



Speech Recognition and Spatial Release from Masking in Individuals with Down Syndrome

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American Auditory Society – 2026
Poster no: 168



INTRODUCTION

- Perceptual segregation of speech from background talkers matures throughout childhood.
- Notable variability has been observed in speech segregation in individuals with typical development (TD)¹⁻⁶, and it is even more varied in individuals with developmental disabilities, such as Down syndrome (DS)^{7,8}.
- The sources of this variability remain poorly understood and likely reflect complex interactions between auditory and non-auditory processes, the latter including executive functioning.
- Here, we first investigated the development of speech recognition and spatial hearing when target speech and speech interferers are spatially separated vs. spatially co-located (spatial release from masking, SRM) across both children and adults with TD.
- We also investigated how executive functioning is associated with individual variability in speech recognition and the magnitude of SRM in children and adults with TD.
- Secondly, we examined speech recognition, spatial hearing, and executive functioning in children and adults with DS in comparison to TD controls.

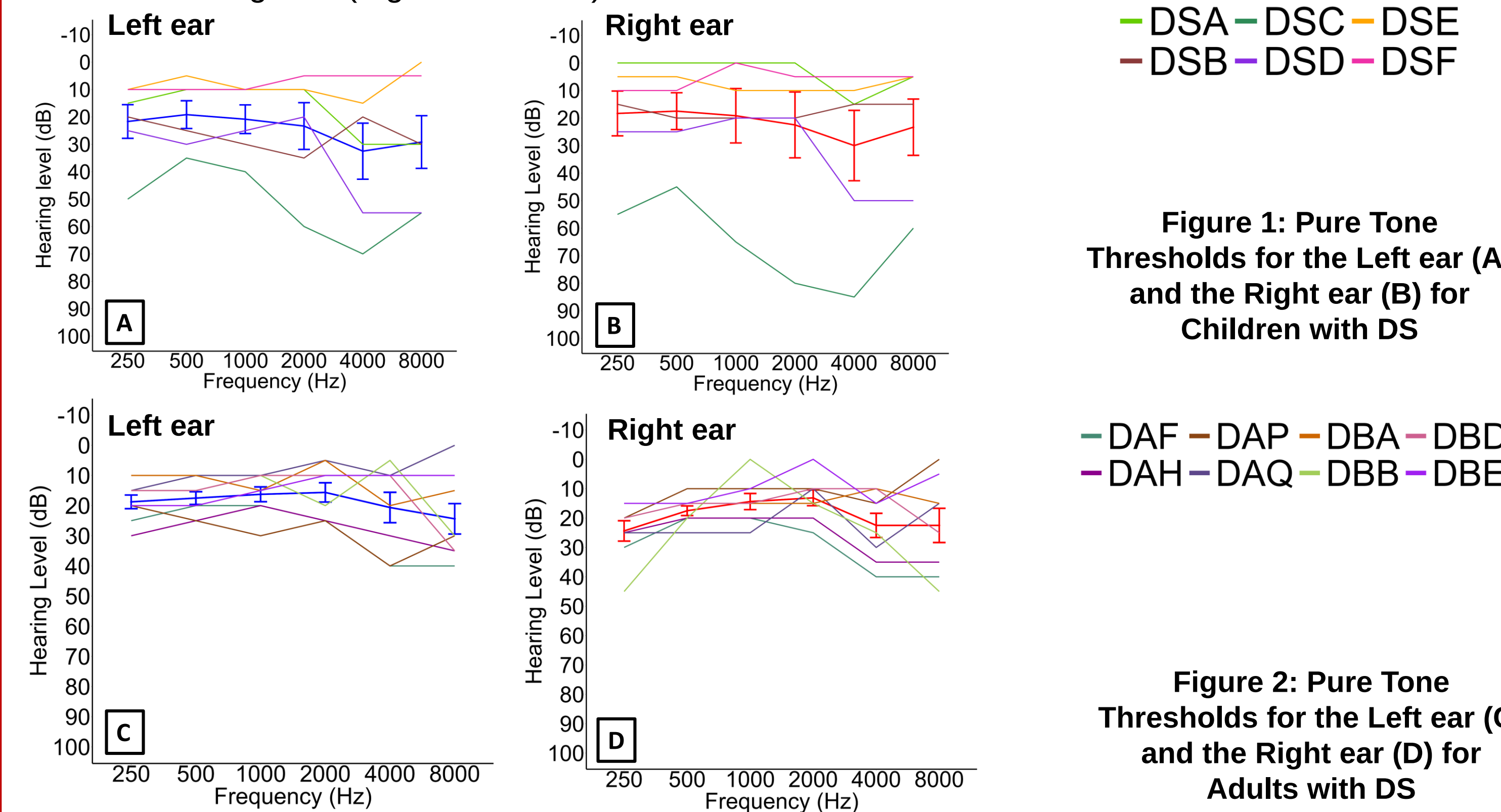
Study Objectives

- To investigate the development of speech recognition measured as speech reception thresholds (SRTs) and SRM in individuals with TD, and examine associations with executive functioning skills.
- To investigate SRTs and SRM in children and adults with DS in comparison to individuals with TD, and examine the functional benefits of hearing aid usage.

