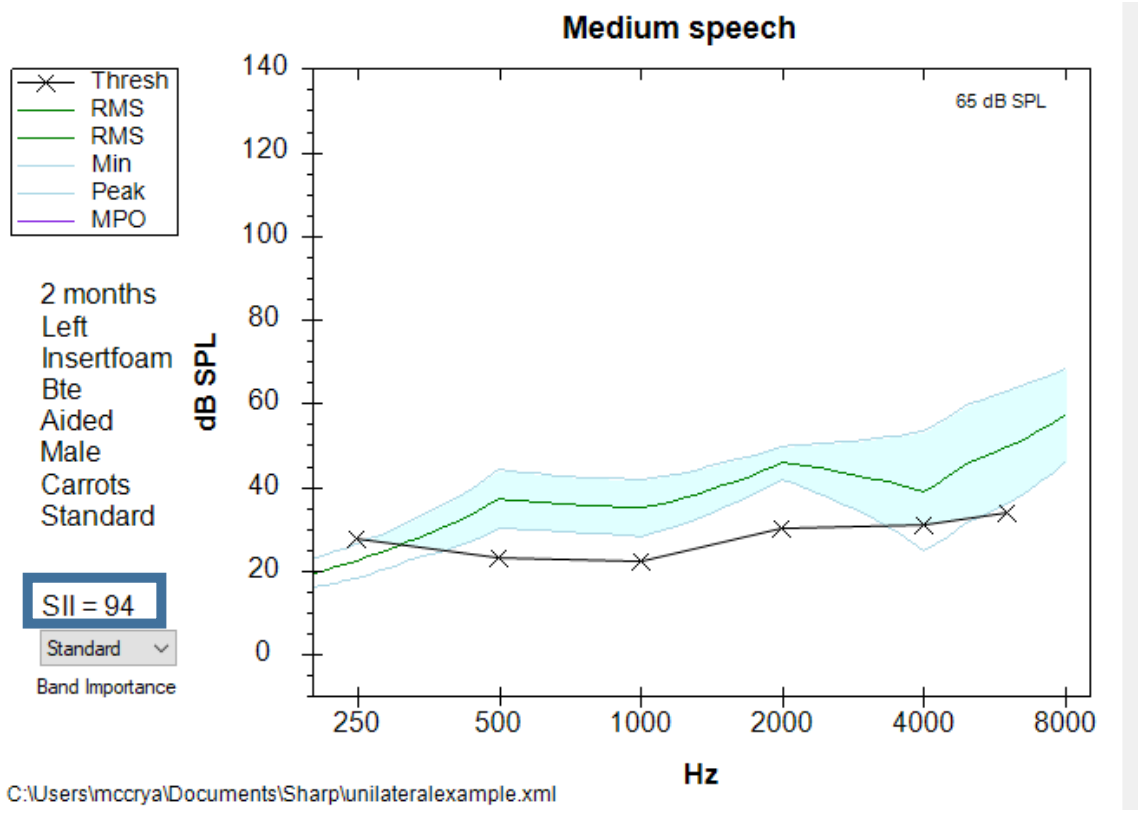
Crossover to normal-hearing ear

Using conservative interaural attenuation values from Munro and Contractor (2010)



