Right Fit, Real Life: Optimizing Hearing Aids for Adolescents

Ryan McCreery, Ph.D.

Ryan.McCreery@boystown.org

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Advancing the science of communication to improve lives

BC Early Hearing Program

The BC Early Hearing Program works towards achieving the best language outcomes for all young children in BC.

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What do teenagers and adolescents with hearing aids need?



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Adolescence

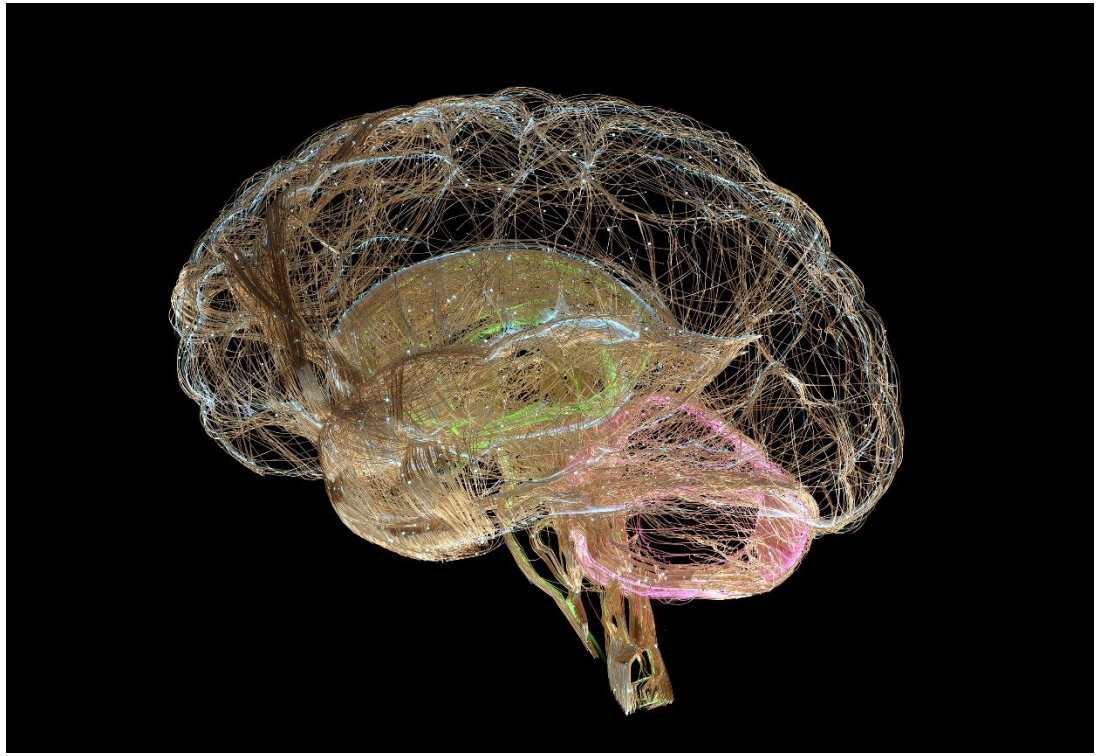


- Developmental period from approximately 10-19 years.
- Understudied relative to early development
- Onset of puberty
- Social and developmental changes.

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Adolescent brain development

- Synaptic pruning
- White matter myelination and connectivity
- Maturation of prefrontal cortex (PFC)
  - Executive function
- Neuroplasticity remains high
- Amygdala
  - Social and emotional development



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The Model of Cumulative Auditory Experience for Children Who Use Hearing Aids

Language outcomes are built over time through the combination of aided speech audibility and hearing aid wear time.

1. AIDED SPEECH AUDIBILITY

How much speech is available to the child through their hearing aids



×

2. HEARING AID WEAR TIME

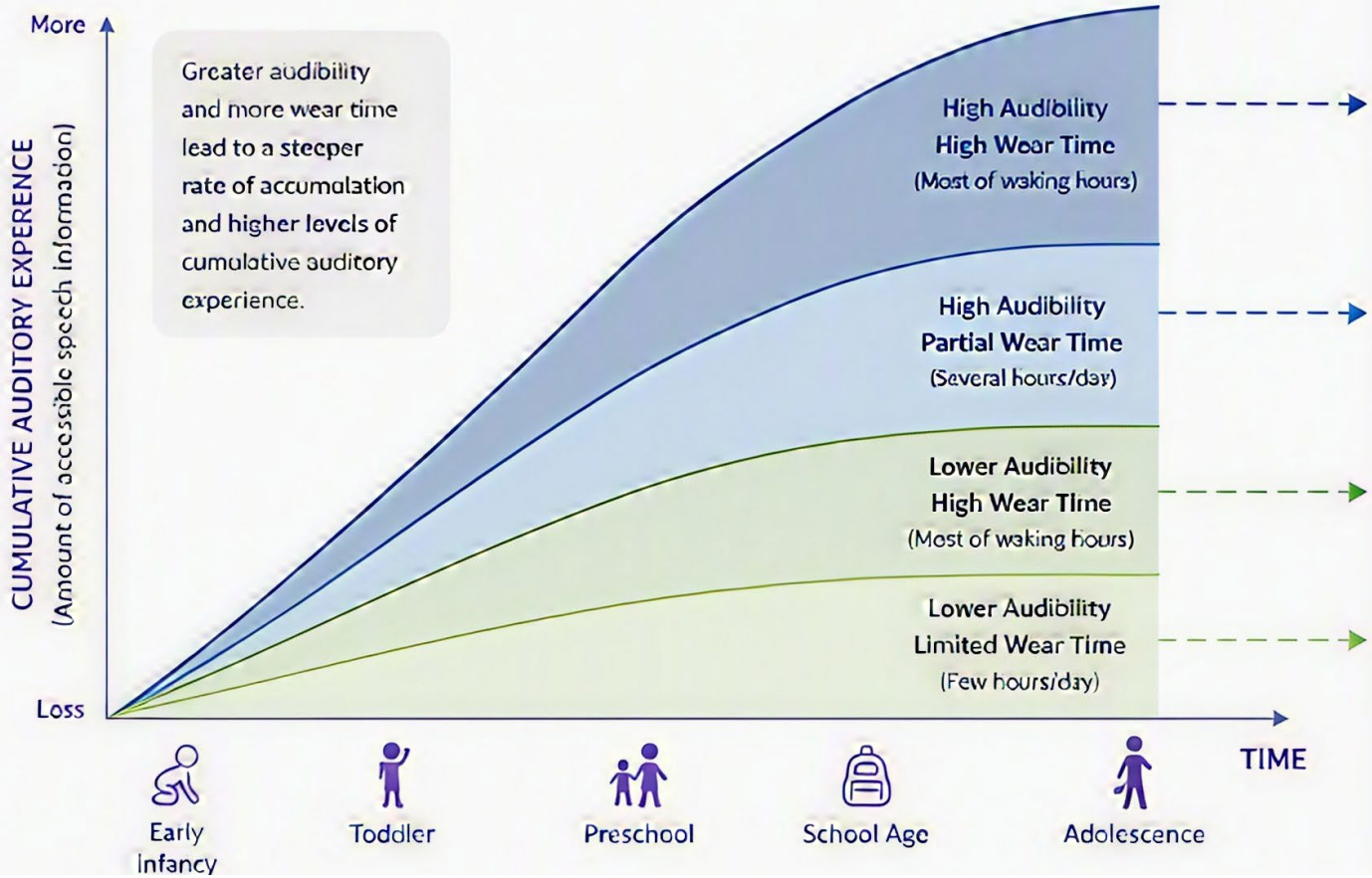
How much time the hearing aids are worn



3. CUMULATIVE AUDITORY EXPERIENCE

The combination of audibility and wear time builds auditory experience every day. This experience accumulates over time.

Greater audibility and more wear time lead to a steeper rate of accumulation and higher levels of cumulative auditory experience.



4. LANGUAGE OUTCOMES

Better language outcomes are associated with greater cumulative auditory experience.



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What do we know about adolescents who use hearing aids?

1

Hearing aid fitting quality

2

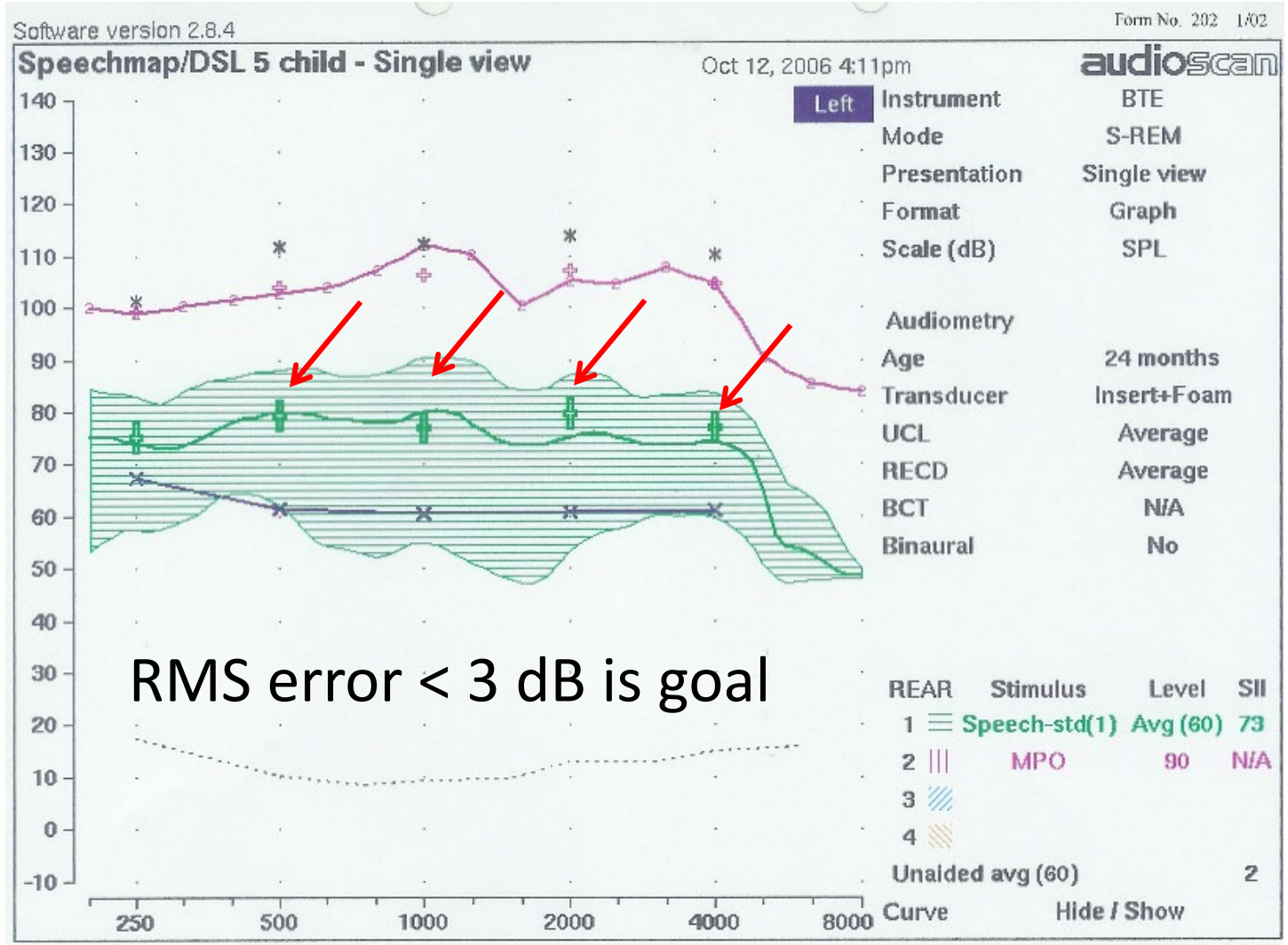
Hearing aid use

3

Hearing aid signal processing

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Target vs. Actual (RMS error)



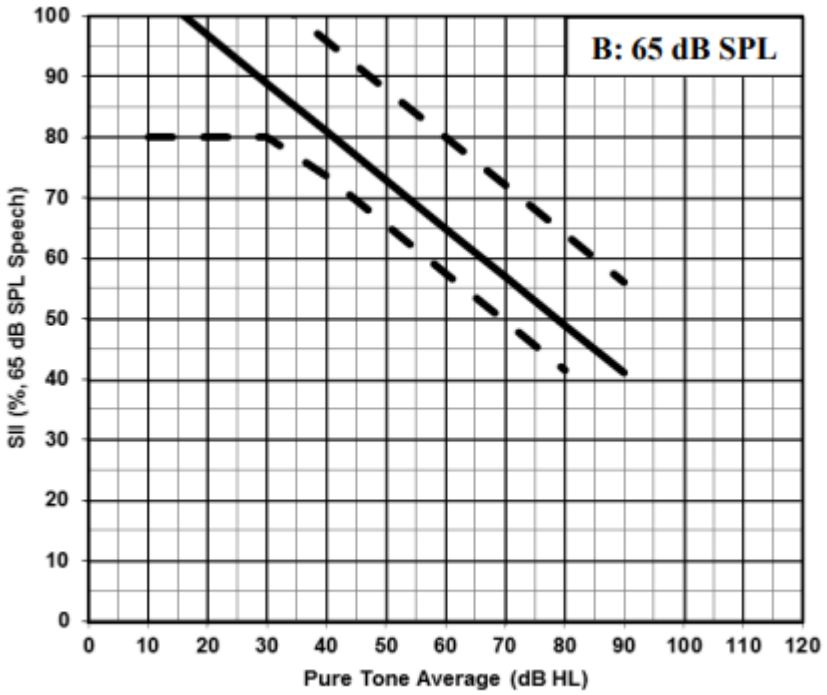
Fitting data compared to DSL targets

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

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How much audibility?