METHODS

Participant Demographics:

- Experiment 1 included TD individuals (total N=126): [5 to 8 years (M = 7.15, SD = 1.16); N = 21], [9 to 12 years (M = 10.84, SD = 1.13); N = 24], [13 to 17 years (M = 15.27, SD = 1.46); N = 25], [18 to 24 years (M = 21.13, SD = 1.74); N = 56]. Participants had normal hearing across all frequencies tested bilaterally.
- Experiment 2 included children with DS [10 to 17 years (M = 14.79, SD = 2.06); N = 06], adults with DS [21 to 25 years (M = 24.04, SD = 1.07); N = 08], and TD controls (children [10 to 17 years (M = 15.15, SD = 2.52); N = 08], adults [18 to 24 years (M = 21.13, SD = 1.74); N = 56]). Pure tone audiometric air conduction thresholds of individuals with DS ranged from within normal limits to severe hearing loss (Figures 1 and 2).



Speech Recognition Task:

- A closed-set four alternative forced choice task⁶ (Figure 3) was used to estimate speech reception thresholds (SRTs) using an adaptive tracking algorithm (3-down/1-up), estimating 79.4% correct on the psychometric function. Each adaptive track ended after five reversals.
- Interferers were fixed at 55 dB SPL, with the target speech initially presented at 60 dB SPL when testing individuals with normal hearing, and individuals with DS using hearing aids.
- Interferers were fixed at 65 dB SPL, with the target speech initially presented at 70 dB SPL when testing individuals with DS with hearing loss in the unaided condition.

Cognitive Measures (Only for children with TD and children and adults with DS):

- Digit Span Forward (WISC-V) was used to assess Verbal Attention
- Digit Span Backward (WISC-V) was used to assess Verbal Working memory