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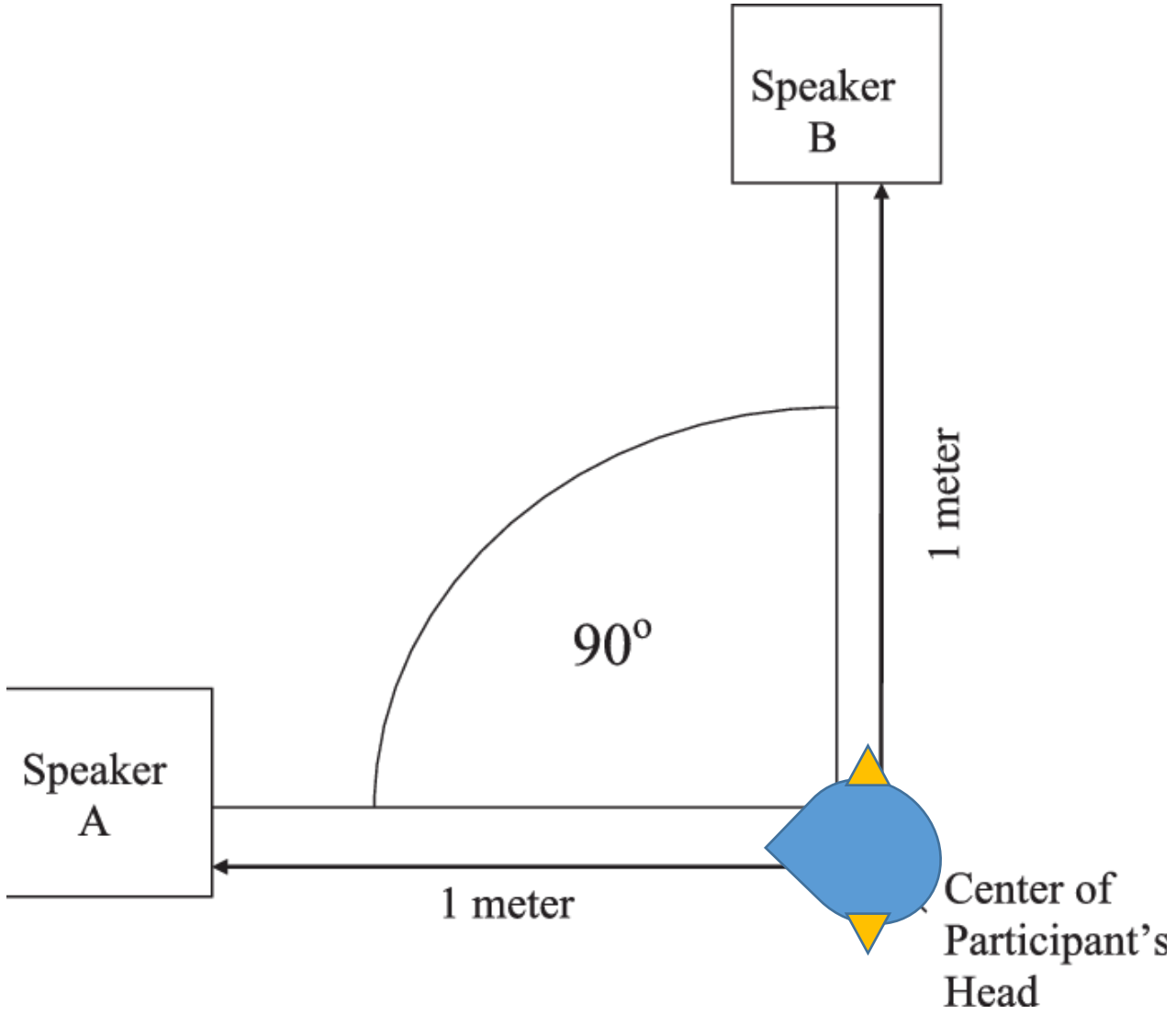
Aided SII > 50 does not = hearing aid benefit

Use conservative crossover estimates

Thresholds > 80 dB may result in crossover

Spatial release from masking set-up (aided)

- Binaural
- Adaptive or percent correct
- Aids



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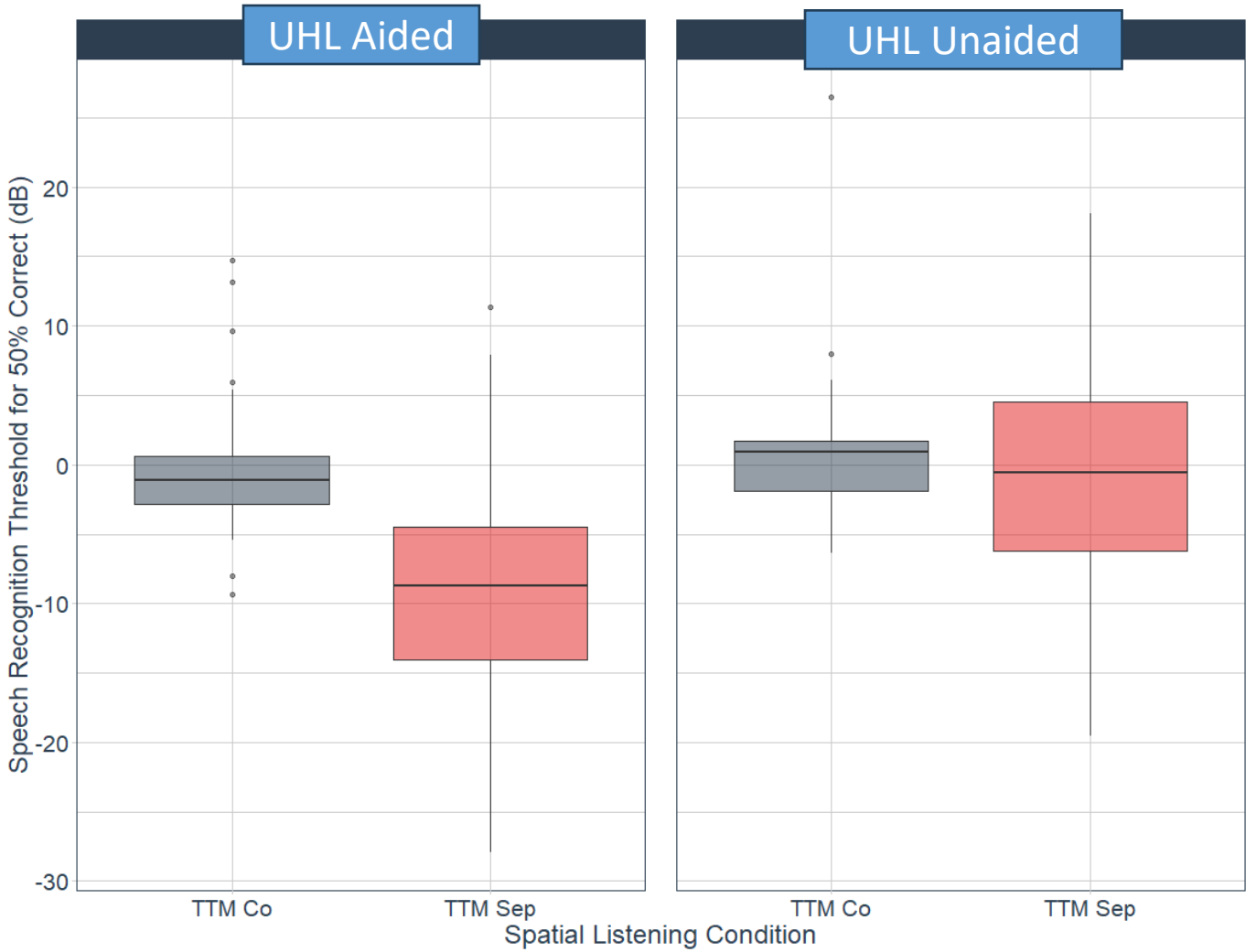