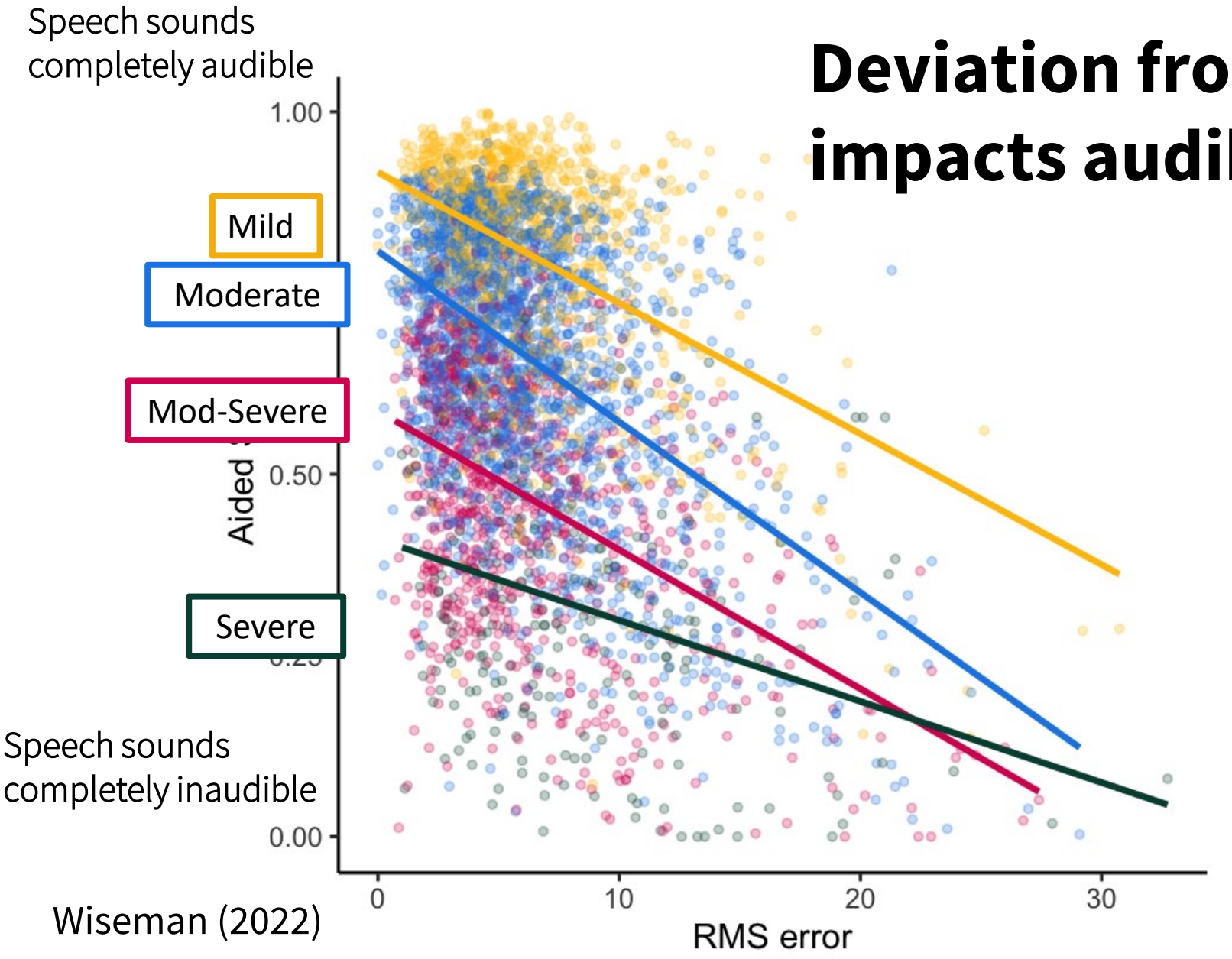
- Low RMS error (< 3 dB ideally)
- Normative range for audibility



Bagatto et al. 2015
www.dslio.com

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Deviation from target negatively impacts audibility



Wiseman (2022)

Fitting error (RMS error)

Audibility (aided SII)

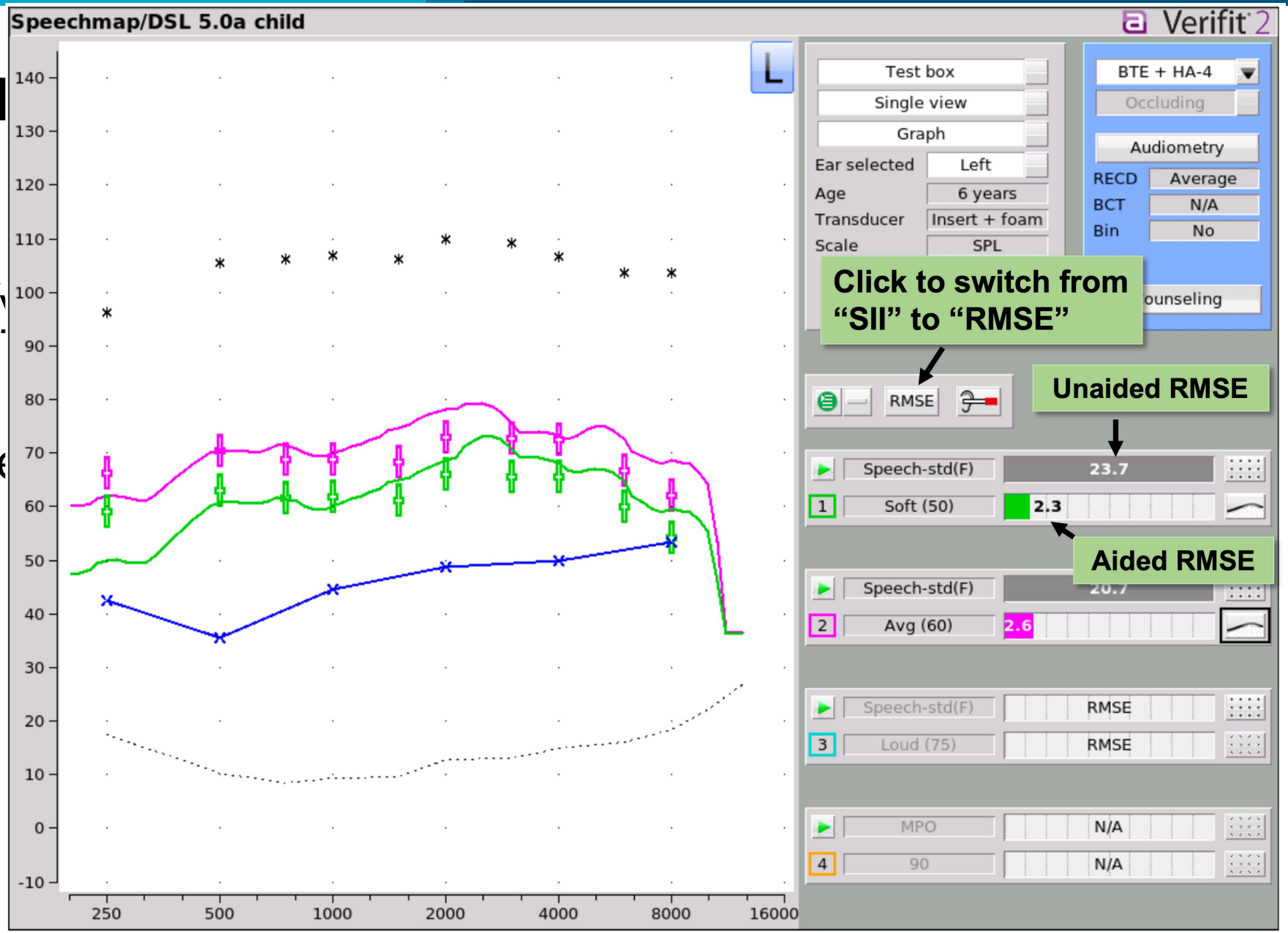
.02 decrease in aided SII for every
1 dB increase in RMS error

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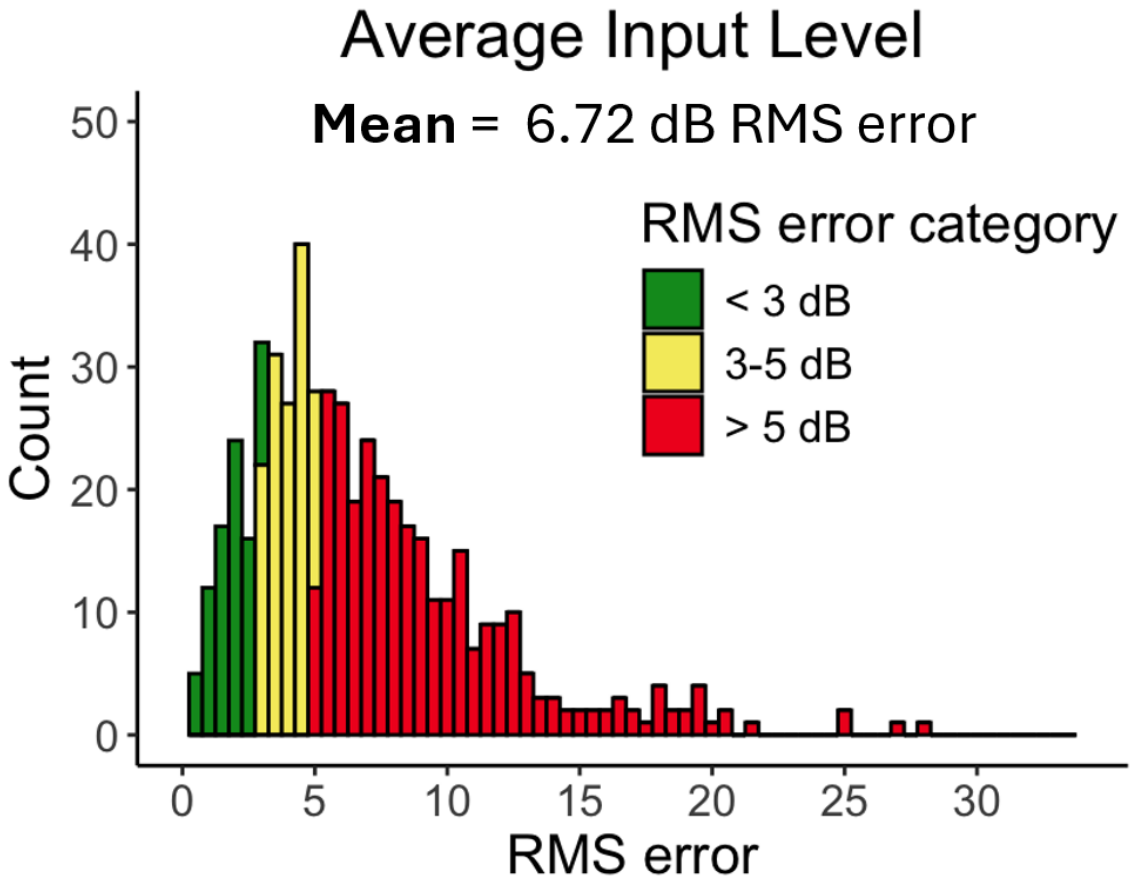
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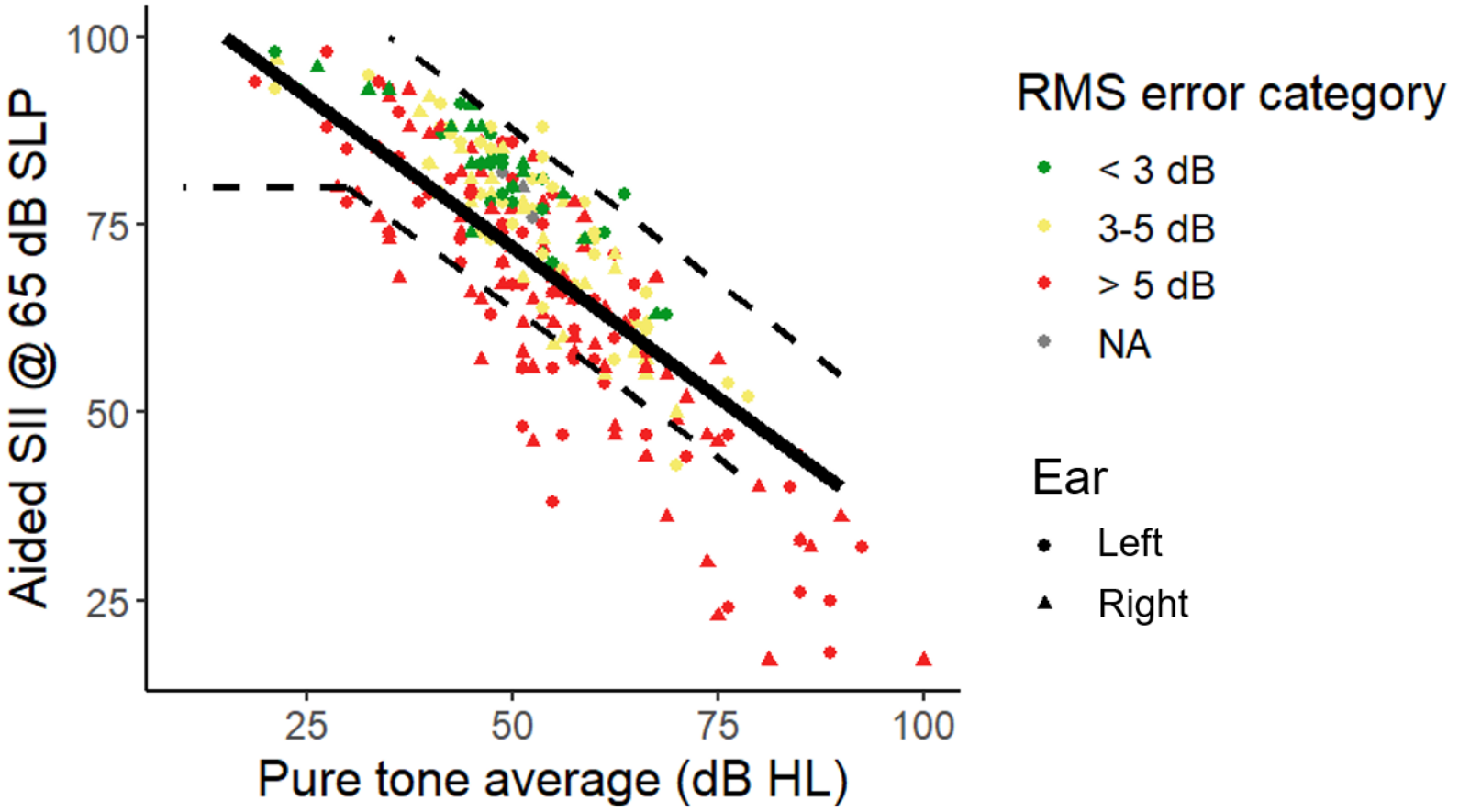


