Effects of Semantic Context on Speech Recognition & Spatial Release from Masking in Children using Bilateral Cochlear Implants and Age-Matched Typical Hearing Children

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INTRODUCTION

- Much of the research[1-4] to date on speech understanding in children using bilateral cochlear implants (BiCIs) and children with typical hearing (TH) has used standardized tests with contextually meaningful content.
- Significant variability was found in both groups of children, and it was greater for children with BiCIs compared to TH due to factors including auditory experience, neurocognitive abilities, integrity of the auditory system and etc.
- Processing of semantically meaningful sentences (Coherent) is different from processing of sentences that violate the semantic context (Anomalous) due to the involvement of top down vs. bottom up processing (Figure 1).
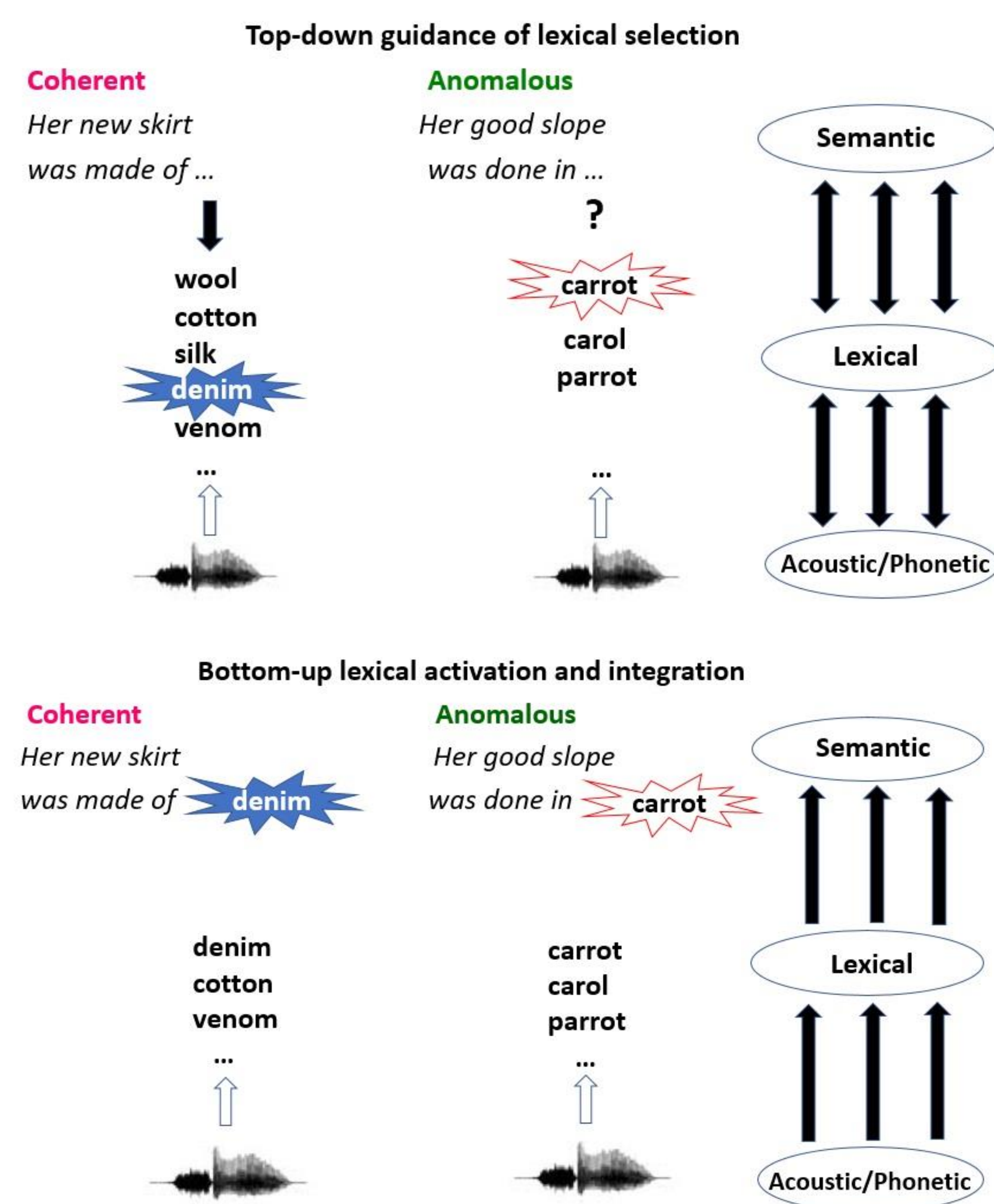

Figure 1: Effect of Semantic Context on Speech Perception[5]