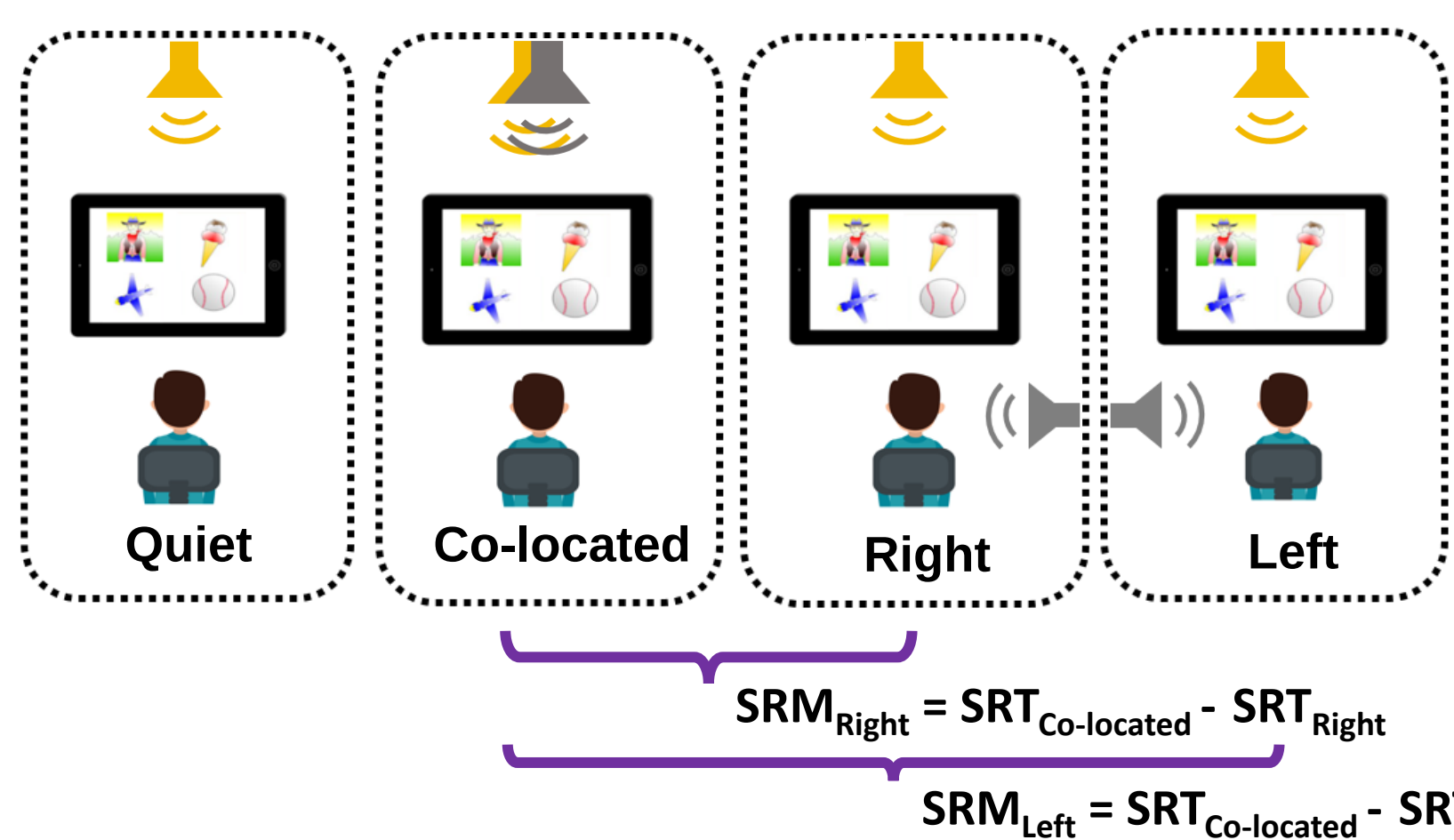


Figure 3: Children's Realistic Index for Speech Perception (CRISP)

Target: 25 Spondees spoken by a male talker

Interferers: IEEE sentences spoken by two male talkers

Experiment 1: Maturation of Speech Recognition and SRM in Individuals with TD

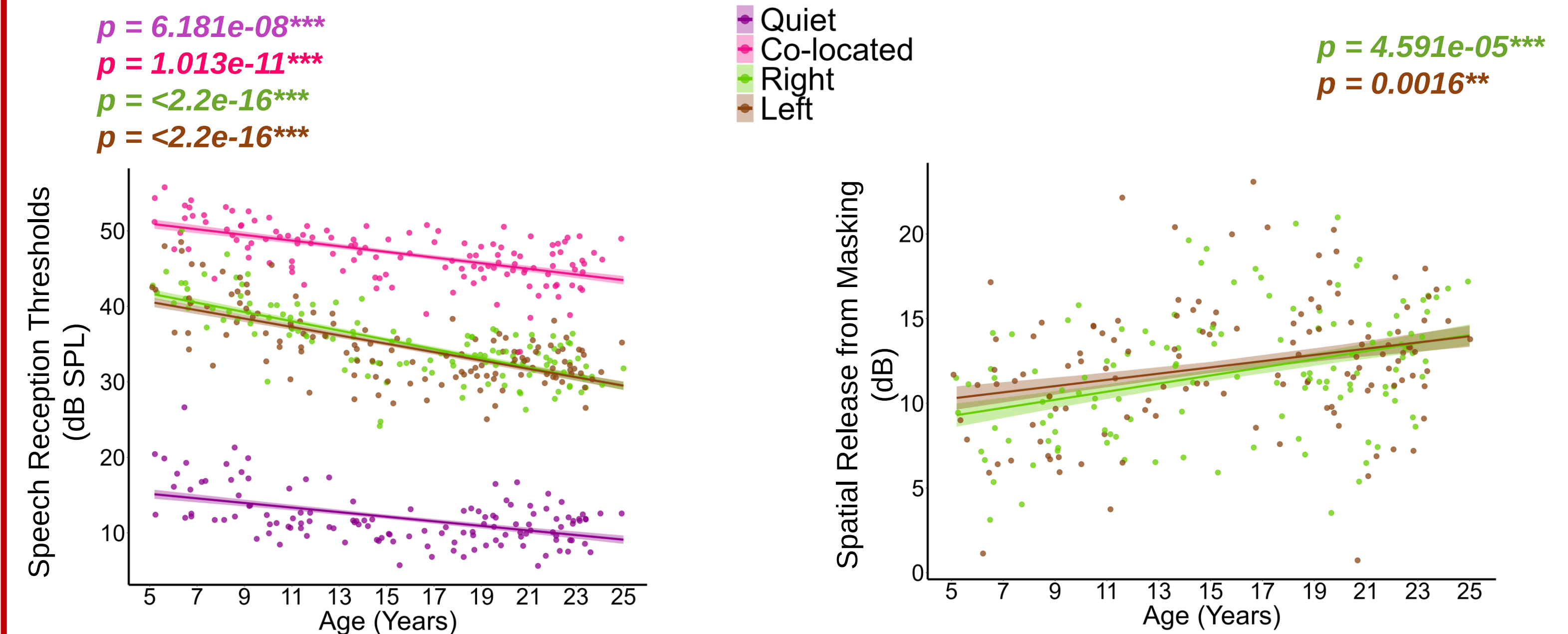


Figure 4: Speech Reception Thresholds as a function of Age in individuals with TD

Figure 5: Spatial Release from Masking as a function of Age in individuals with TD