Adolescent HA fitting quality



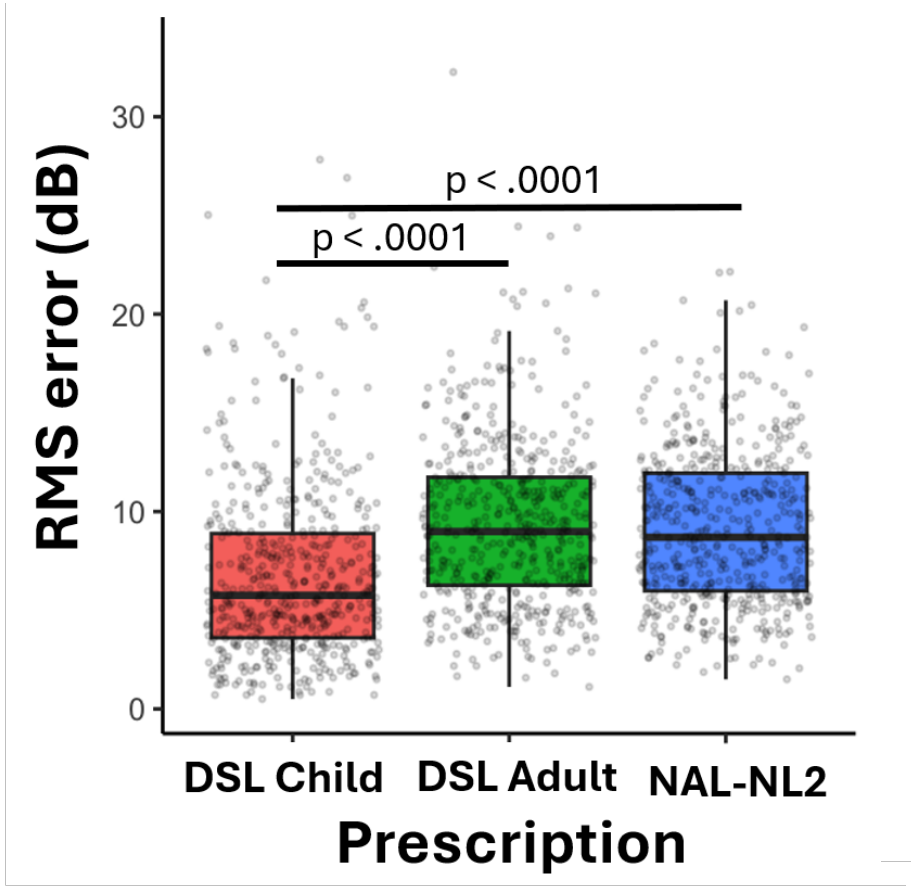
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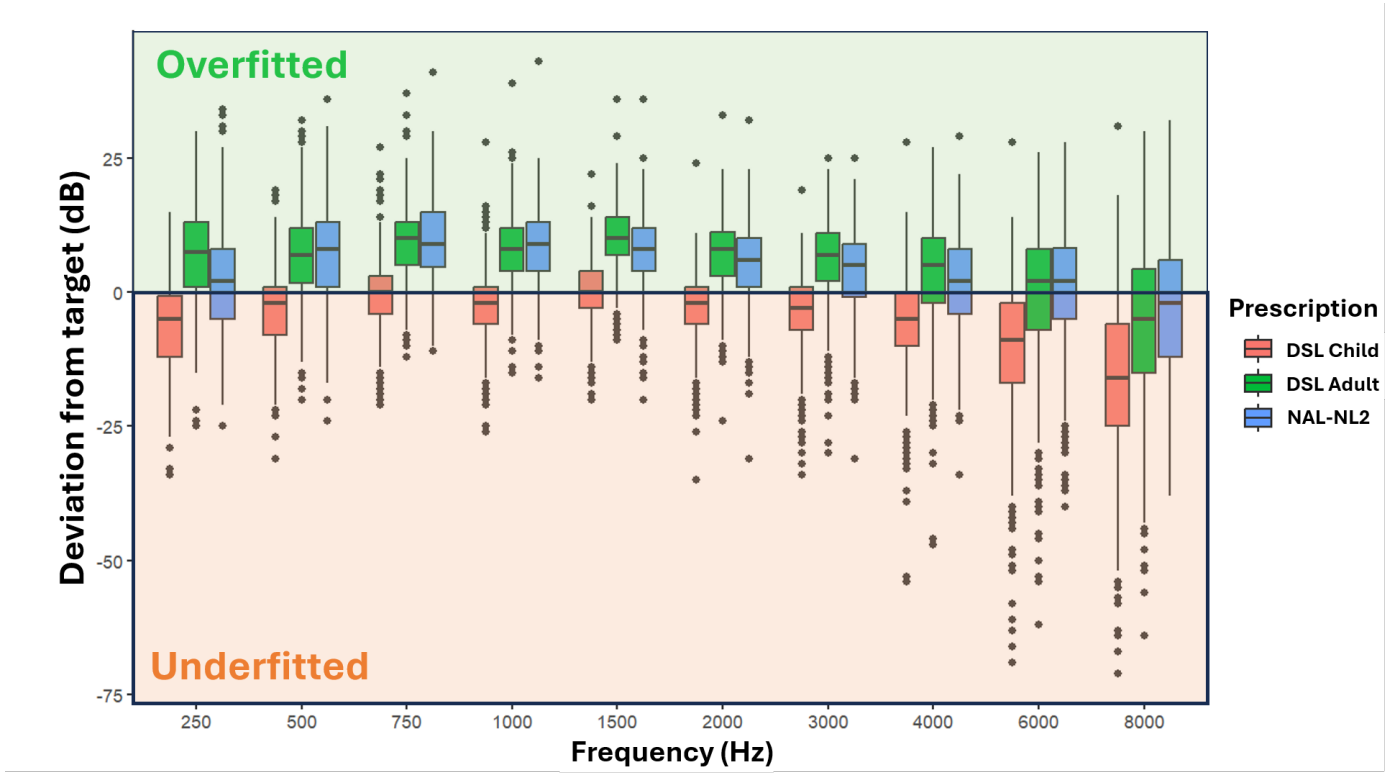
RMSe and SII by PTA



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Fitting formulae?





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The Refit Project

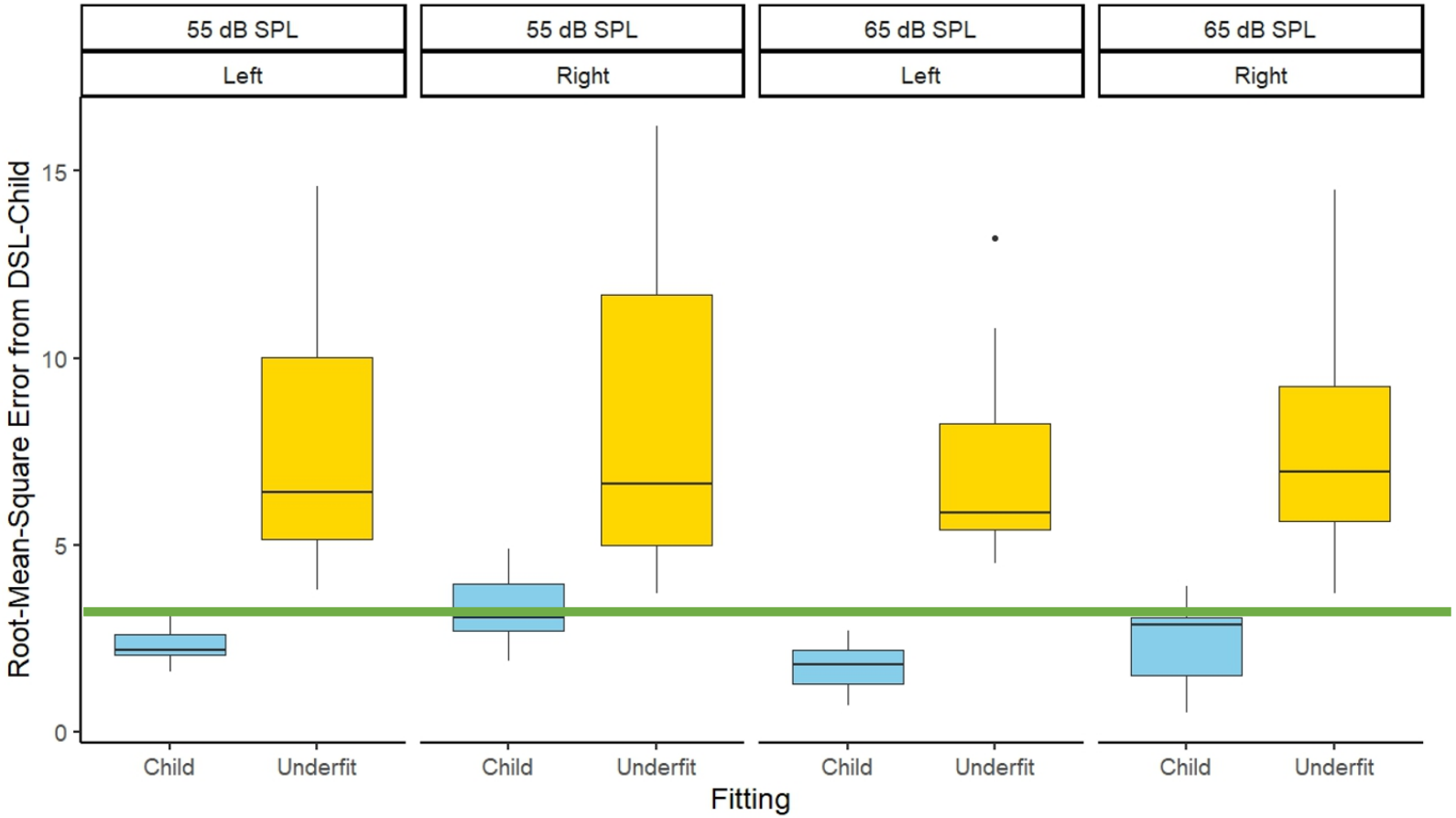
- Examined audibility and speech recognition for adolescents with hearing aids.
- Refitted devices to DSL-Child to see if there are changes in:
  - Speech perception in noise
  - Categorical loudness perception
  - Listener preference
- Current data:
  - N= 8 adolescents (12-18 years old, mean = 15.7 years)
  - Experienced bilateral hearing aid users
  - Mild to moderate permanent hearing loss (better-ear pure-tone average (BEPTA) = 42.8 dB HL; Range = 19-57 dB HL)

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Initial fitting vs. DSL-Child fitting RMSe

Initial fitting

DSL-Child fitting



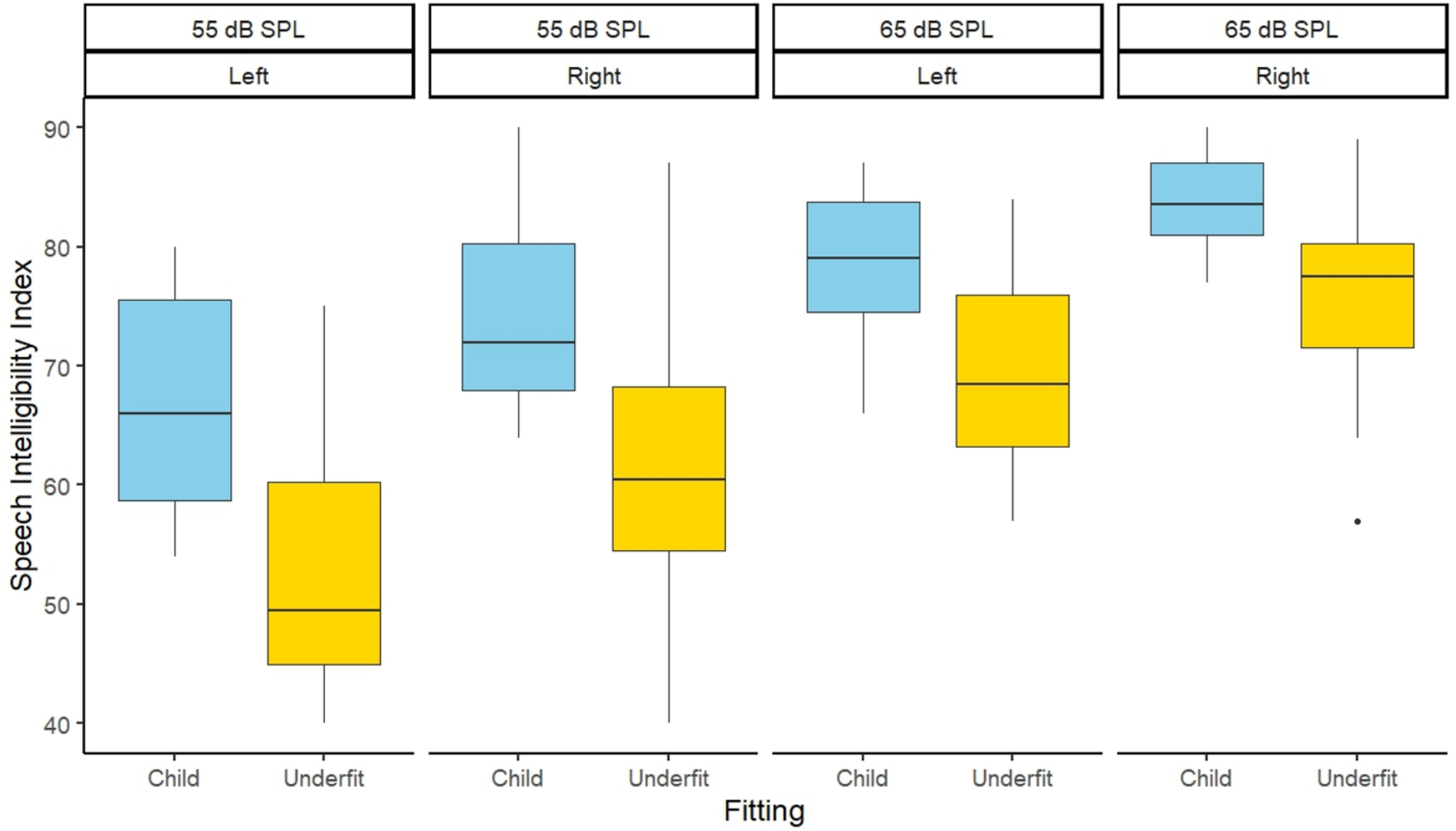
3 dB RMSe

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Initial fitting vs. DSL-Child fitting Aided SII