- Effect of semantic context on speech recognition in noise (Figure 2) and source segregation introduced by Spatial Release from Masking (SRM) (Figure 3) was examined in a previous study[6] for children with TH (n=23; 9 to 15 yrs) using semantically Coherent and Anomalous sentences.
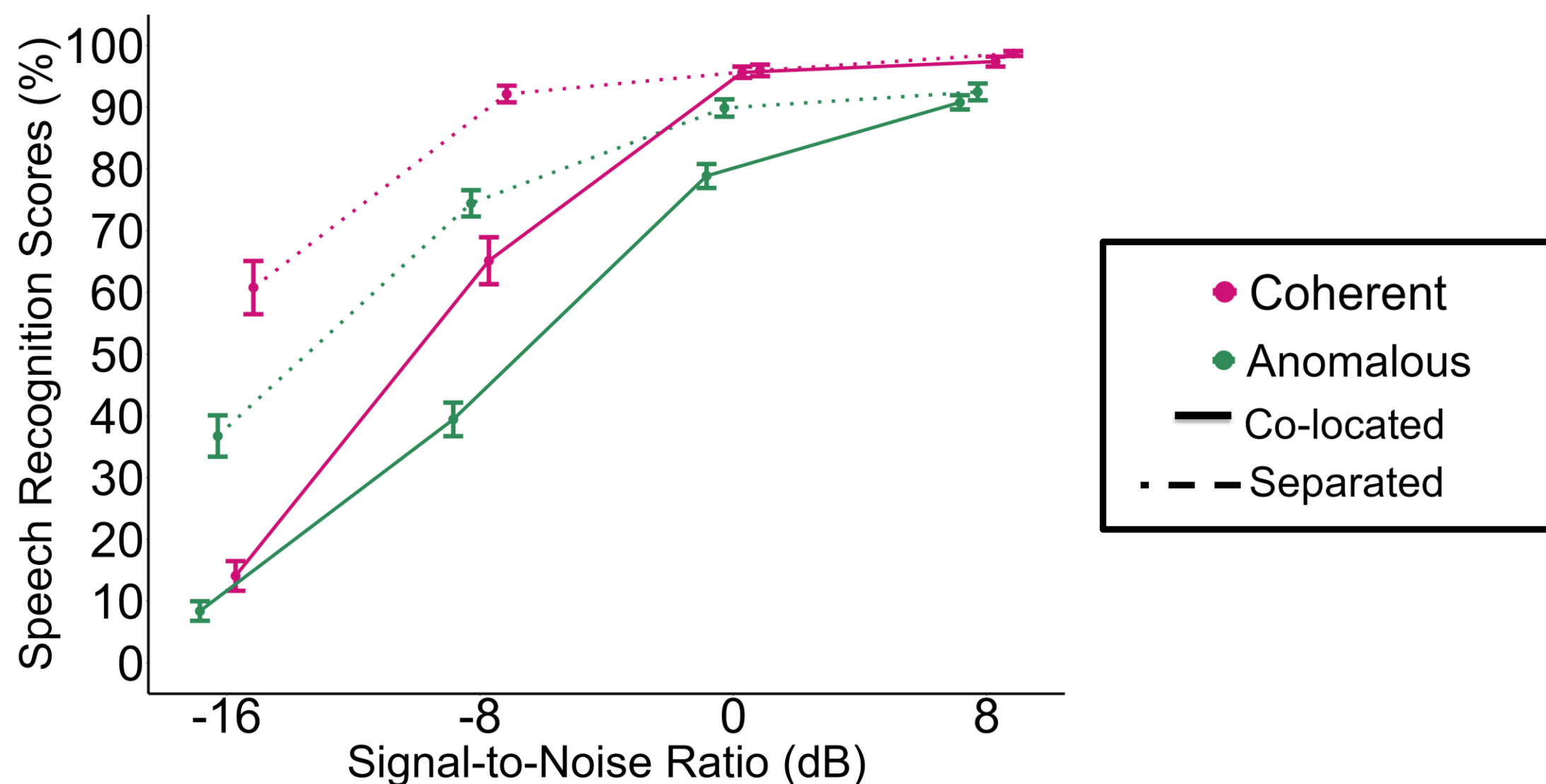

Figure 2: Effect of Semantic Context on Speech Recognition in children with TH in varying Signal-to-Noise Ratios and Spatial Configurations of Target and Interferers[6]
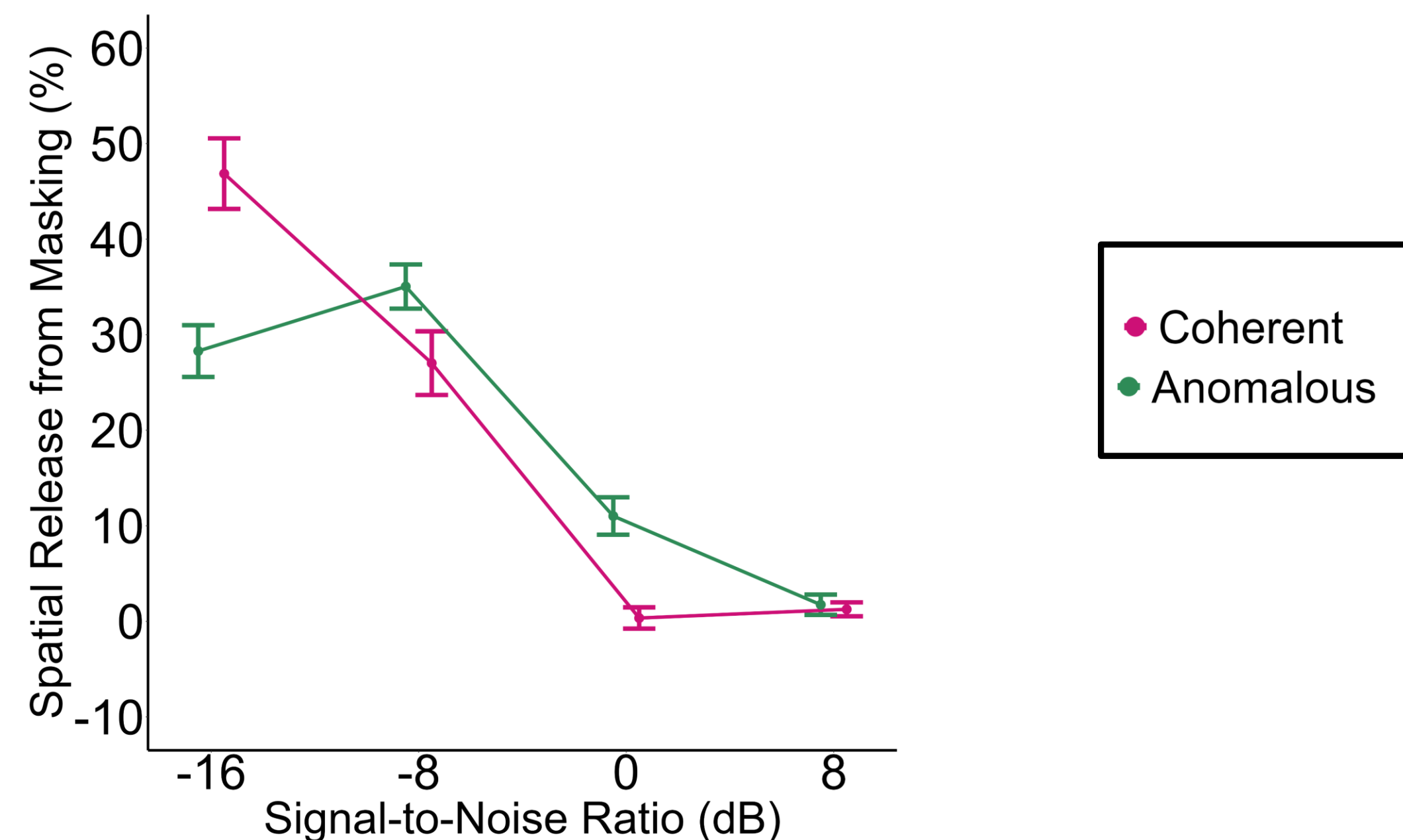