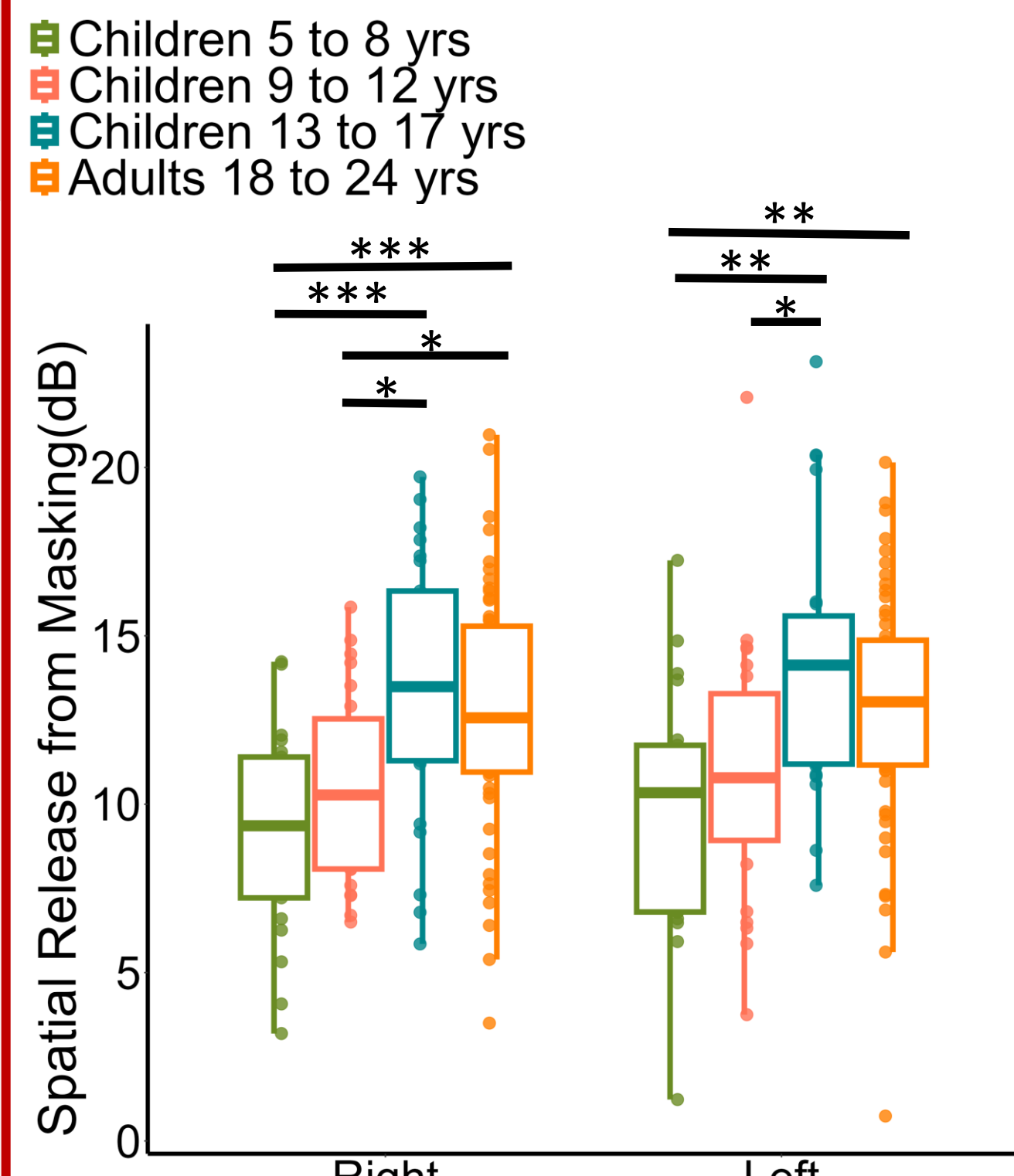


Figure 6: Spatial Release from Masking across age groups in TD individuals

Association between Speech Recognition and Attention in TD Children