Initial fitting

DSL-Child fitting



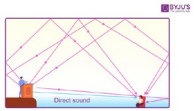
Conditions

1. Two-Talker Masker (TTM), Co-located, No Reverberation
2. Two-Talker Masker, Co-located, Reverberation
3. Two-Talker Masker, spatially separated

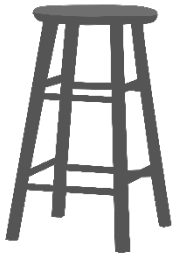
0° azimuth







90° azimuth





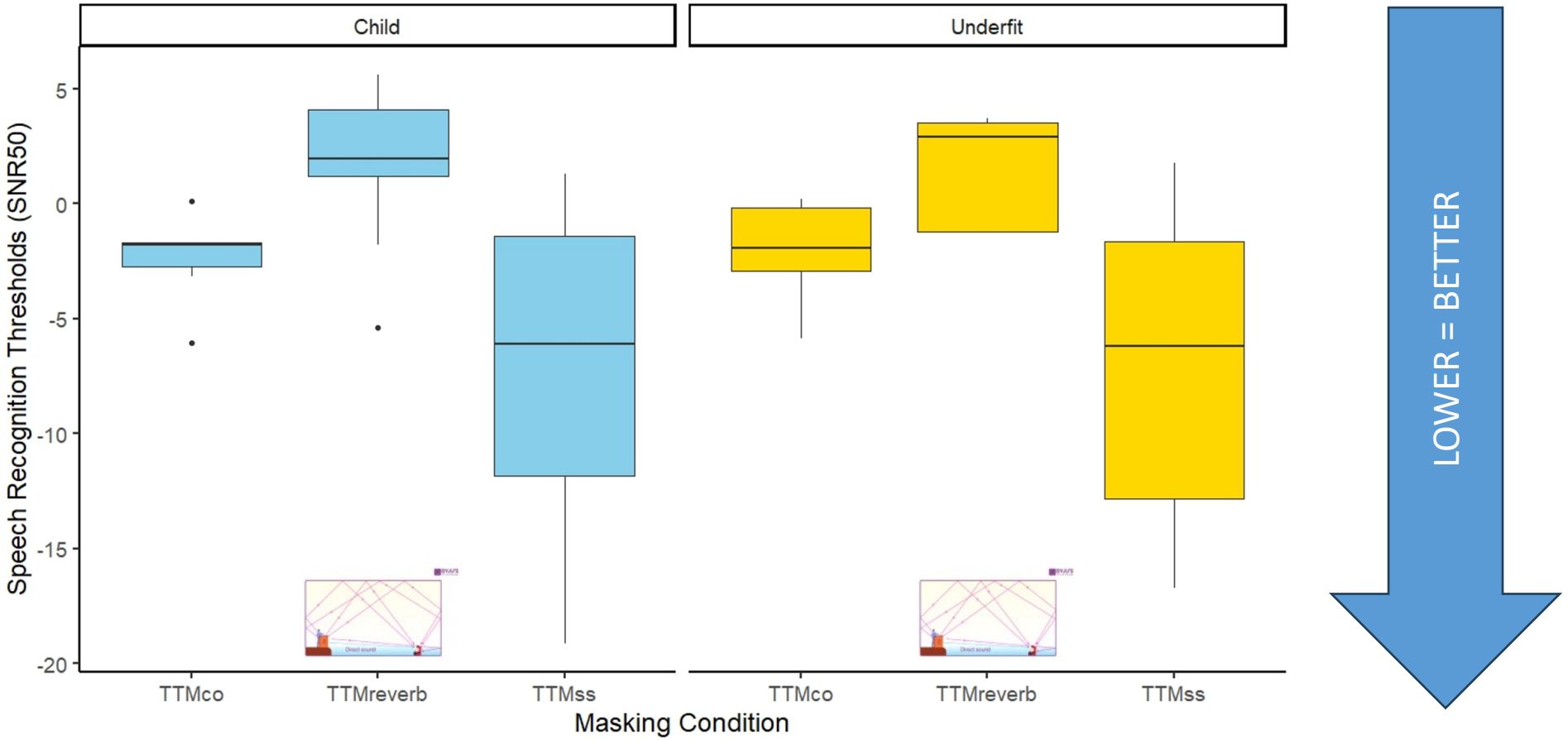


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Initial vs. DSL-Child – Speech-in-noise

Initial fitting

DSL-Child fitting

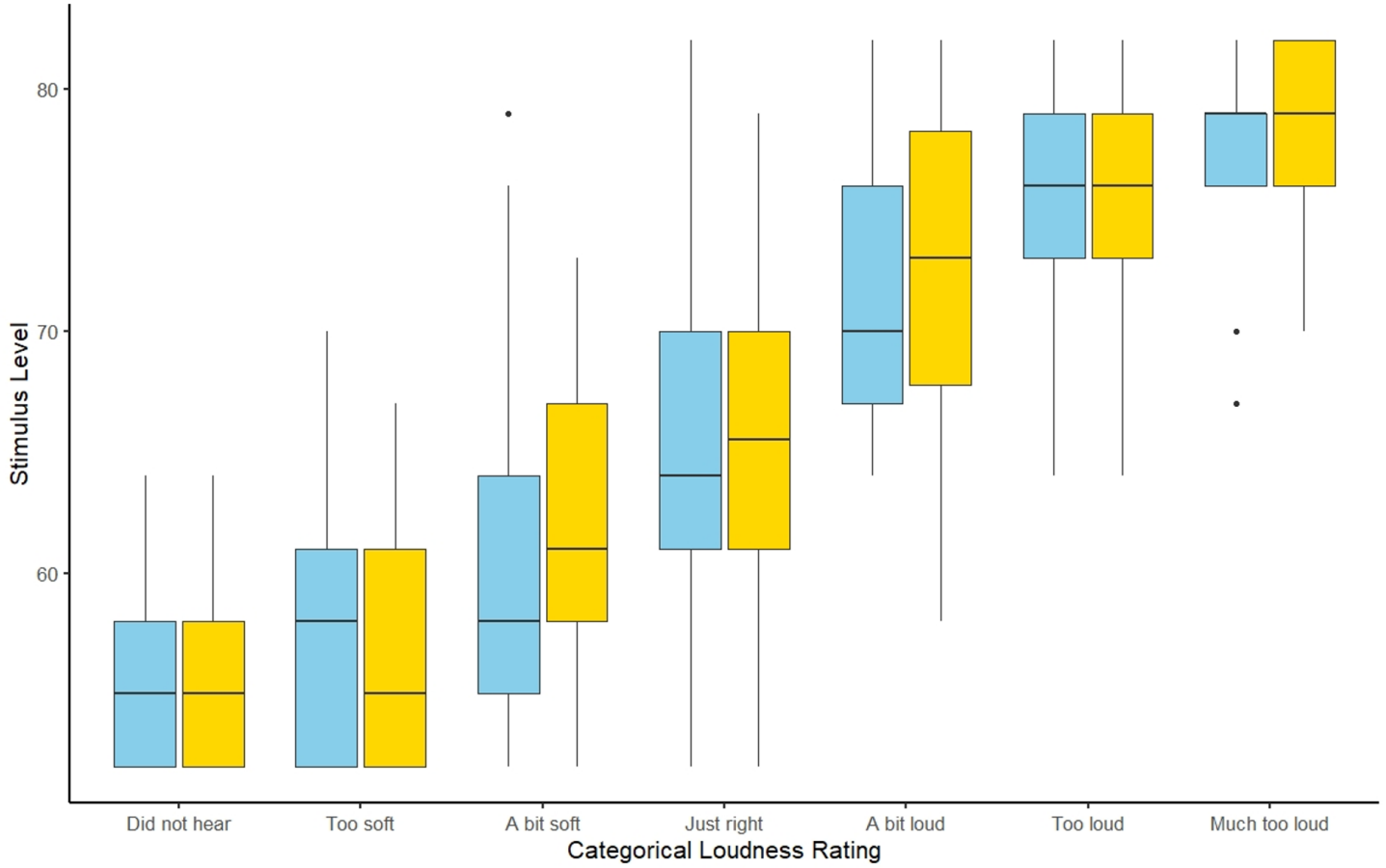


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Initial vs. DSL-Child - Loudness

Initial fitting

DSL-Child fitting



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Refit – Take-aways

- DSL-Child fittings provided more aided audibility than underfitted devices.
- No differences in sentence recognition in noise
  - Spatial release from masking was larger for teens with more audibility
- No differences in loudness
- All but one participant so far preferred DSL-Child
- Real world listening data are needed

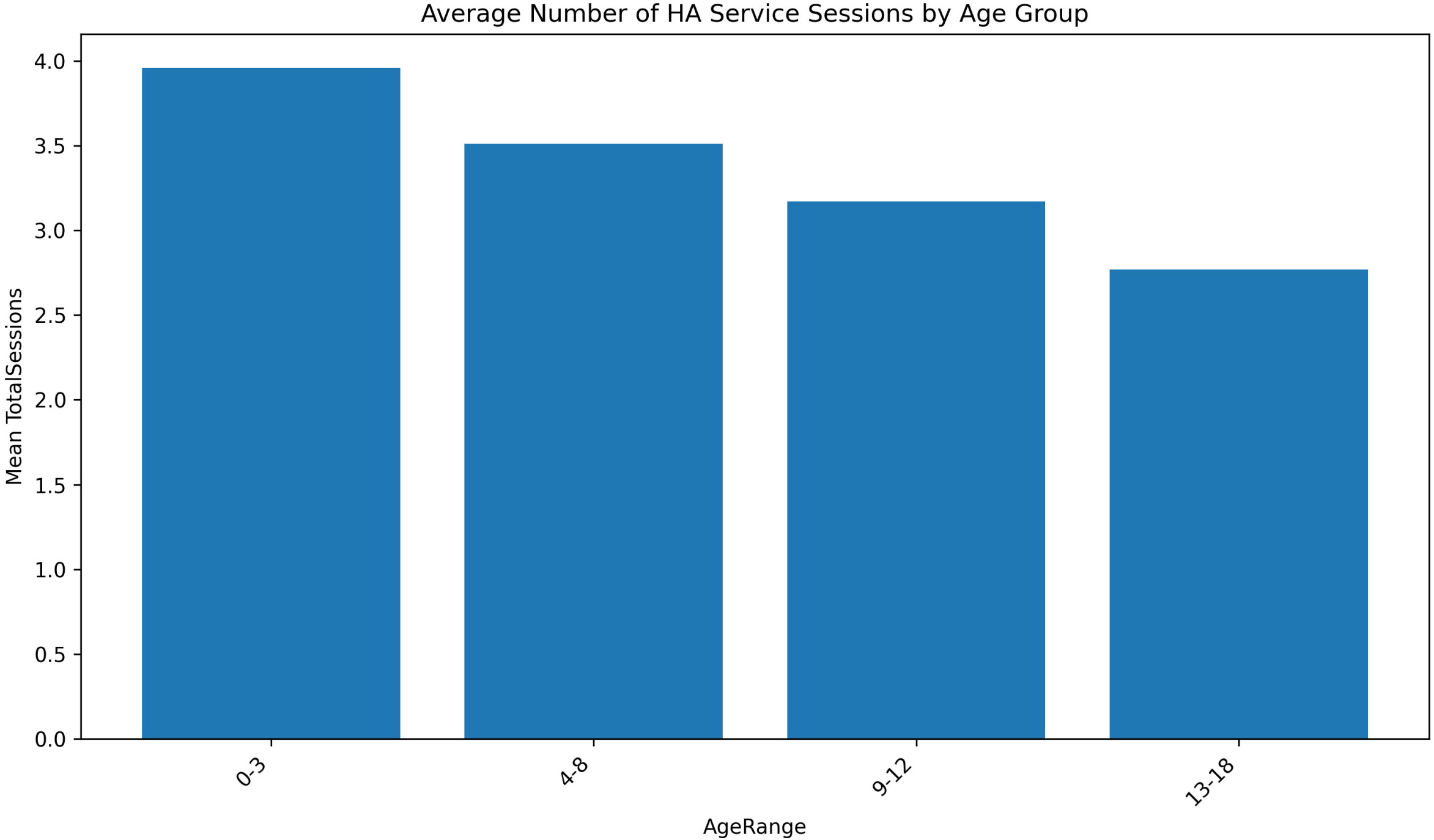
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Clinical focus

No evidence to support modifying HA fittings for adolescents away from DSL-Child

Many participants reported that audiological follow-up during middle and high school becomes less frequent.

Currently conducting a survey of audiologists about adolescent hearing aid fitting practices.


