**Speech babble interferes with verbal working memory in 5-year-old children**

Tina M. Greico-Calub, Maya-Simone Collins, Hillary Snyder
Northwestern University, The Roxelyn & Richard Pepper Department of Communication Sciences and Disorders

**Introduction**

Children often find themselves needing to listen and learn in noisy environments, including home and the classroom. These adverse listening environments not only interfere with access to the target speech signal (i.e., “energetic” masking), but they also tax a listener’s cognitive resources (i.e., “informational masking”). Young children experience greater masking than older children and adults, consistent with the idea that performance in background noise has a slow developmental time course (e.g., Wightman & Kistler, 2005; Leibold & Buss, 2013; Jones, Moore, & Amitay, 2015). The mechanisms underlying this development, however, are unclear. Recent work suggests that background noise directly interferes with auditory working memory, which is a key cognitive function that subserves speech perception in noise (e.g., Osman & Sullivan, 2014). This work, however, has largely focused on recall tasks (e.g., digit span) which may be too complex for younger children. The present study aimed to test young children’s working memory capacity in the presence of background noise, including speech babble (Experiment 1) and speech-shaped noise (Experiment 2). We implemented the Missing Scan Task which requires children to retrieve items in immediate memory but only verbally identify the “missing” item from a set of objects that were previously viewed. We hypothesized that young children will retrieve fewer items in the presence of background noise.

**Methods**

**Participants:** Forty-three (N = 26 females) 5-yr-old children (range: 58.6 - 66.2 months) were recruited to participate in the study. Children were native English speaking and had normal medical and neurological histories, per parent report.

**Background noise stimuli:**

**Experiment 1: Two-talker male babble.** 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. Sentences were RMS-averaged and scaled to yield an overall intensity level of 60 dB SPL.

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

**Procedure:** Participants were naïve to the experiment and were told that they would be told stories by the researcher. The researcher then implemented the Missing Scan Task which requires children to retrieve items in immediate memory but only verbally identify the “missing” item from a set of objects that were previously viewed.

We hypothesized that young children will retrieve fewer items in the presence of background noise.

---

**Results**

**Figure 3: Experiment 1, Effect of two-talker male babble**

A. Span scores (mean ± SE) of children who completed the MST in quiet only. B. Span scores of children who completed the MST in quiet (black bars) and in the presence of two-talker male babble (red bars). Children had statistically significantly greater span scores in quiet ([t(1,15)] = 2.83, p = 0.05; red asterisk). C. Children in 3B were split into two groups based on the first condition that they completed (e.g., quiet, babble). The numbers in white indicate presentation order. A mixed analysis of variance (ANOVA) revealed a main effect of condition [F(1,14) = 7.5, p=0.05]. There was no main effect of order, and no condition x order interaction. These results suggest that children consistently performed poorer in the presence of babble, regardless of presentation order. D. Children’s span score in quiet was positively correlated to their receptive vocabulary score [r(28) = 0.471, p < 0.05]. This relation was not significant for the babble condition.

**Figure 4: Experiment 2, Effect of speech-shaped noise**

A. Span scores (mean ± SE) of children who completed the MST in quiet only. B. Span scores of children who completed the MST in quiet (black bars) and in the presence of speech-shaped noise (SSN, red bars). A mixed analysis of variance (ANOVA) failed to show main effects of condition and order, but revealed a significant condition x order interaction [F(1,13) = 5.2, p=0.05]. This finding suggests that children always performed better on the first task, regardless of condition. Span scores in quiet or in the presence of speech-shaped noise did not correlate with receptive vocabulary scores.

---

**Summary**

1. Speech babble interferes with working memory in 5-year-old children. This is consistent with recent data collected from school-age children (Osman & Sullivan, 2014).

2. The condition x order interaction observed in Experiment 2, with the speech-shaped noise condition, was an unexpected finding. Children who completed the MST in quiet first performed similarly to the children in the quiet conditions of Experiment 1, suggesting that the sample of children in Experiment 2 are representative of typical 5-year-old children. However, children who completed the MST in speech-shaped noise first scored lower in quiet (completed after the noise condition). One possibility is that, unlike the babble, the speech-shaped noise had a longer-lasting impact on cognitive processing. In other words, the speech-shaped noise had a forward masking effect on the quiet condition. Additional studies are necessary to investigate this finding.

3. The MST likely engages the phonological loop of working memory, or verbal working memory, due to retrieval of lexical items. The MST may also, however, 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.

4. In conclusion, acute exposure to background noise, regardless of its content, interferes with cognitive processing in 5-year-old children. This has implications for both speech perception in noise as well as performance on cognitively-taxing tasks, like those commonly encountered in school.

---

**References**


---

**Acknowledgments**

We would like to acknowledge Tiffany Fang for her assistance in participant recruitment and data collection. We would also like to acknowledge Kristi Ward for her help with data analysis. This project was approved by the Institutional Review Board of Northwestern University. This project was supported by an Undergraduate Research Grant from Northwestern University.