Figure 3: Effect of Semantic Context on Spatial Release from Masking in children with TH in varying SNRs[6]

- **Vocoded CI Simulation** in TH Children: effect of semantic context on speech recognition in quiet and at +8 dB SNR (recent study in our lab[7])
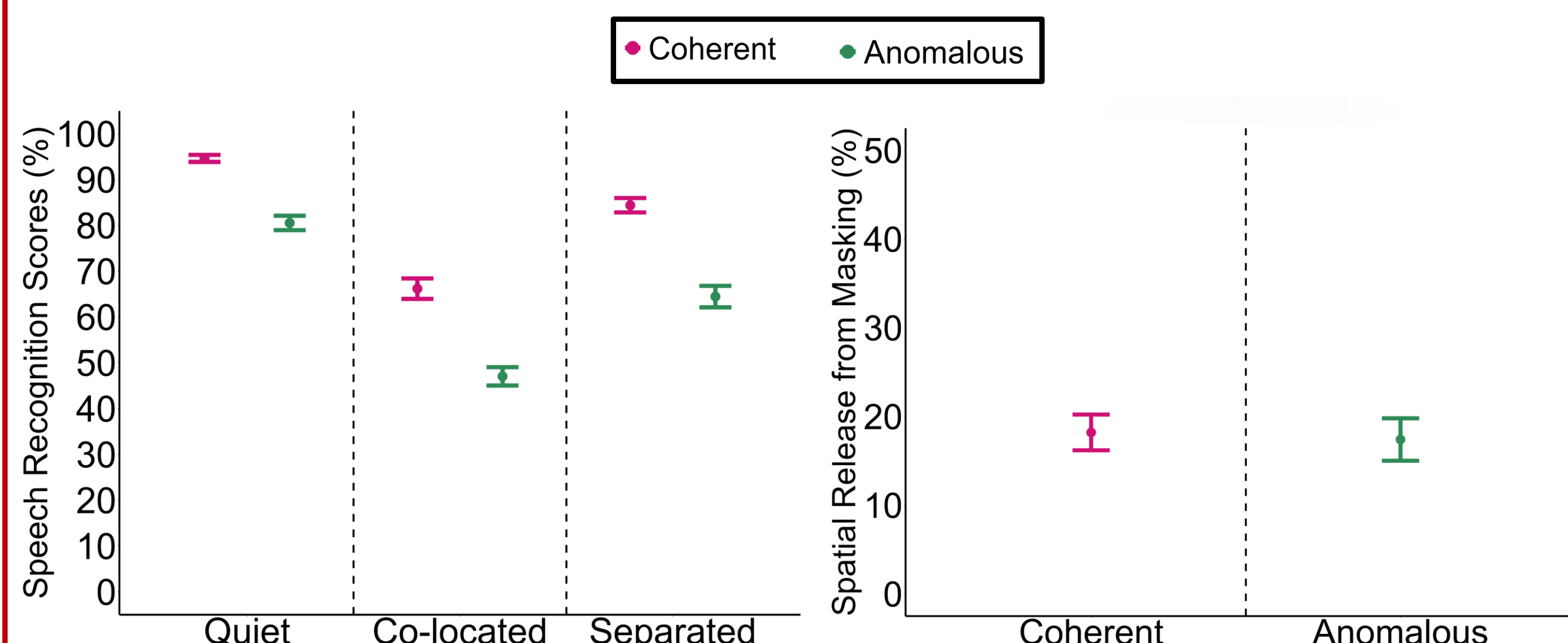