Average Number of HA Service Sessions by Age Group
Mean TotalSessions
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0-3
4-8
9-12
13-18
AgeRange

ASHAWIRE LSHSS LANGUAGE, SPEECH, AND HEARING SERVICES IN SCHOOLS
RELATED TOPICS | FOR AUTHORS | SUBSCRIBE

Lang Speech Hear Serv Sch. 2025 May 19;56(3):522–541. doi: 10.1044/2025_LSHSS-24-00096

Characteristics of Hearing Aid Use in Adolescents Who Are Deaf and Hard of Hearing

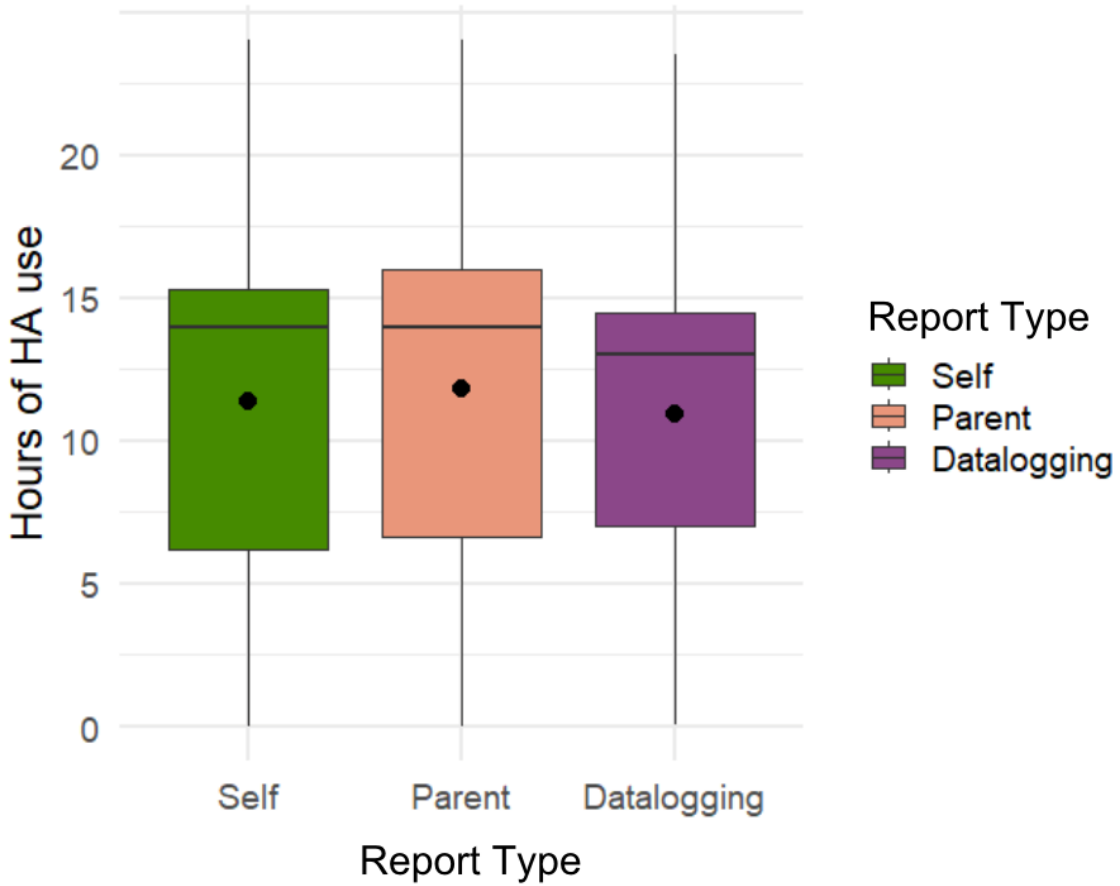
Elizabeth A Walker [a,✉], Meredith Spratford [b], Meaghan Foody [a], Ryan McCreery [b]

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PMCID: PMC12303600 PMID: 40388836

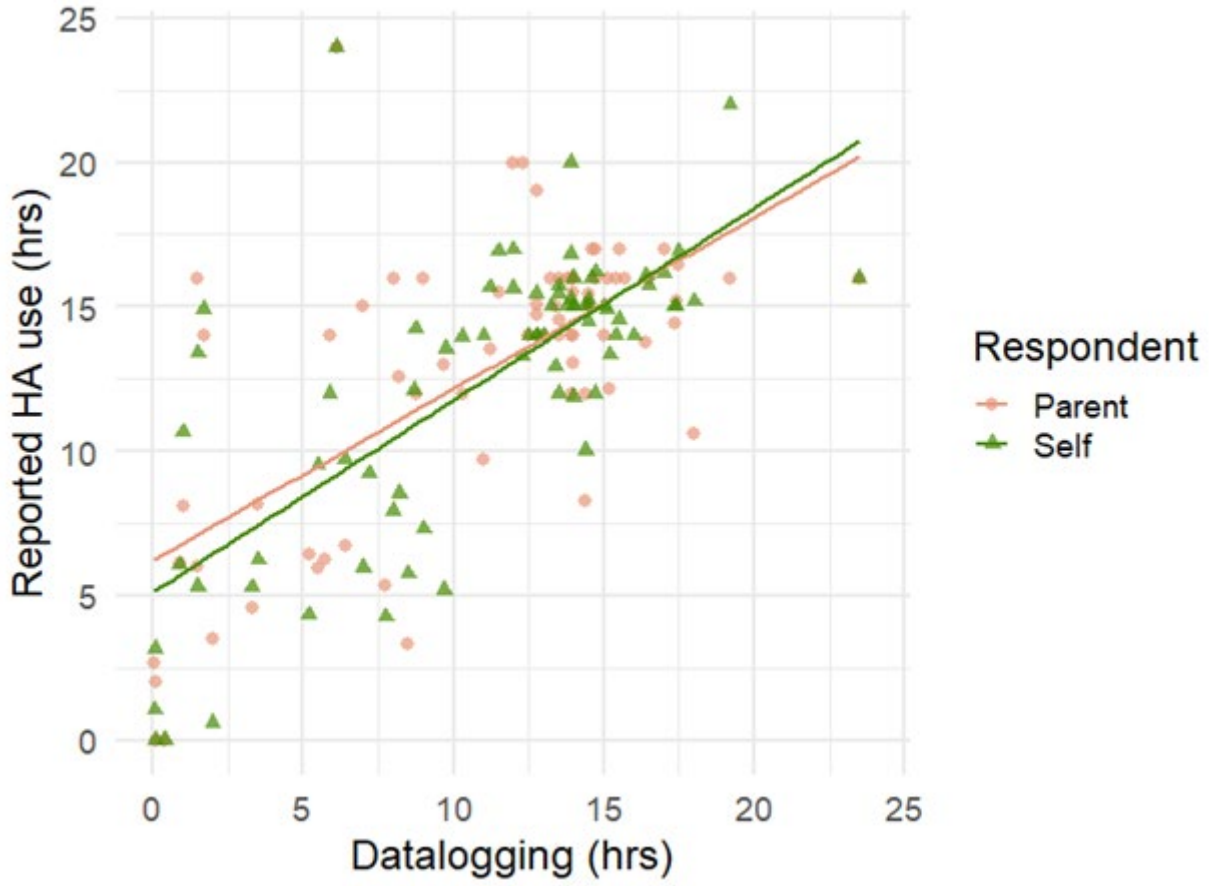
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Type of report



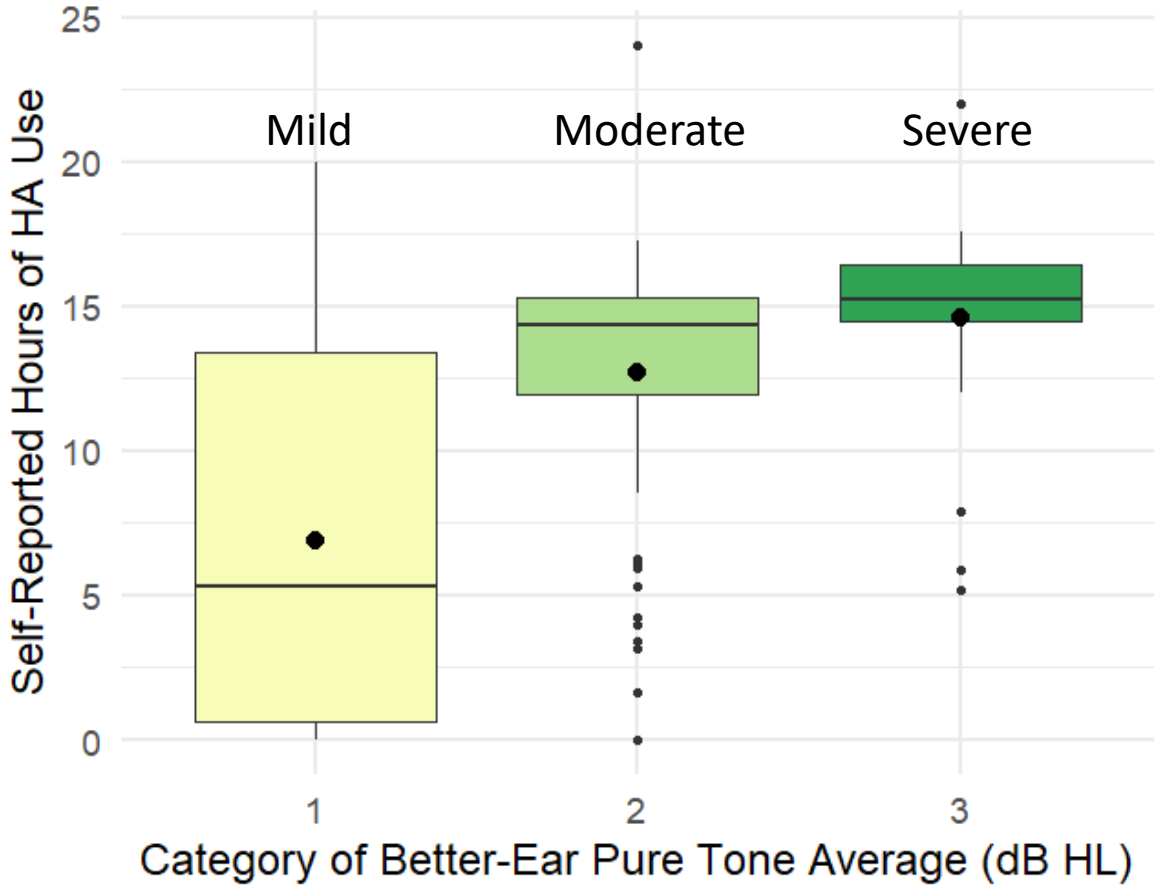
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Association between self/parent report



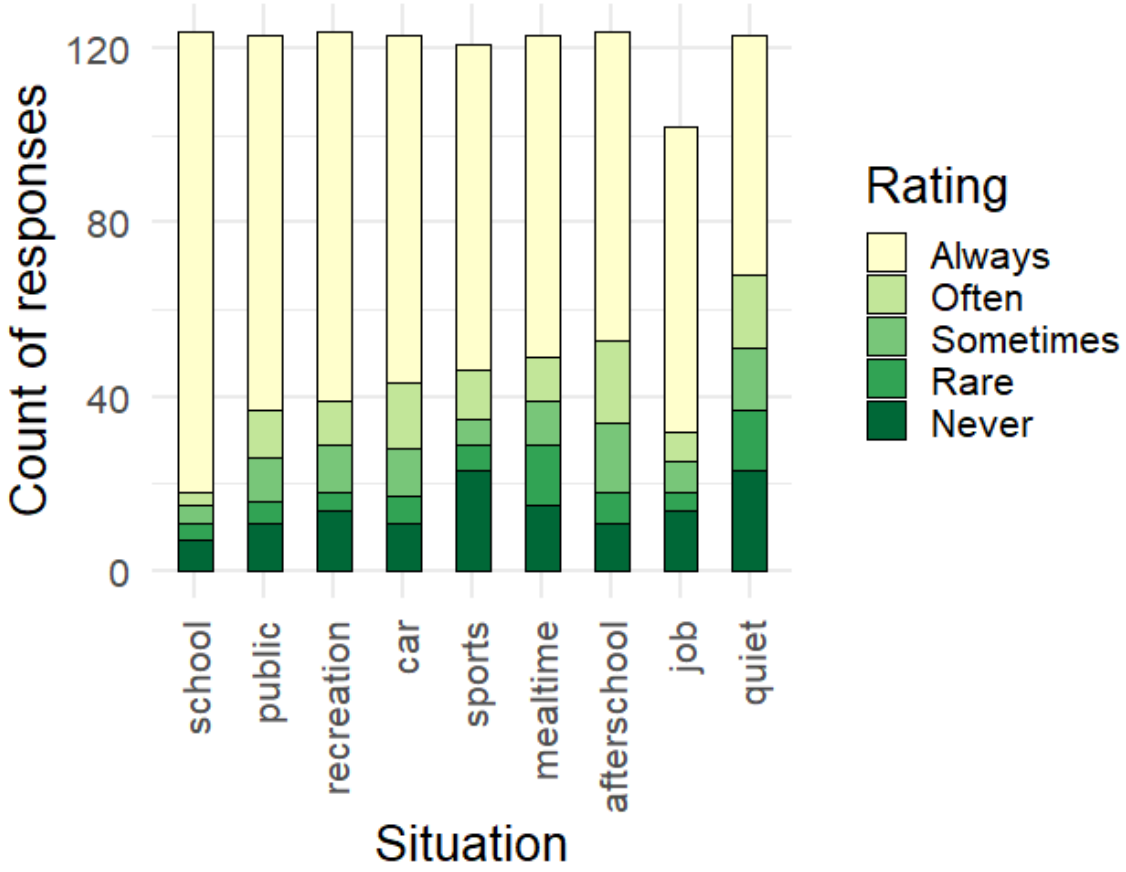
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Self-report by degree of hearing loss



