Kindergarten children’s working memory is differentially sensitive to acoustic competitors

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Abstract

Children often need to listen and learn in the presence of acoustic competitors, such as other talkers or environmental sounds. Performance in these complex acoustic environments depends on the extent to which the competitors interfere with the children's sensory and/or cognitive processes. Recent work (Osman & Sullivan, 2014) suggests that acoustic competition interfere with auditory working memory, a cognitive function integral to listening and learning. The purpose of the present study was to extend this prior work to determine the effect of acoustic competitors on working memory in children after removing the auditory demands of the task. Five-year-old children participated in the Missing Scan Test in quiet and in the presence of an acoustic competitor, either a two-talker speech masker or speech-shaped noise. Memory span was calculated as the largest number of items that children recalled in each condition. The two-talker masker, but not the speech-shaped noise, disrupted children’s memory span. These results suggest that acoustic competitors interfere with working memory in children even if there are no auditory demands associated with the target task. However, the interference appears to be specific to the acoustic signature and content of the competitor.

Methods

Participants Eighty-five 5-year-old children (36 females, range 58.6 - 67 mons, average = 61.5 mons) participated. Children were native English speaking and had normal medical and otological histories, per parental report.

Acoustic competitors

Experiment 1: Speech masker. Pairs of sentences from the IEEE corpus (Rothauser et al., 1969) spoken by an adult male were randomly chosen from a list of pre-recorded sentences and digitally mixed to create the two-talker speech masker. Sentences were RMS-averaged and scaled to yield an overall intensity level of 60 dB SPL.

Experiment 2: Speech-shaped noise masker. Gaussian noise was multiplied by the spectral envelope of the two-talker male speech and scaled to yield an overall intensity level of 60 dB SPL.

Procedure Children participated in an adapted version of the Missing Scan Task (MST; Buschke, 1963; Roman, Piironi, & Kronenberger, 2014; Figure 2). Countercalibrating was used to minimize an order effect when children were exposed to multiple conditions. Children were administered the Receptive One-Word Picture Vocabulary Test (RO-POVT).

Research question: Do acoustic competitors interfere with non-auditory verbal working memory?

Figure 3: Speech maskers interfere with non-auditory verbal working memory.

A. Span scores of children who completed the MST in quiet only. B1. Span scores of children who completed the MST twice: once in quiet (gray) and once in the presence of a speech masker (blue). Children had statistically significantly greater span scores in quiet ([t(1,15) = 2.83, p < .05]). B2. The group was divided based on their test order (e.g., quiet, masker or masker, quiet). A mixed analysis of variance (ANOVA) revealed a main effect of condition [F(1,14) = 7.5, p < .05]. There was no main effect of order [F(1,14) = 2.2, p = .16] and no condition x order interaction [F(1,14) = 0.01, p = .91]. Results suggest that children consistently perform worse in the presence of the speech masker, regardless of presentation order.

C.1. Span scores of children who completed the MST twice: once in quiet (gray) and once in the presence of a speech-shaped noise masker (green). Children performed equivalently in each condition [F(1,15) = 0.11, p = .91]. C2. The group was divided based on their test order. A mixed ANOVA revealed no main effect of condition [F(1,14) = 0.018, p = .91] and no main effect of order [F(1,15) = 1.5, p = .24]. A significant condition x order interaction [F(1,14) = 6.5, p < .05], however, suggested that children’s performance across the two conditions was dependent on the order of the tests. Results suggest a fatigue effect on the second condition, regardless of whether it was in quiet or in the presence of speech-shaped noise.

Figure 4: Speech maskers interfere with non-auditory verbal working memory when controlling for fatigue effects.

A - C. Three groups of children completed the MST three times within one session, with a break (purple arrow) between the 2nd and 3rd trial. A. All three trials were in quiet. A repeated-measures ANOVA found no main effect of trial [F(2,20) = 1.0, p = .39]. B. The first two trials were in quiet, and the third trial was in the presence of a speech masker. A repeated-measures ANOVA found a main effect of trial [F(2,18) = 4.9, p < .05]. Performance in the presence of the speech masker was significantly poorer than performance on trial 1 in quiet (p < .05). The first two trials were in quiet, and the third trial was in the presence of a speech-shaped noise masker. A repeated-measures ANOVA found no main effect of trial [F(2,18) = 1.8, p = .19]. Results suggest that children consistently perform worse in the presence of a speech masker but not in the presence of speech-shaped noise.

Conclusion

1. A two-talker male speech masker interferes with non-auditory verbal working memory in 5-year-old children. This is consistent with recent data collected from school-age children (Osman & Sullivan, 2014). Performance in the presence of a speech-shaped noise masker does not have a similar effect. Data collection is ongoing to ensure adequate statistical power for these analyses.

2. In addition to engaging verbal working memory, the MST may also engage the visual sketchpad (Roman et al., 2014). It is unclear which strategies children used to identify the “missing” animal, and therefore it is unclear which part of working memory was engaged by the background noise. Additional studies are necessary to disambiguate this issue.

3. In conclusion, acoustic competitors with speech content interfere with cognitive processing in 5-year-old children, even when the task does not perceptually overlap with the competitors. This has implications for children who are performing cognitively-demanding tasks in the presence of background noise, like that commonly encountered in school.

References


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