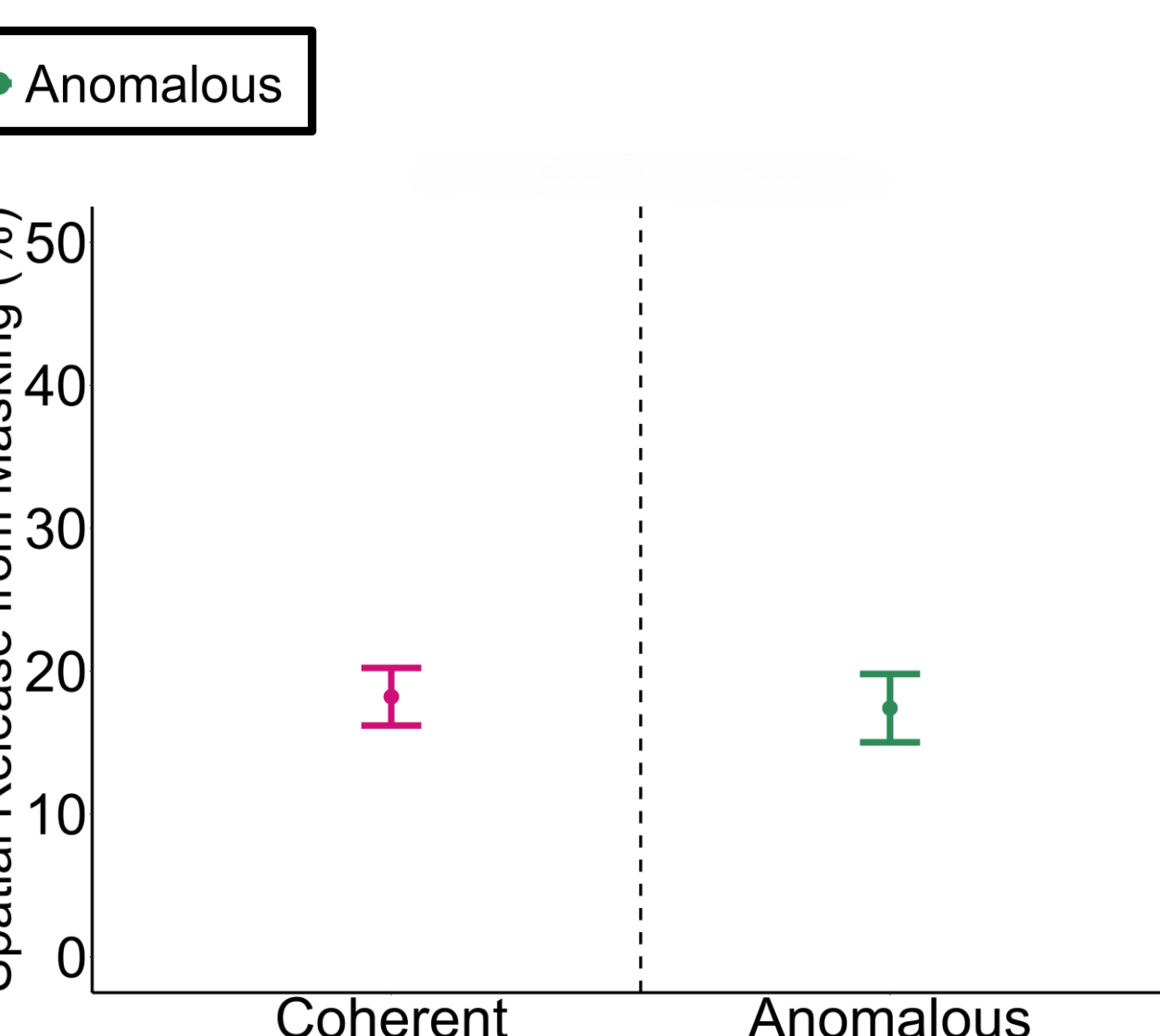**Figure 4**: Effect of Semantic Context on Speech Recognition in children with TH[7]

Figure 5: Effect of Semantic Context on Spatial Release from Masking in children with TH[7]

Study Objectives

1. To examine the performance at varying SNRs of target and interferers, in children with BiCIs and TH, for semantically Coherent and Anomalous sentences.
2. To examine the effect of Coherent vs Anomalous speech on speech recognition and SRM, in children with BiCIs and TH.