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Situational hearing aid use

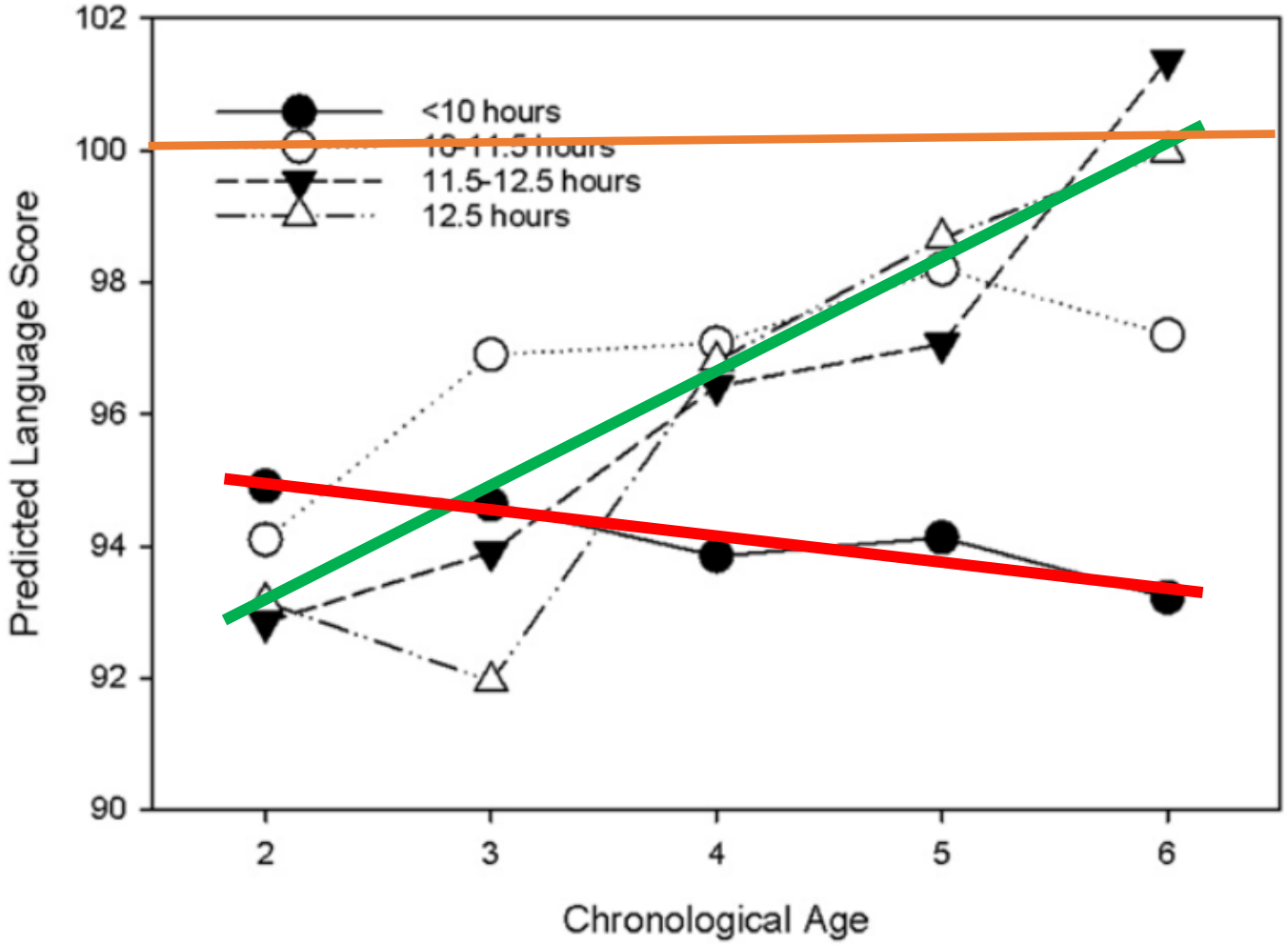


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Language Outcomes in Young Children with Mild to Severe Hearing Loss

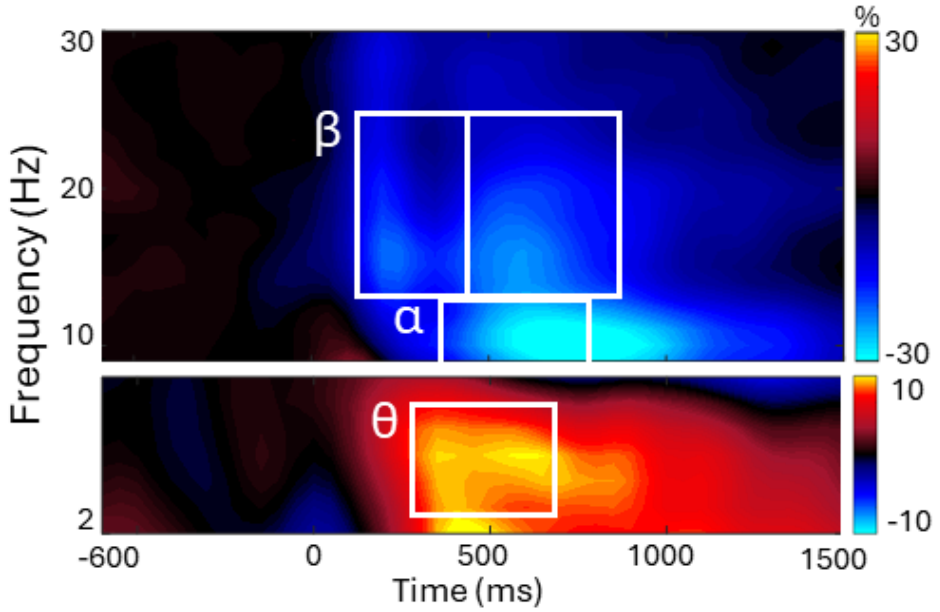
J. Bruce Tomblin,[1] Melody Harrison,[2] Sophie E. Ambrose,[3] Elizabeth A. Walker,[1] Jacob J. Oleson,[4] and Mary Pat Moeller[3]

Hours of HA use



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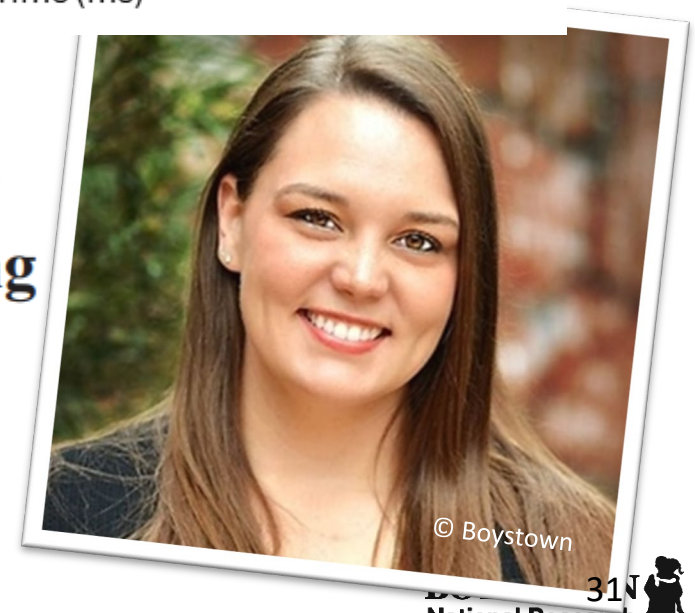




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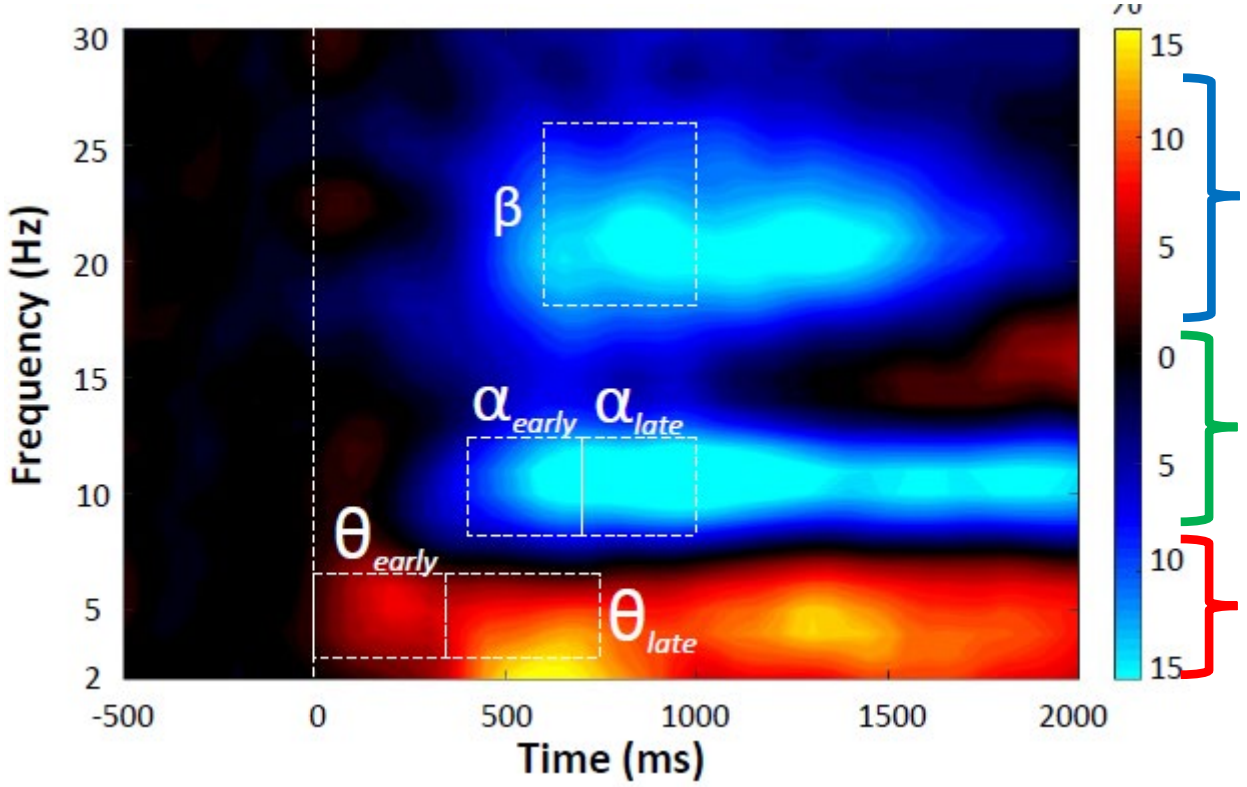
Amount of Hearing Aid Use Impacts Neural Oscillatory Dynamics Underlying Verbal Working Memory Processing for Children With Hearing Loss

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



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Neural dynamics



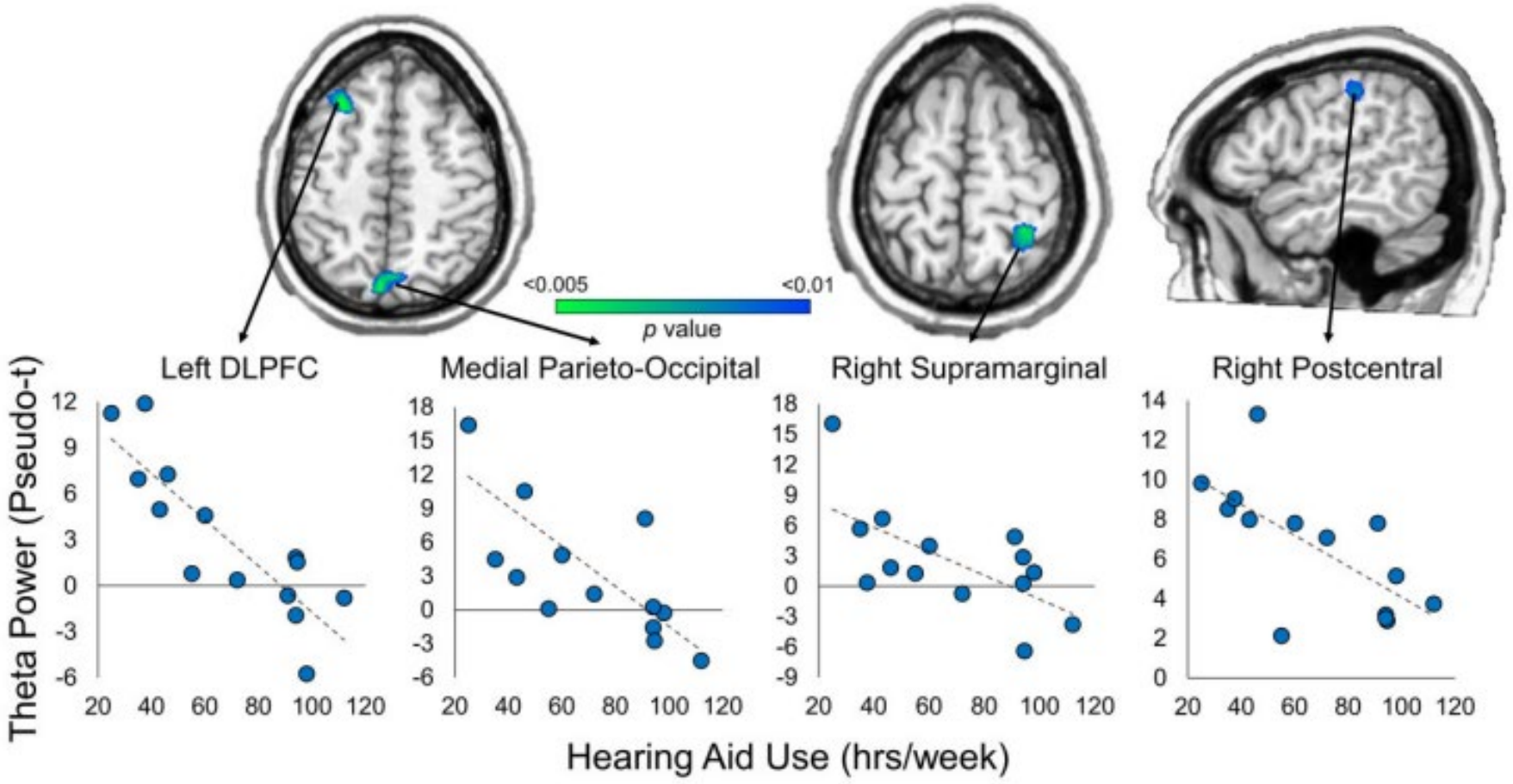
β = 12.5 – 30 Hz
Sensory integration
Motor planning / activity