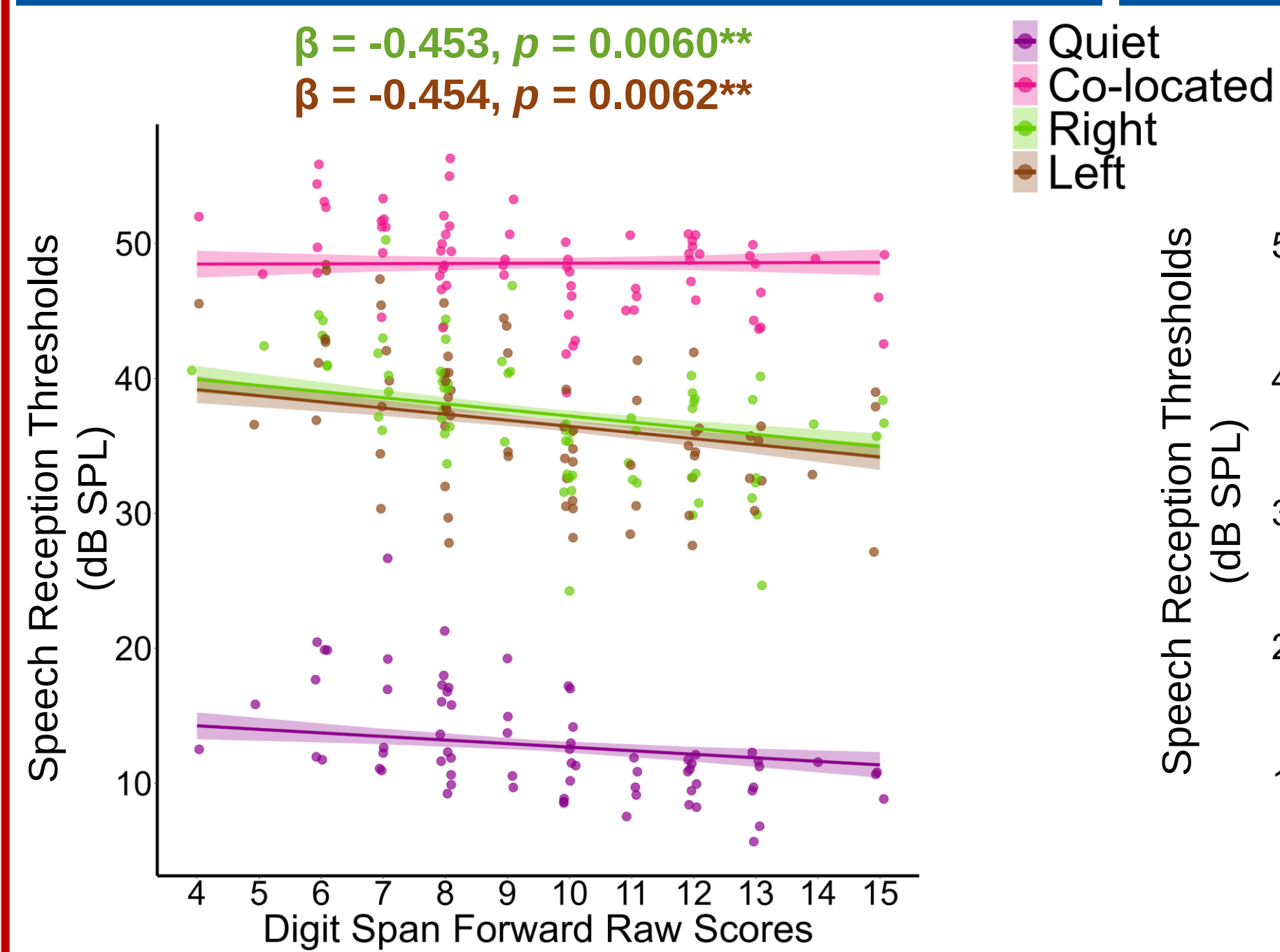


Figure 7: Speech Reception Thresholds as a function of Digit Span Forward Scores in TD Children (adjusted for age)