METHODS

- **Participant Characteristics:** Children with BiCIs ages 9-17 years, and TH ages 9-15 years. To date we tested two children with BiCIs and five TH children; all are native English speakers. Children with TH were screened for bilateral normal hearing sensitivity from 250-8000Hz.
- **Test Environment:** Testing was conducted in a standard, carpeted sound-treated booth (~200 ms RT_{60}); stimuli were presented through loudspeakers with the target at 0° and interferers at either 0° or +90° azimuth. Loudspeakers were positioned at ear level, at a distance of 1.2m from the center of the head.
- **Target Stimuli:** Pre-recorded sentences[5] were spoken by a male talker with standard American English accent, presented at 60 dB SPL.
  - Phonologically, lexically, and syntactically balanced sentences with 6 to 13 words
  - Ten sentences per condition, half the sentences were coherent, and half were anomalous.
- **Interferers:** Sentences (2-talker interferer created by overlaying two recordings from the same female talker); presentation level of interferers was adjusted to create four Signal-to-Noise Ratios (SNRs).
- **Familiarization:** Four coherent and four anomalous sentences presented in Quiet and Co-located conditions.
- **SNRs tested:** SNRs were selected based on pilot data indicating which SNRs should be targeted for use with children who use BiCIs. Both groups of children were tested at -5, 0, +5 and +10 SNRs in co-located and separated conditions (Figure 6).
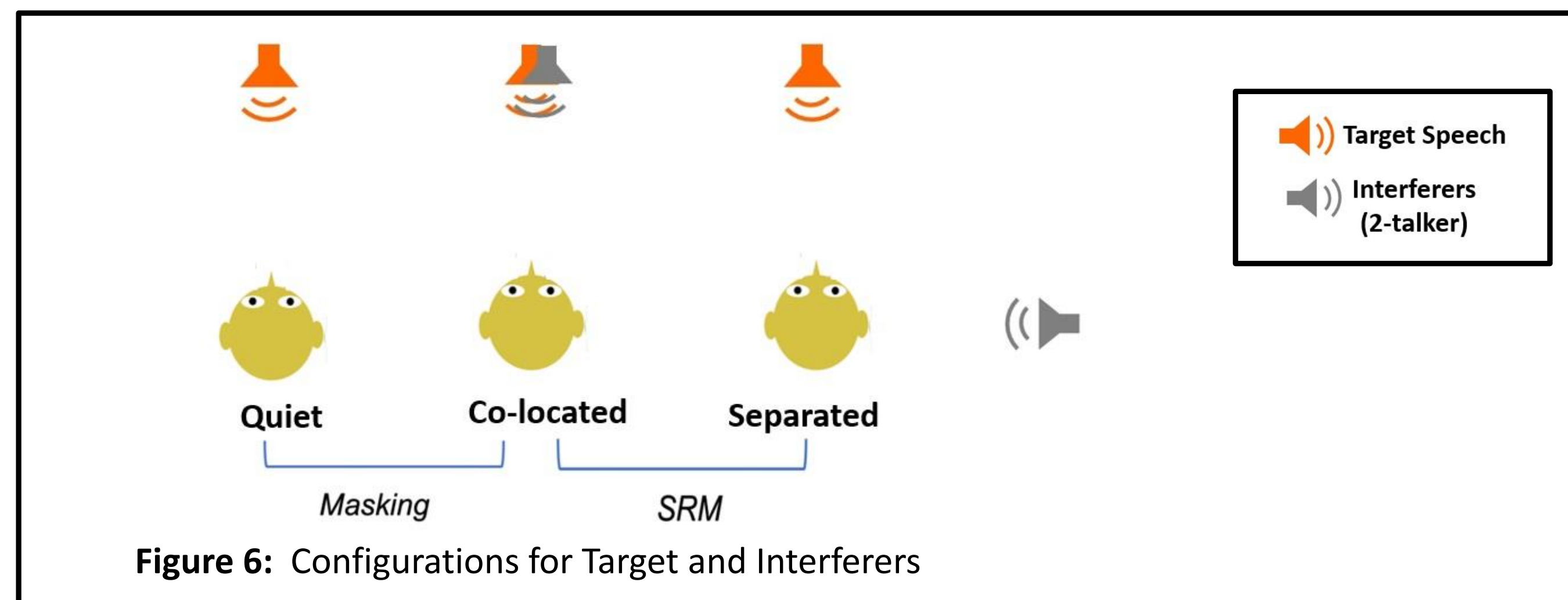- Both groups of children were also tested in quiet.

Figure 6: Configurations for Target and Interferers
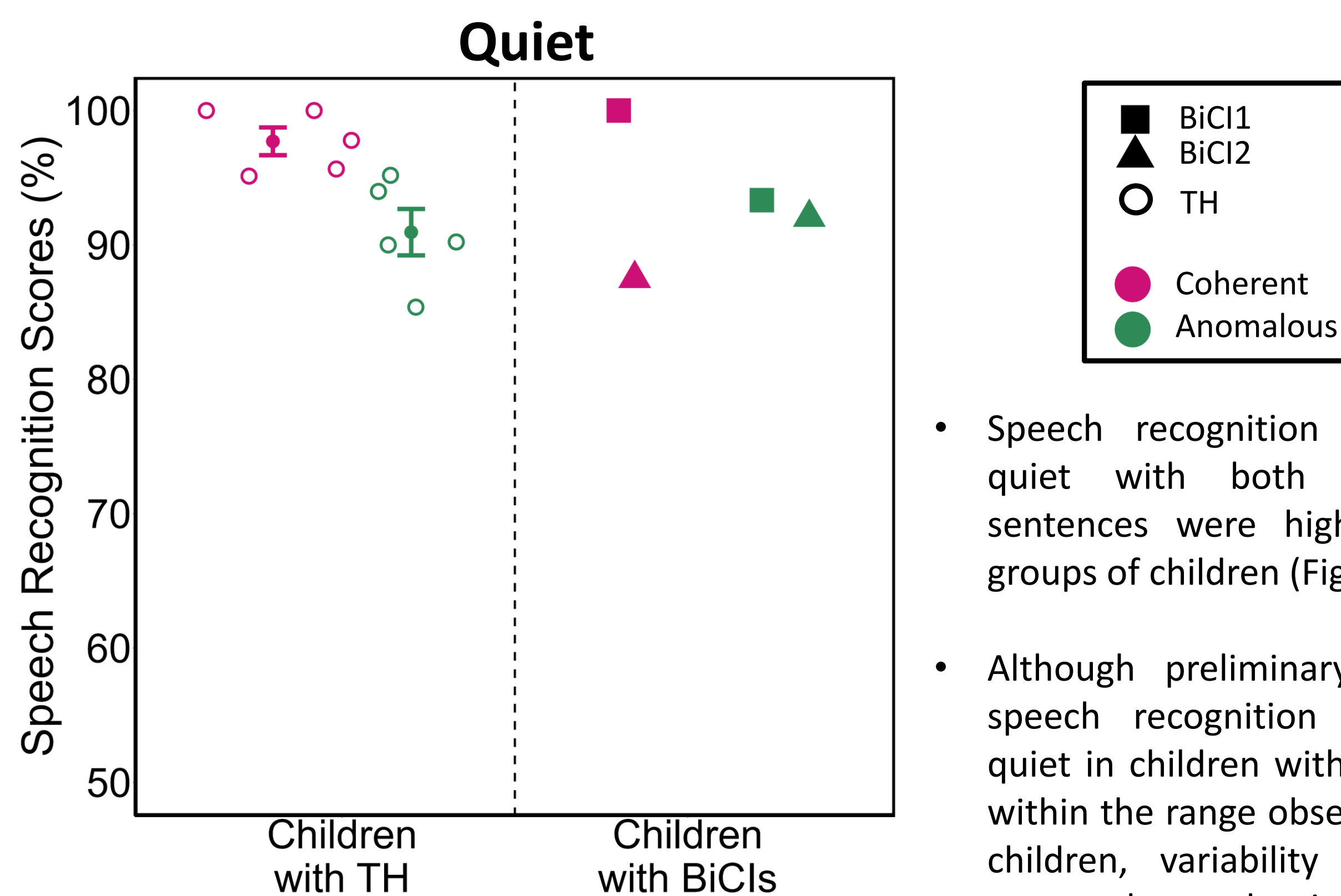
RESULTS