α = 8 - 12 Hz
Attention, memory, sensory gating

θ = 4 - 8 Hz
Cognition, memory

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



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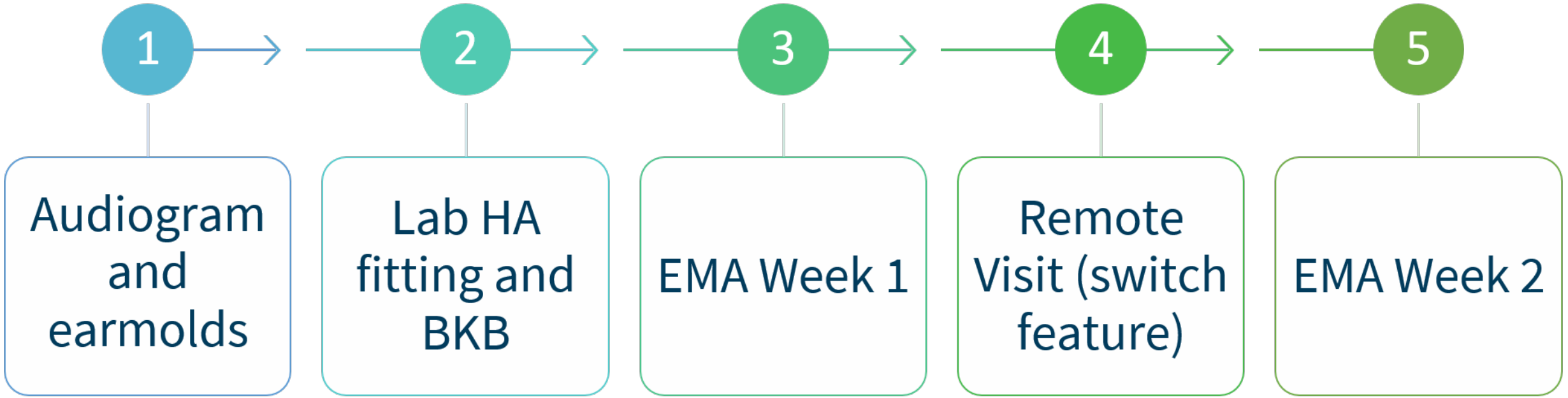
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Take-aways

- 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

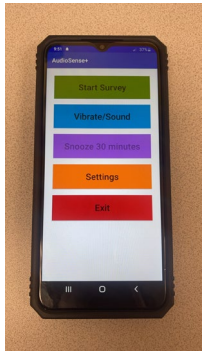
Hearing aid signal processing for adolescents?

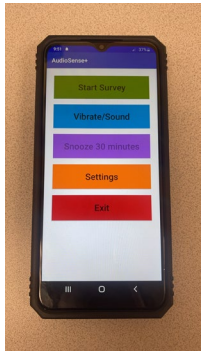
- Do adolescents benefit from advanced hearing aid signal processing?
  - Sensor-based directionality (Oticon Intent)



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Study Design





Visit 1
Audio/Earmolds

Visit 2 Lab
Fitting A/B

EMA A

One week

Remote
programming B

EMA B

One week

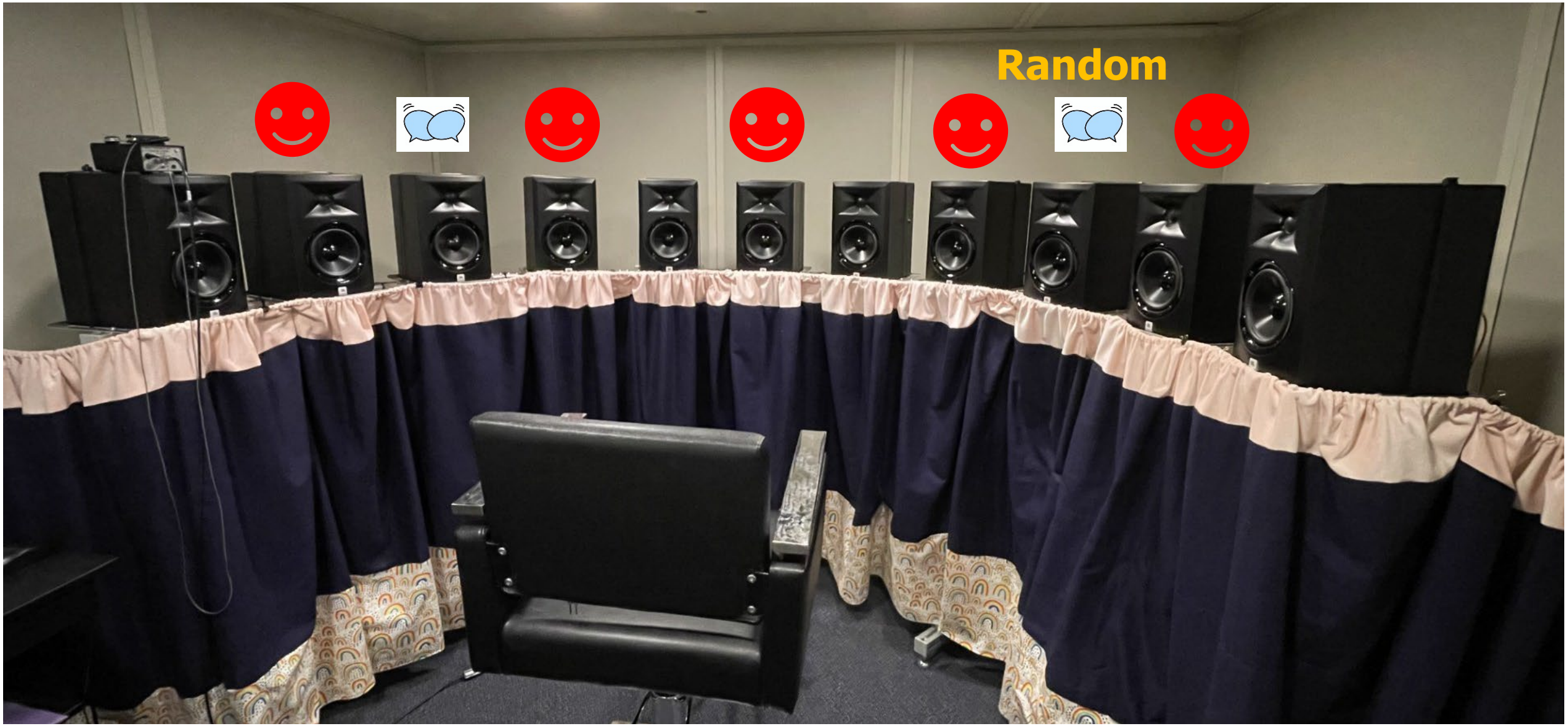
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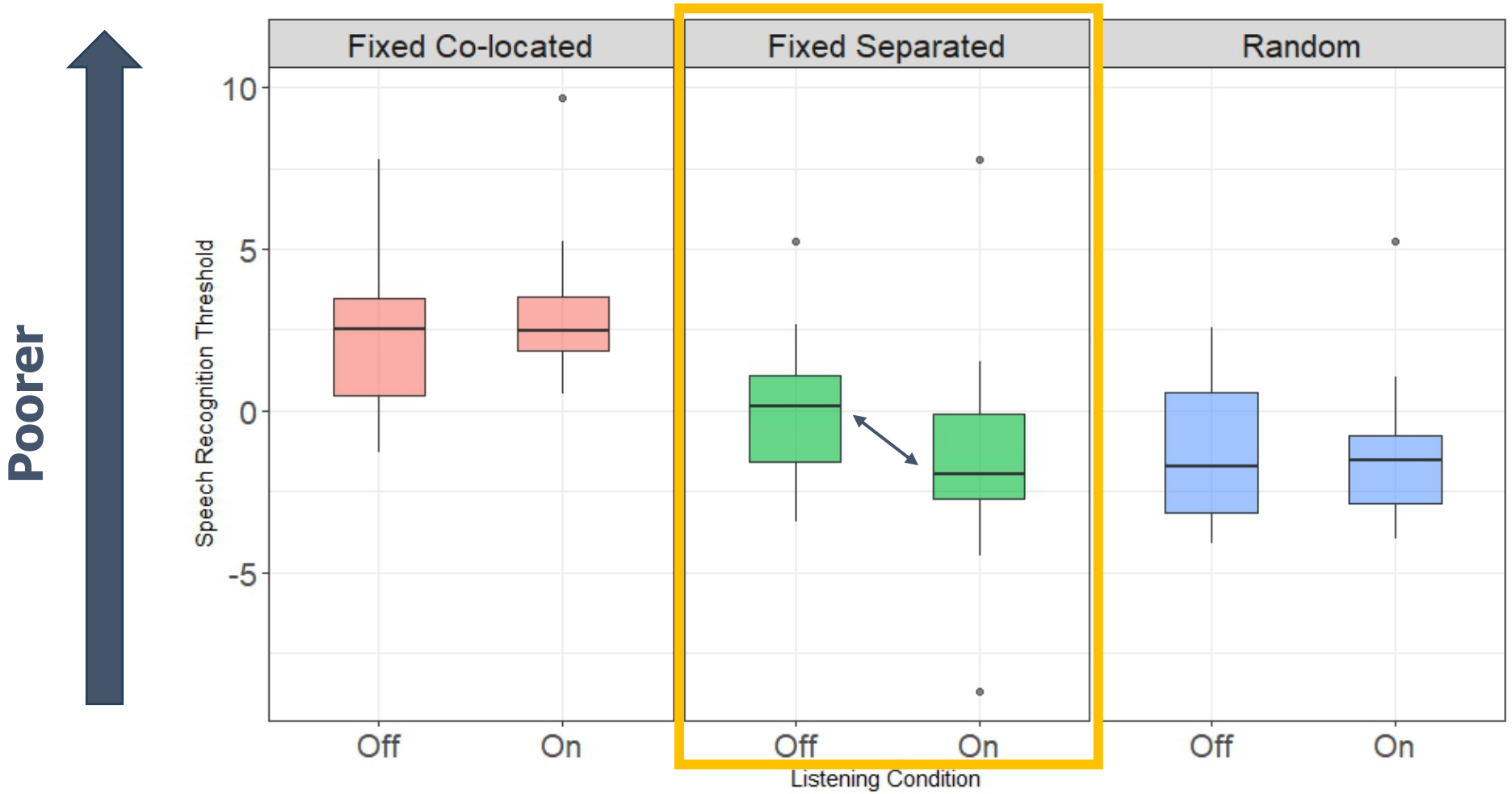


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Laboratory Speech Recognition Results



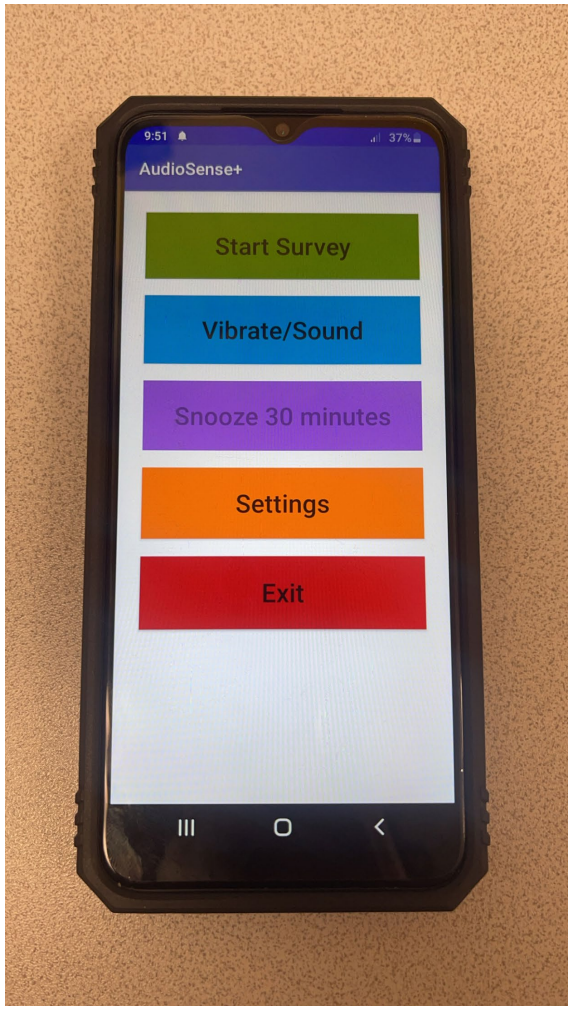
Significantly lower SNR50 threshold for Feature On condition in Fixed Separated compared to Feature Off

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Ecological Momentary Assessment (EMA)

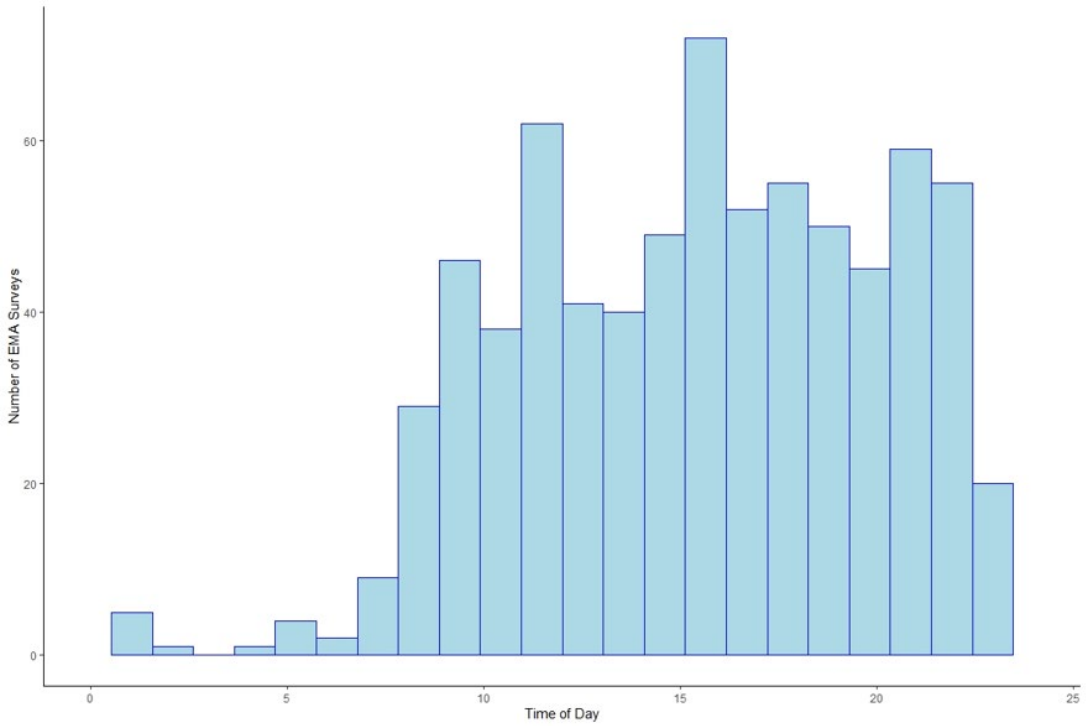
Asked questions about:

- Acoustics of listening environment
- HA use
- Fatigue / tiredness



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EMA survey by time of day



- 745 surveys during 2-week trial (average 45/participant)
- 77% of the responses occurred when hearing aids were worn
  - No difference between feature on and feature off period.