Association between Speech Recognition and Working Memory in TD Children

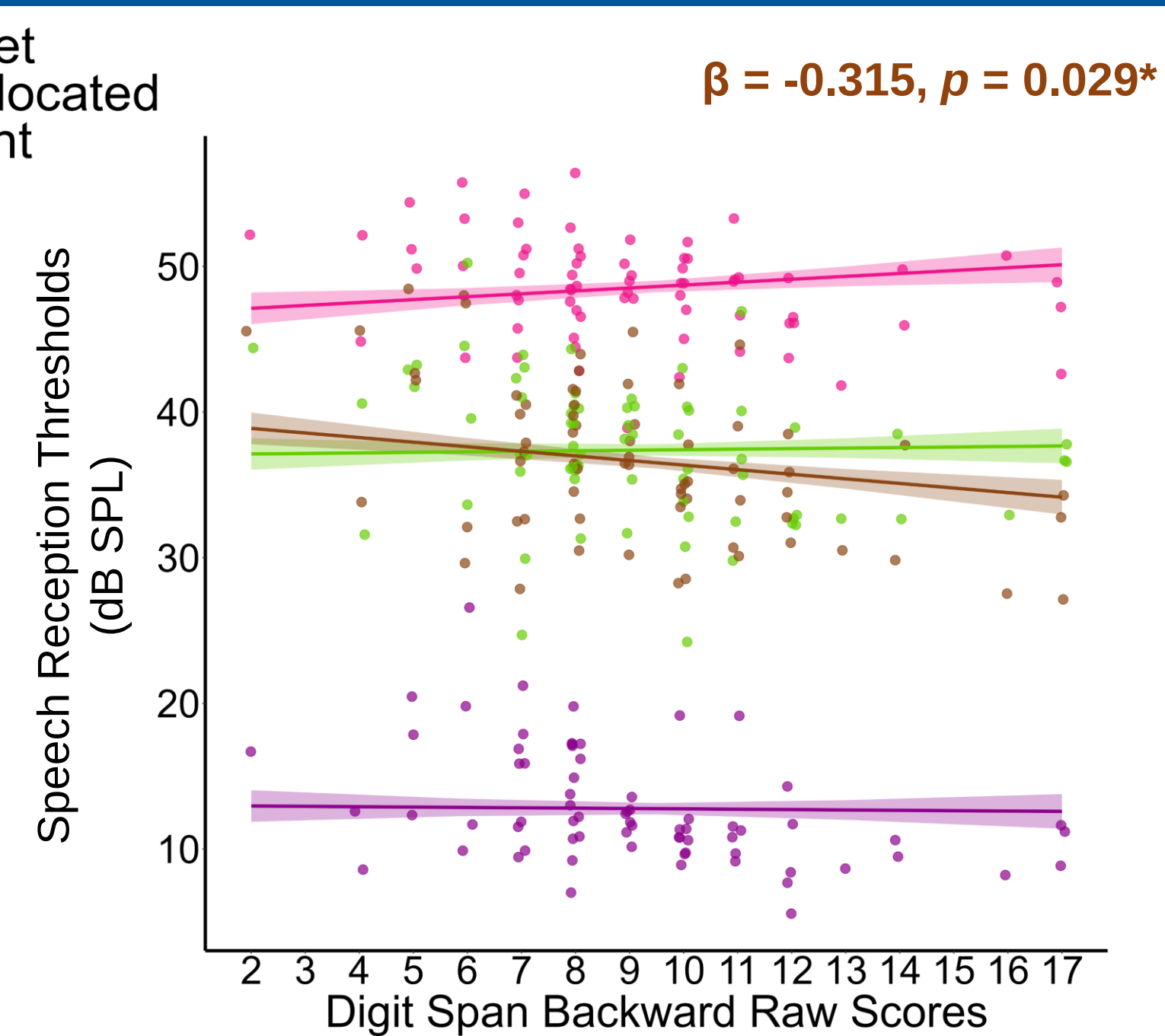


Figure 8: Speech Reception Thresholds as a function of Digit Span Backward Scores in TD Children (adjusted for age)