Figure 7: Effect of Semantic Context on Speech Recognition in Quiet in children with BiCIs and TH

- Speech recognition scores in quiet with both types of sentences were high in both groups of children (Figure 7).
- Although preliminary data of speech recognition scores in quiet in children with BiCIs was within the range observed in TH children, variability in scores was observed in varying semantic context (Figure 7).
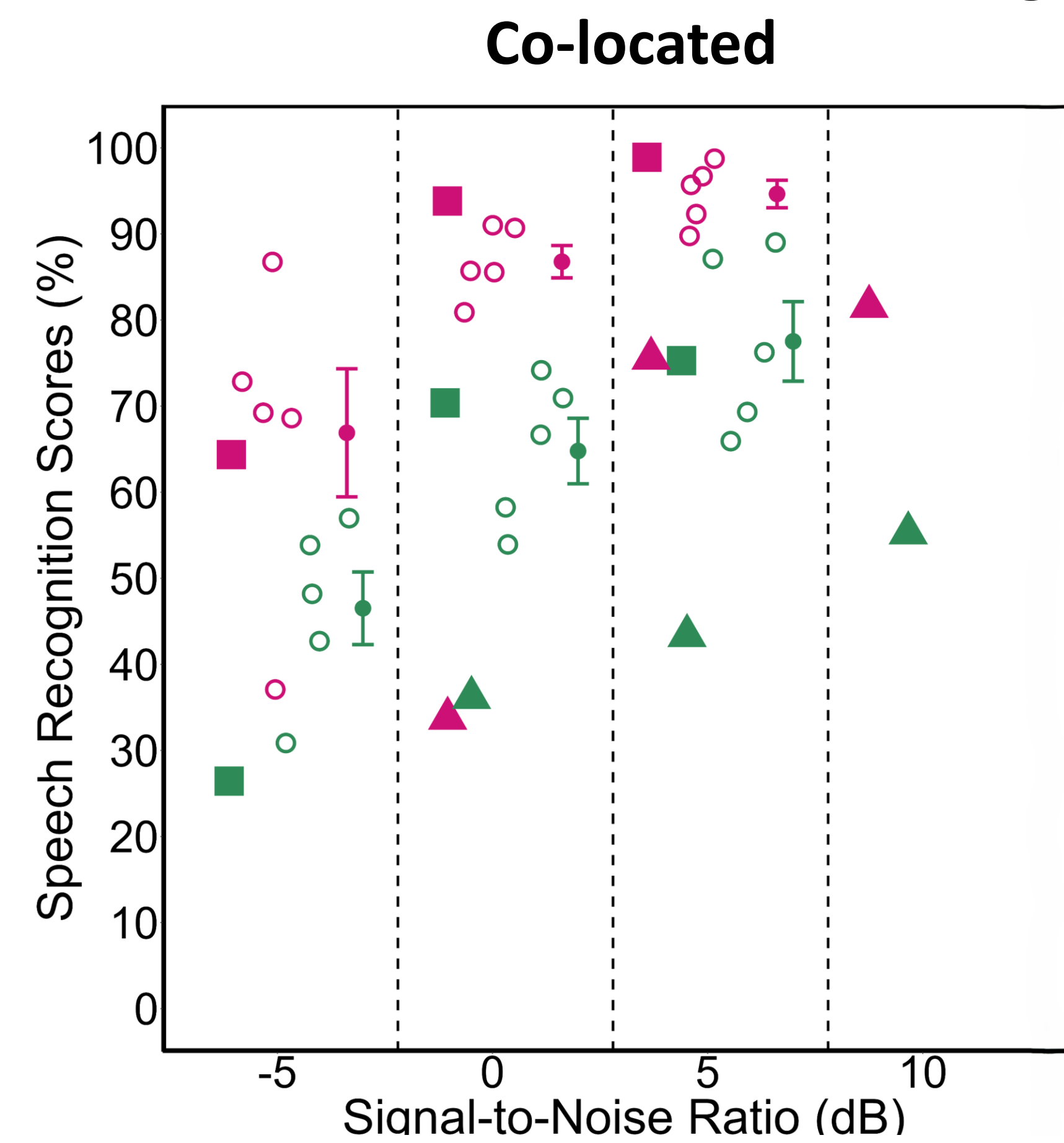
RESULTS cont.