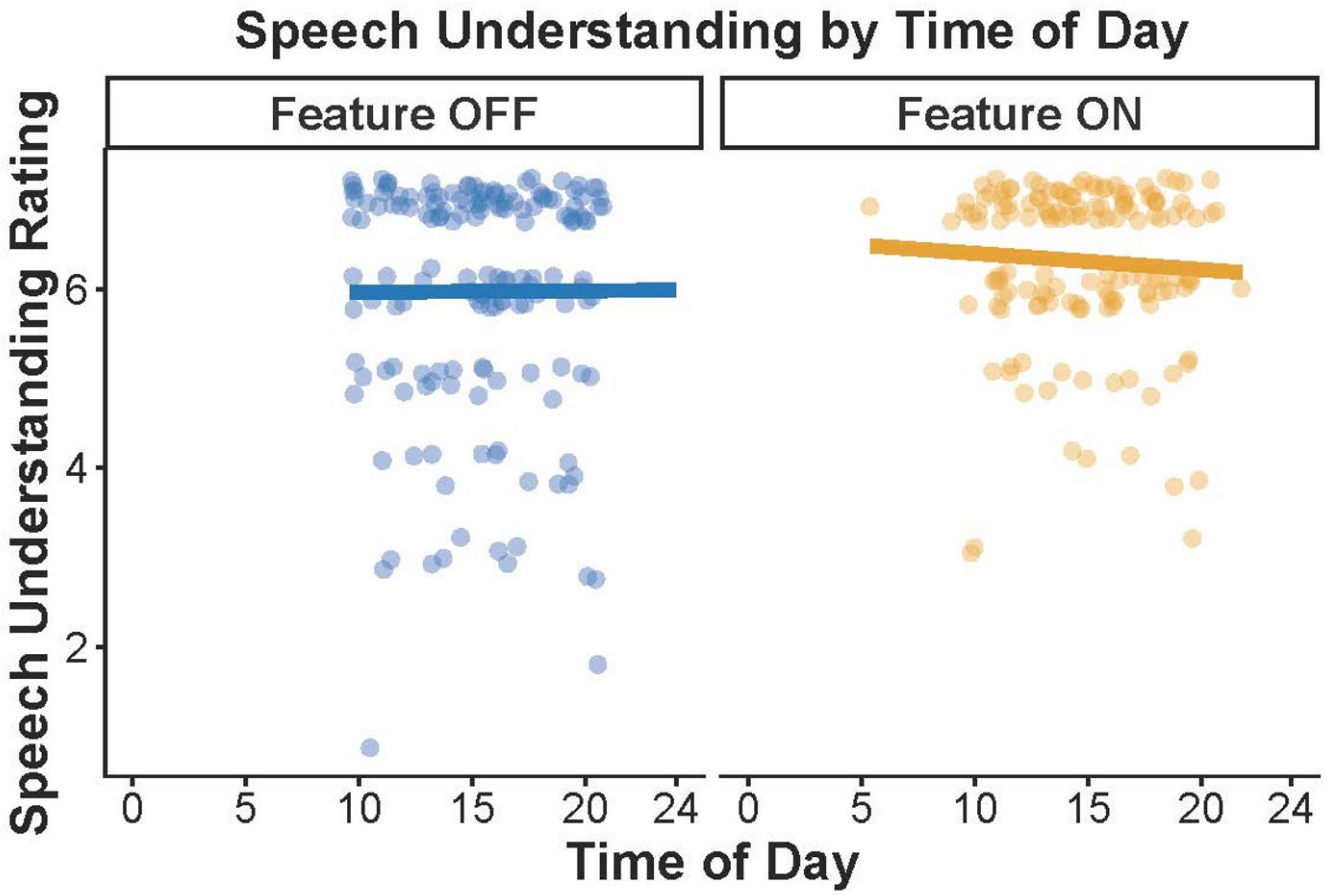
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What were they doing during EMA?

Listening Activity	Number of Surveys	Response (%)
Conversation (1 on 1)	85	11%
Conversation (group)	129	17%
Listening to speech	93	12%
Listening to music	45	6%
Listening to environmental sounds (not speech or music)	67	9%

EMA – Speech Understanding

Sensor-based directionality ON was higher (1.06; p = 0.03)
than without sensor-based directionality

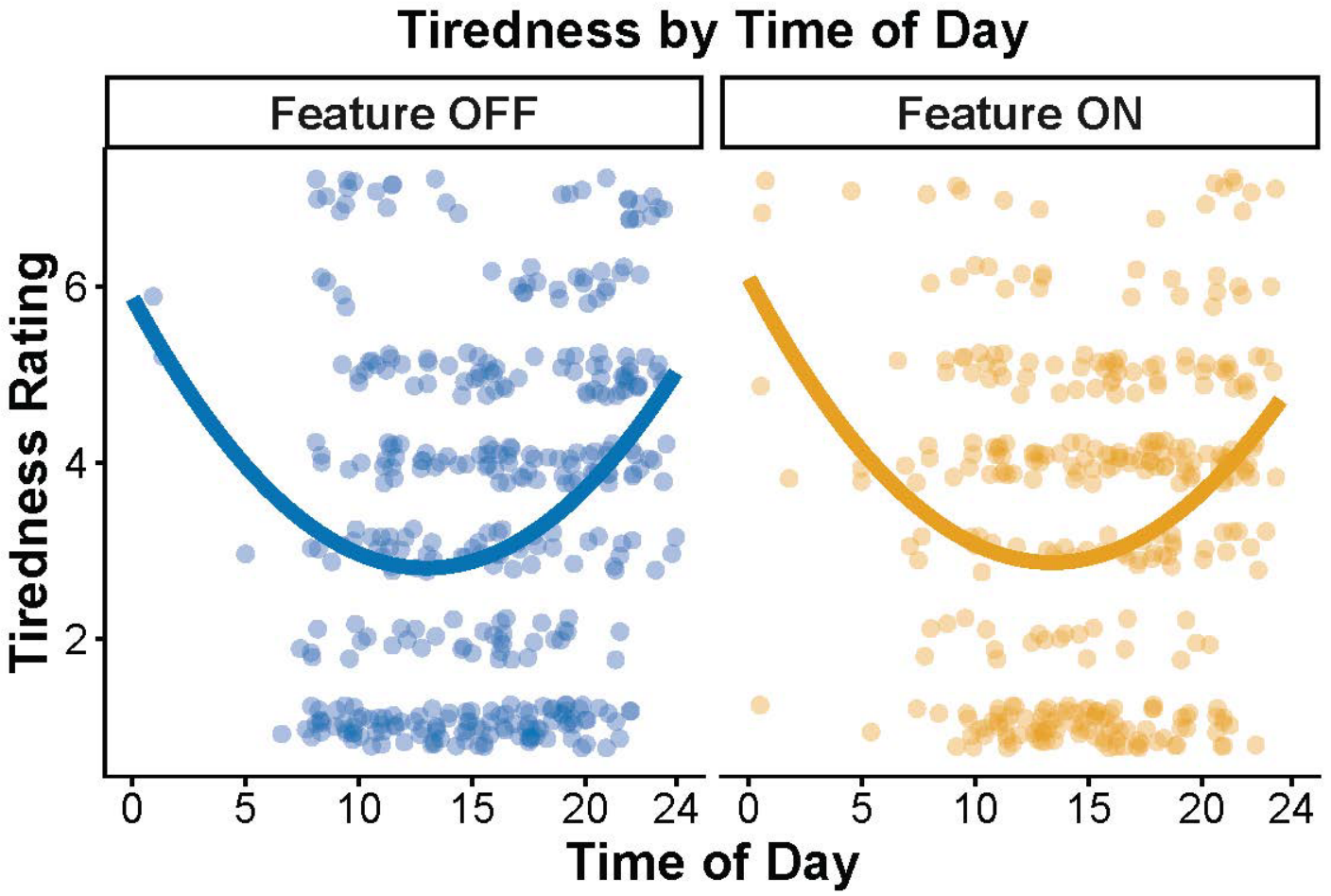


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EMA - Tiredness

Sensor-based directionality ON was lower than without sensor-based directionality.

Significant time of day effect

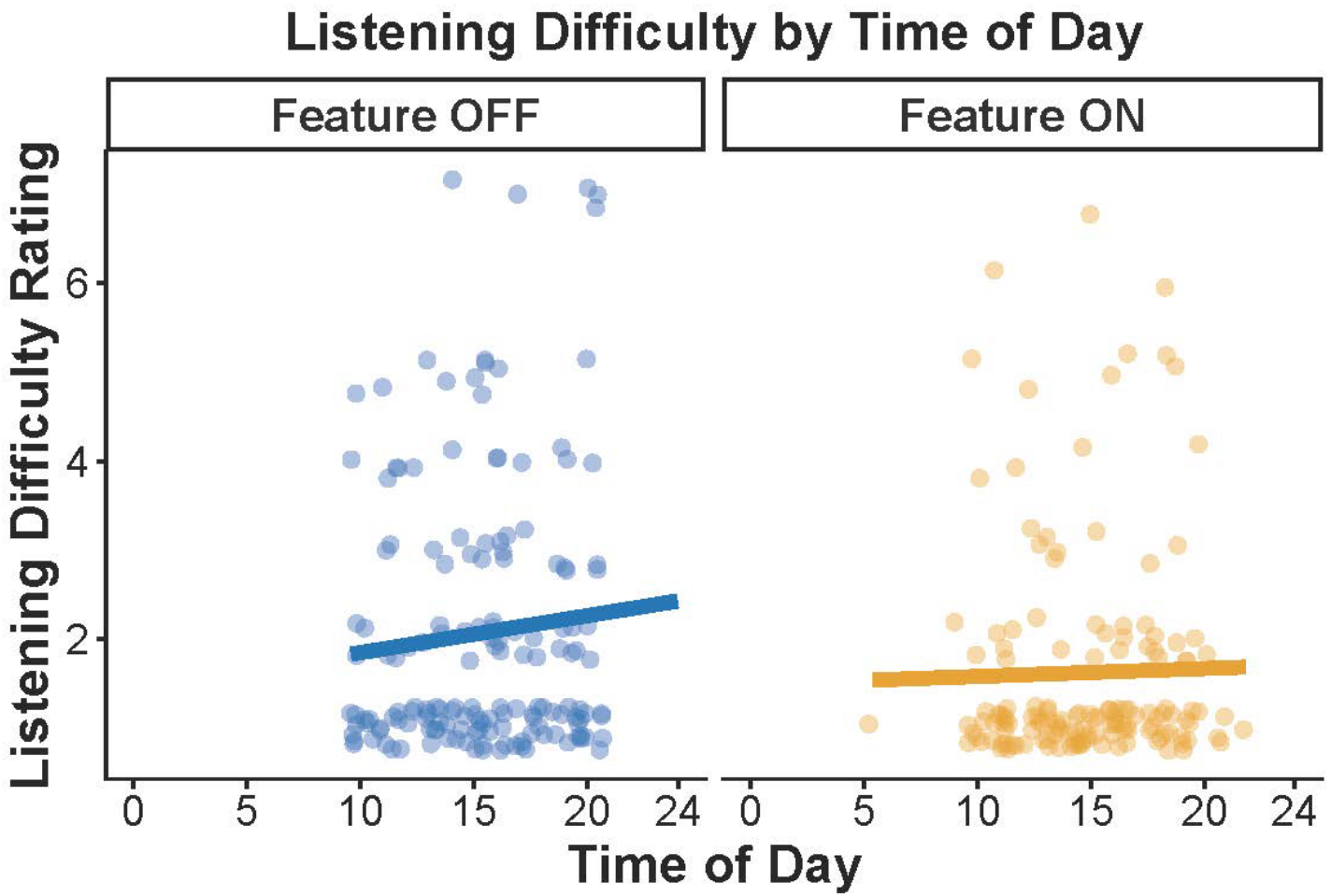


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EMA – Listening difficulty

Sensor-based directionality ON was lower than without sensor-based directionality.

Significant time of day effect and time of day by feature interaction.



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Summary

- Sensor-based directionality benefits adolescents who wear hearing aids.
  - Lab-based speech recognition in noise
  - Real-world EMA surveys

Overall Take-aways

Adolescents who use hearing aids are underfitted (in the US)

Adolescents who use hearing aids wear their devices

Adolescents who use hearing aids can benefit from advanced signal processing.

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