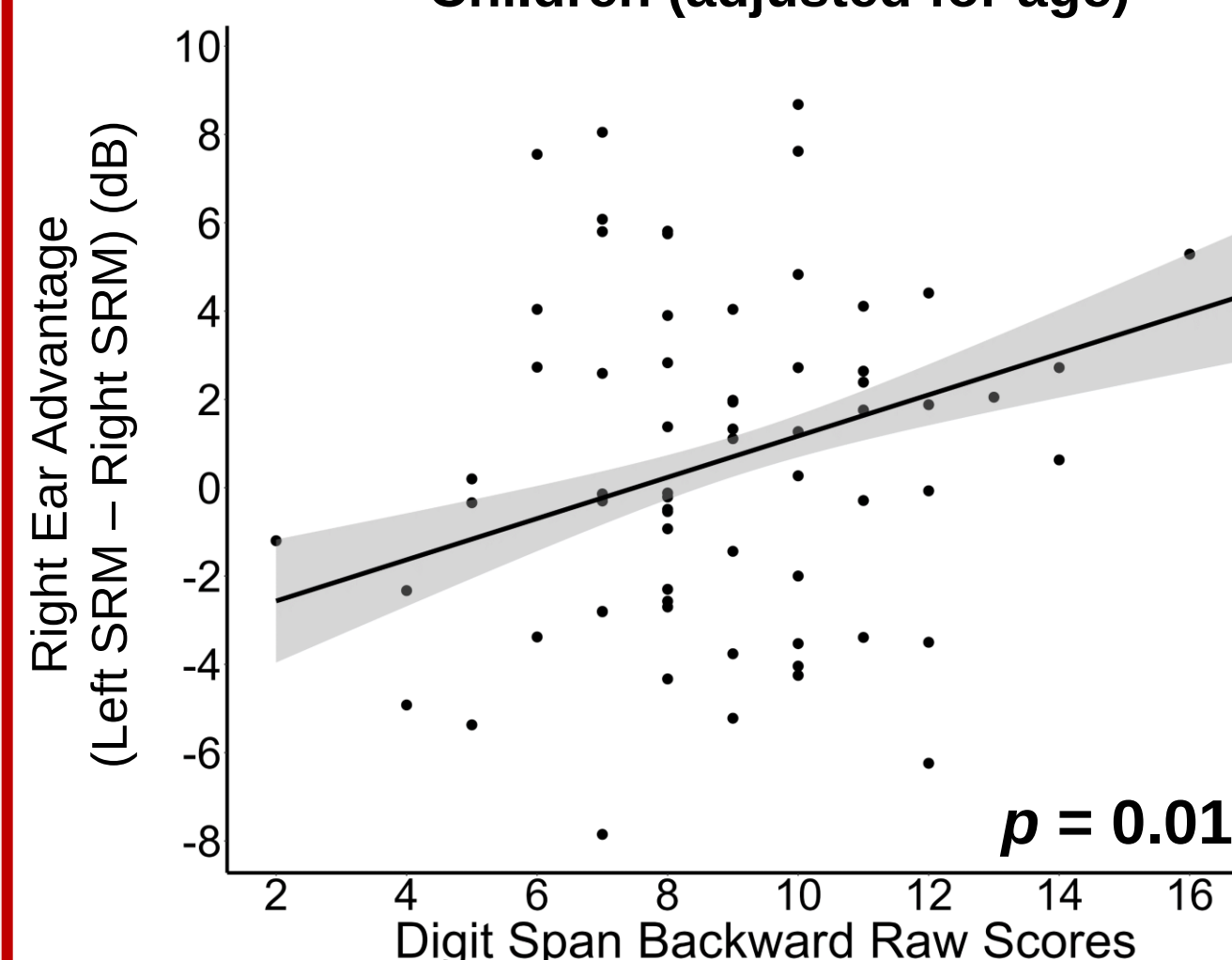


Figure 9: Right Ear Advantage as a function of Digit Span Backward Raw Scores in TD Children (adjusted for age)

RESULTS

Experiment 2: Speech Recognition and SRM in Children and Adults with DS in Comparison to TD controls

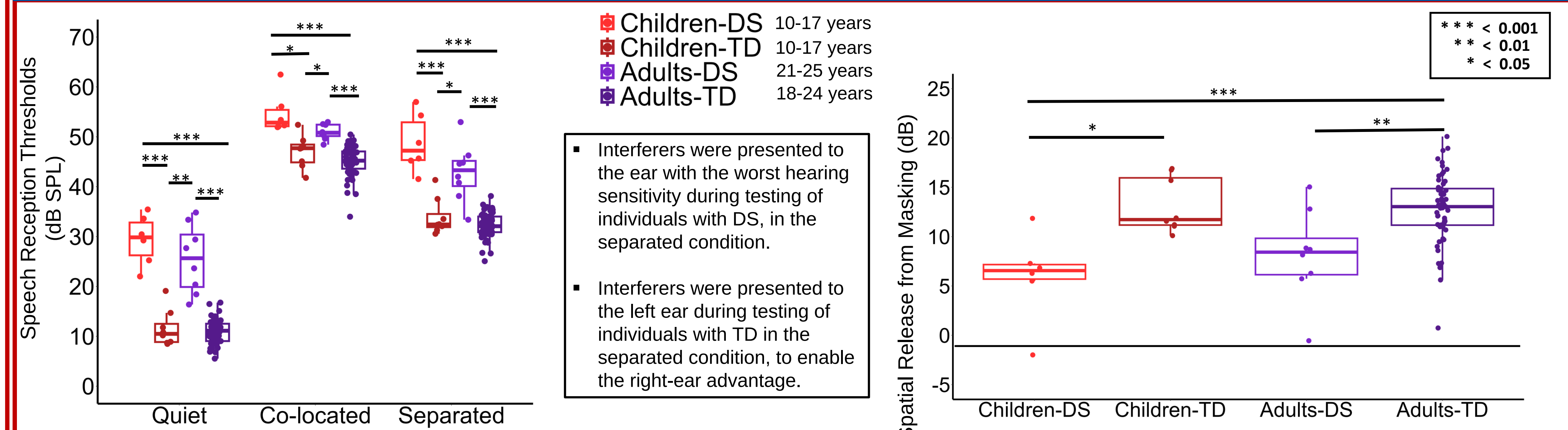


Figure 10: Speech reception thresholds in quiet and with interferers co-located or separated in individuals with DS and TD

Figure 11: Spatial Release from Masking in individuals with DS and TD

- SRTs in quiet were significantly higher in children and adults with DS than in children and adults with TD (Figure 10; pairwise comparisons with Bonferroni corrections).
- SRTs with interferers were significantly higher in children and adults with DS than in children and adults with TD, regardless of the location of the interferers (Figure 10).
- SRM was significantly lower in individuals with DS than in individuals with TD, except between children with TD and adults with DS (Figure 11).
- SRTs were not significantly different between children and adults with DS in any conditions tested (Figure 10). The same was observed for SRM (Figure 11).
- Within-group comparisons showed that SRTs in the quiet condition were lower than SRTs in either co-located or separated conditions for all groups (Figure 10). Also, the separated SRTs were lower than the co-located SRTs, indicating release from masking, except for children with DS (Figure 10).

Children with DS: Functional Benefits associated with the Hearing Aid Usage on Speech Recognition measured with SRTs and Spatial Hearing with SRM