Figure 8: Effect of Semantic Context on Speech Recognition with interferers Co-located with the target speech in children with BiCIs and children with TH
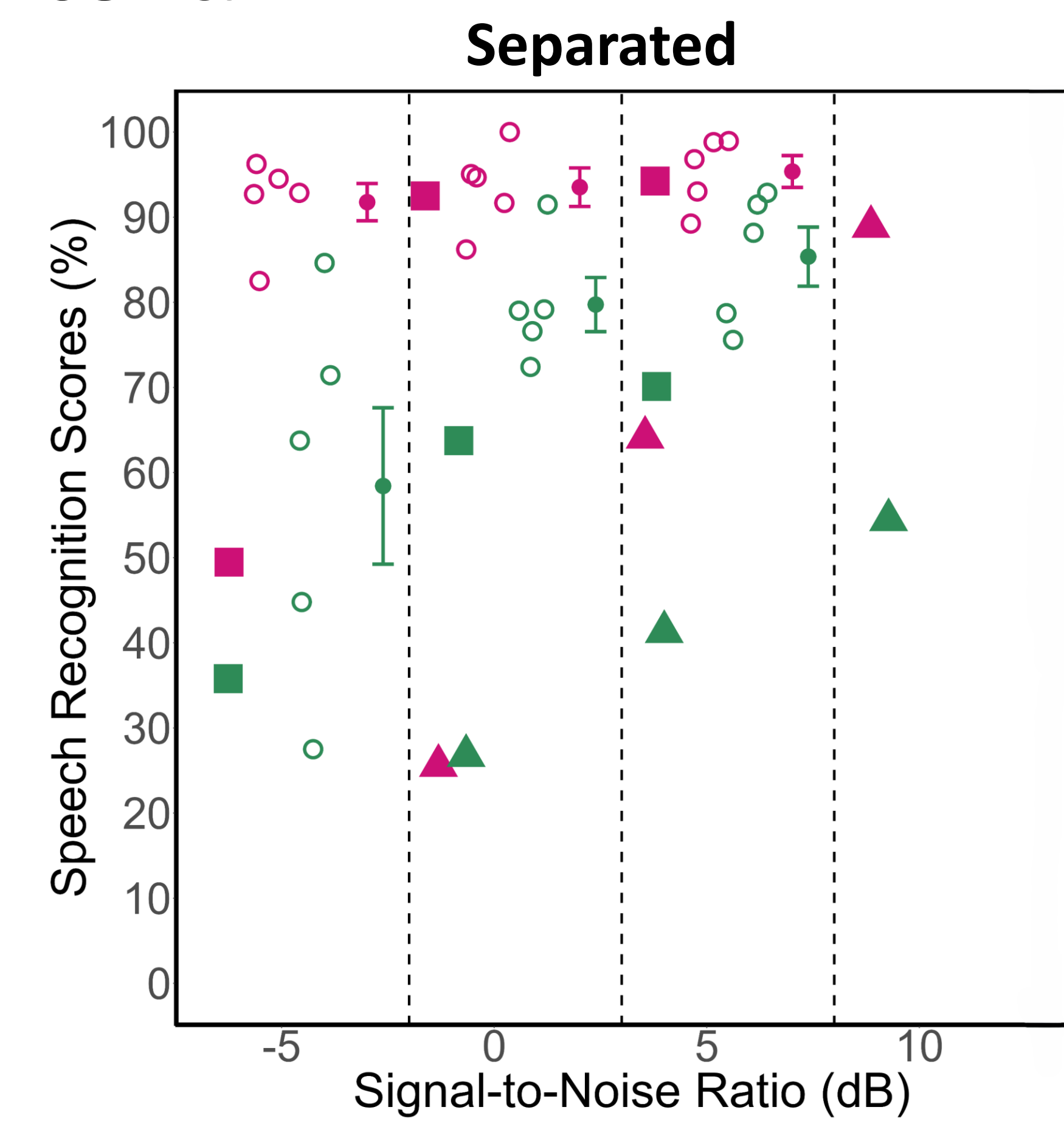