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VCLASS Questionnaire

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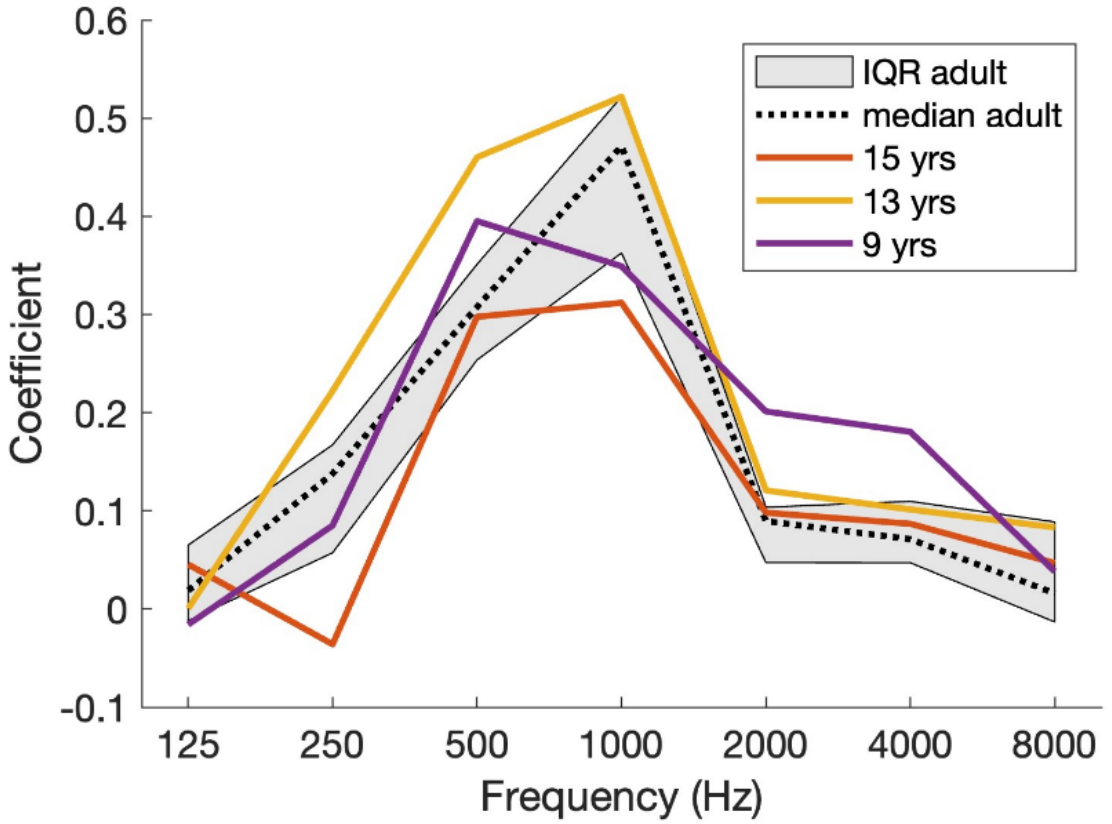
Spatial localization weighting



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Clinical Guidance

- Prevent gaps in services for children who fall between amplification and cochlear implant candidacy.
- Two groups:
  - Moderately-severe or severe thresholds (< 70 dB HL)
    - Evaluate hearing aid candidacy
  - Severe-to-profound thresholds (at least one threshold > 90 dB HL)
    - Refer to Cochlear Implant program for candidacy evaluation

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