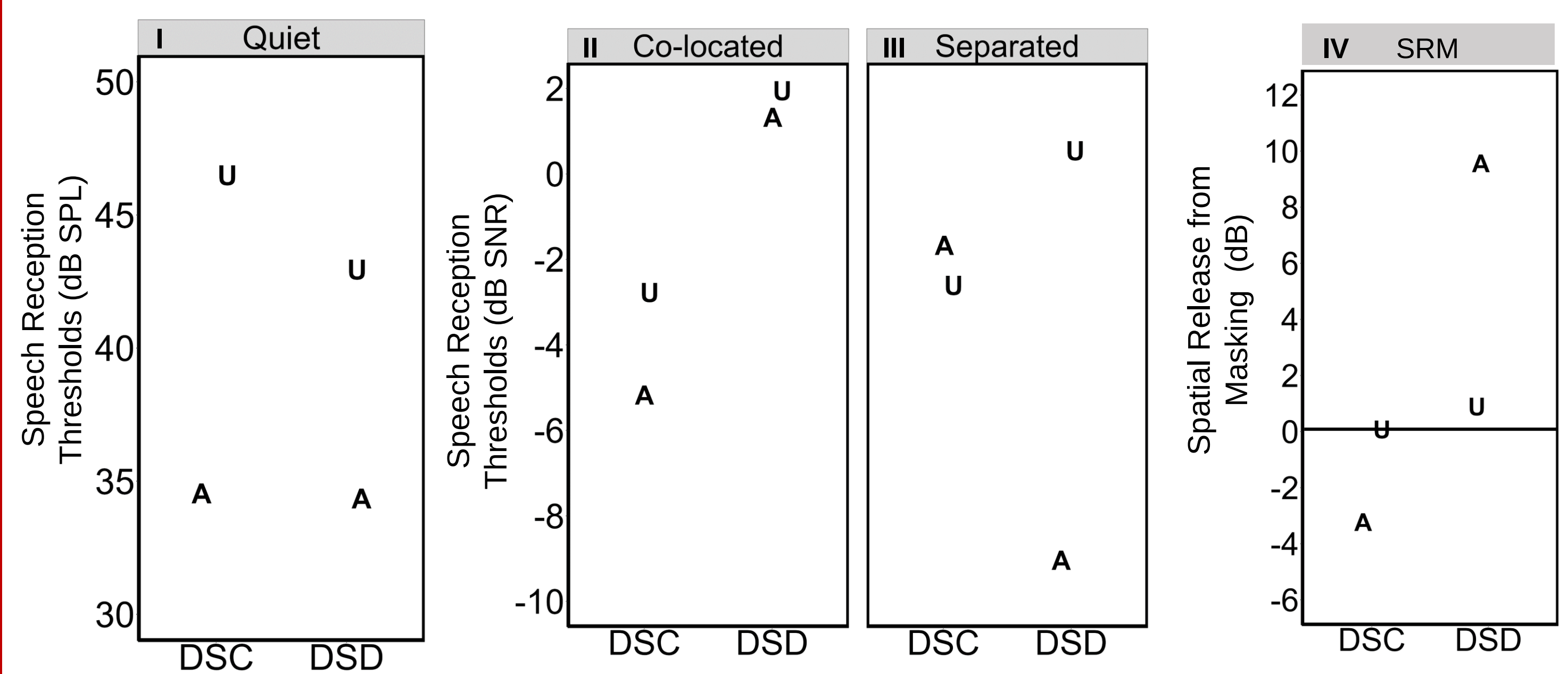


Figure 12: Speech reception thresholds in quiet (I), with interferers (II & III), and SRM (IV) as a function of hearing aid usage in Children with DS (U: Unaided; A: Aided)

- The two participants who used hearing aids were tested under aided and unaided conditions.
- Both participants showed improved performance with their hearing aids for the Quiet and Co-located conditions (Figures 12; I and II).
- Only DSD demonstrated more SRM with hearing aids (Figure 12; IV), indicating the benefit of spatial separation (Figure 12 IV).
- A larger sample is required to fully understand the functional benefits of hearing aid usage on speech recognition and spatial hearing in individuals with DS, with other associated factors.

Conclusions and Future Directions

- In individuals with TD, age is a significant factor in speech recognition in quiet and in noise. Age-related maturation of spatial hearing and source segregation was also observed.
- Attention and working memory of children with TD were significantly associated with speech recognition with interferers spatially separated. The difference between left and right SRM was associated with working memory, providing insight into the right ear advantage.
- Individuals with DS show significantly higher (worse) SRTs and significantly lower (worse) SRM in comparison to individuals with TD.
- Preliminary analysis indicates that both SRTs and SRM were not significantly different between children and adults with DS.
- Preliminary data indicate how speech recognition and source segregation improve in children with DS with the aided conditions compared to the unaided conditions.
- Future Directions:** Data collection is ongoing in children and young adults with DS. Note that a large sample size across a wide age range is required to understand the maturation of speech recognition and SRM in individuals with DS, as well as the role of cognitive skills in speech recognition and the effective use of spatial cues in noisy environments in children and adults with DS.

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Acknowledgement

This work was supported by NIH-NIDCD (R01 DC003083, Litovsky) and NIH-NIDCD (R01 DC019511, MPis Litovsky, Hartley, Sterling, and Alexander). This study was supported in part by a core grant to the Waisman Center from the National Institute of Child Health and Human Development (P50HD105353). Special thanks to Stephanie Sellner, Eva Walsh, Alexis Jentz, Molly Osborn, and other BHSL lab members for data collection. Special thanks to all the study participants.