Figure 9: Effect of Semantic Context on Speech Recognition with interferers Separated to right in children with BiCIs and children with TH
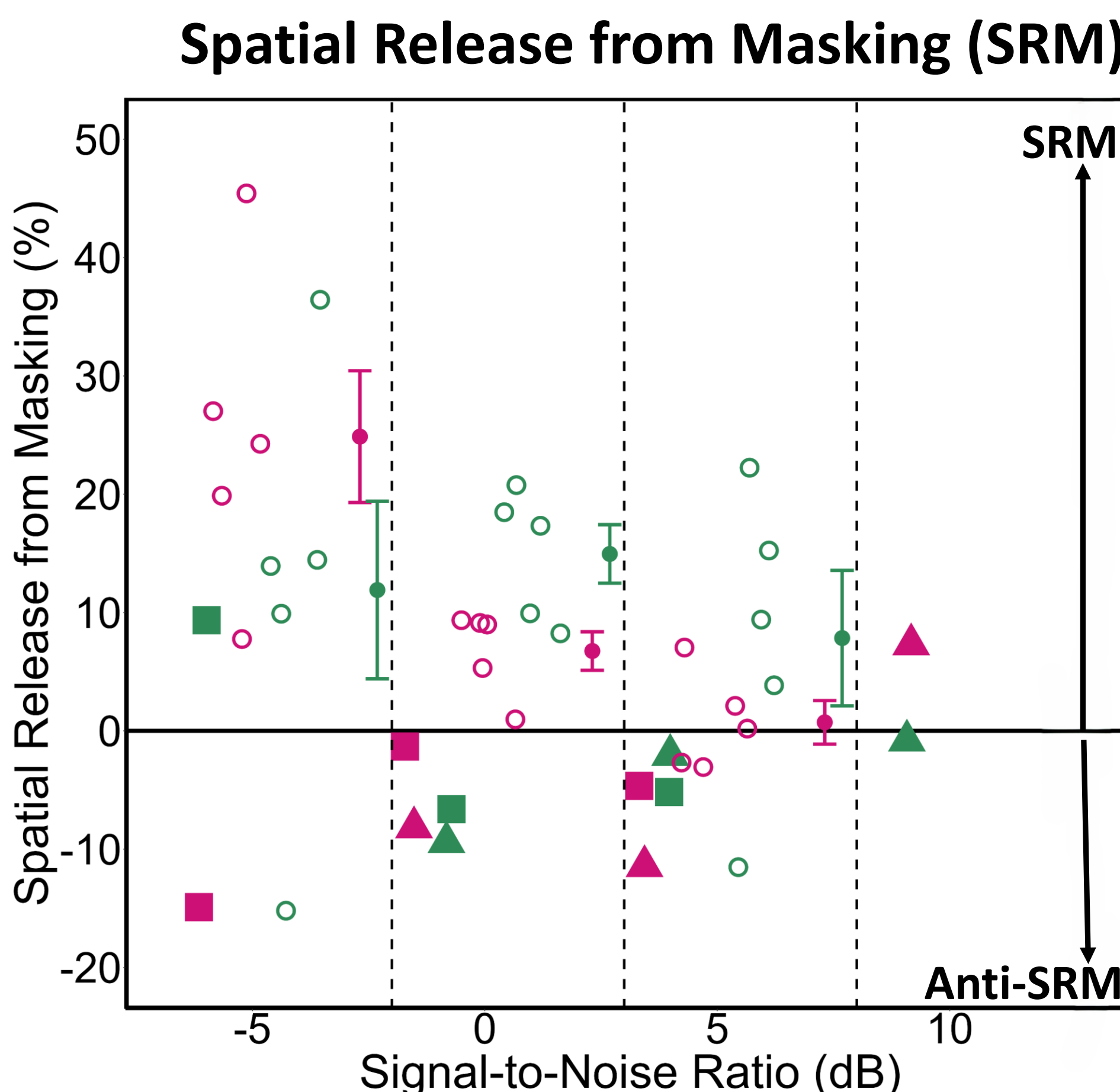

Figure 10: Effect of Semantic Context on Spatial Release from Masking in children with BiCIs and children with TH

- BiCI1 showed SRM only at -5 dB SNR with anomalous sentences. BiCI2 showed SRM only at +10 dB SNR with coherent sentences (Figure 10). Children with TH showed SRM in varying semantic context and SNRs as expected (Figure 10).

- Speech recognition scores in co-located and separated conditions for BiCI1 improved from -5 to +5 dB SNR for both types of sentences and scores were always high with coherent sentences indicating the effect of semantic context (Figure 8 & 9).
- However, speech recognition scores in separated condition for BiCI1 with both types of sentences not improved in comparison to co-located condition (except for -5 dB SNR with anomalous sentences), indicating limited benefit from spatial cues (Figure 9).
- Speech recognition scores in co-located and separated conditions for BiCI2 improved from 0 to +10 dB SNR for both types of sentences and scores were always high with coherent sentences (except at 0 dB SNR), indicating the effect of semantic context (Figure 8 & 9).
- However, speech recognition scores in separated condition for BiCI2 with both types of sentences not improved in comparison to co-located condition (except for +10 dB SNR with coherent sentences), indicating limited benefit from spatial cues (Figure 9).
- Speech recognition scores of children with TH showed the benefit of semantic context and spatial cues as expected in varying SNRs (Figure 8 & 9).

Summary and Future Directions

- Children with TH: Speech recognition scores were higher (better) with coherent vs. anomalous sentences, across SNRs, and interferer locations, suggesting advantage of semantic context to extract meaningful speech information.
- Children with BiCIs: Preliminary data from 2 children indicated that performance was overall within the range observed in children with TH, and that they also took advantage of semantic context in both co-located and separated conditions except for BiCI2 at 0 dB SNR.
- Spatial Release from Masking (SRM): In TH, SRM was greater for the most challenging SNR (-5), and there may be an interaction between SNR and semantic context. For the 2 BiCI participants, SRM was in the negative values for some SNRs (anti SRM) consistent with previous findings[8] of decreased performance with availability of spatial cues. Access to spatial cues in difficult listening situations may also be affected by limitations in availability of spatial cues provided by the CIs.
- Data collection is ongoing; a large sample is required to fully investigate the effect of context on speech recognition and SRM in children with BiCIs.
- The same study will also investigate the contribution of executive functioning skills on speech recognition and SRM.

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