EFFECTS OF MODALITY AND LINGUISTIC MATERIALS ON MEMORY

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1 Introduction

Audiologists can test memory with auditory or visual stimuli. On the one hand, auditory factors such as the level of presentation or the signal-to-noise ratio can affect recall [1,2]. Visual tests can be useful for measuring memory because they are not vulnerable to the effects of hearing loss. On the other hand, auditory speech tests may be more ecologically relevant for audiological rehabilitation than reading working memory measures because speech understanding involves auditory and cognitive processing [3]. In addition, a test that yields a wider range of scores may be more useful to audiologists because there is greater potential for distinguishing the abilities of listeners. In a previous study, a listening memory test using words yielded a greater range of working memory scores than a test based on reading sentences [3]. However, because the linguistic properties of the materials were not matched across tests, the difference in the range of scores could be attributed to either modality or linguistic factors.

In the current study, we compared auditory and visual tests with matched word-level and sentence-level materials in order to tease apart the effects of modality and linguistic factors on recall scores. The results of the present study will inform the ongoing design of clinically feasible tests of working memory for use in audiology.

2 Method

2.1 Participants

Participants were 32 young adults (27 female, 5 male) in good or excellent health, who were native English speakers (mean age = 19.9 years, *SD* = 1.8, range 18-26) and had at least some post-secondary education (mean years of education = 14.1, *SD* = 1.3). All participants had normal hearing thresholds (≤ 25 dB HL) from 250-8000 Hz, except for two participants who had thresholds of 30 dB HL at 8000 Hz in the left ear.

2.2 Materials

The complex auditory and visual stimuli were sentences taken from the Revised Speech Perception in Noise (R-SPIN) Test materials [4]. The simple auditory and visual stimuli were taken from the Word Auditory Recognition and Recall Measure (WARRM) materials [5].

2.3 Procedures

Participants completed each of the four tests (2 modalities x 2 linguistic levels): simple (word-level materials) auditory, complex (sentence-level materials) auditory, simple reading, complex reading. In simple conditions, participants repeated a target word introduced by a carrier phrase. In complex conditions, every target word was introduced by a different sentence. All auditory conditions were completed in quiet. The order of conditions was counter-balanced. In each test, 100 items were presented, with five trials in each of five setsizes (2, 3, 4, 5, 6). The number of words correctly recognized, judged and recalled was measured (similar to the protocol of Daneman & Carpenter [6,7]).

3 Results

There was a significant main effect of linguistic complexity ($F(1,31) = 81.0$, $p < .001$, ηp2 = .72), with higher recall for words than sentences. There was also a main effect of modality ($F(1,31) = 57.1$, $p < .001$, ηp2 = .65), with higher recall for auditory than visual stimuli. In addition, there was a main effect of setsize, ($F(4,124) = 336.5$, p <.001, ηp2 = .92), with recall decreasing with increasing setsize. There were significant interactions between linguistic complexity and setsize ($F(4,124) = 9.3$, $p < .001$, ηp2 = .23) and modality and setsize ($F(4, 124) = 14.4$, $p < .001$, ηp2 = .32). As setsize increased, the differences in recall due to complexity and modality became more pronounced (see Figure 1). There was no three-way interaction. We conducted a Bonferroni post-hoc, corrected for multiple comparisons. Recall scores in all setsizes were significantly different from each other. Collapsed across modality, recall was better for word-level than sentence-level materials by 8.1%. Collapsed across linguistic complexity, recall was better for auditory than for visual materials by 9.1%.

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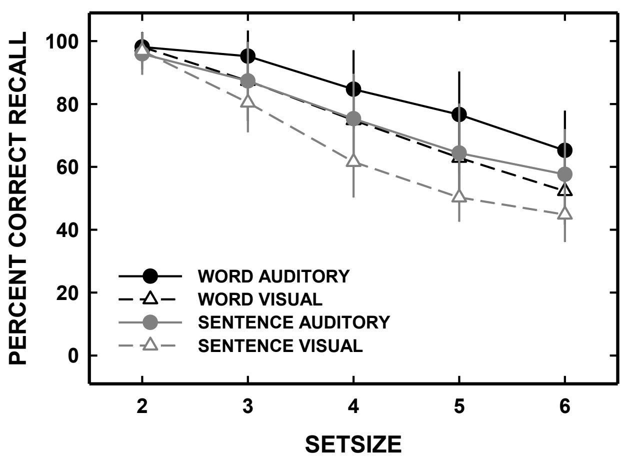

Figure 1: Percent correct recall by setsize for target words in word-level and sentence-level materials during listening and reading tests. Error bars represent SDs.

Using the total scores, recall was better for word- than for sentence-level materials by 8.9% and recall was better for auditory than for visual materials by 10.8%. There was a significant main effect of linguistic complexity ($F(1,31) = 83.1$, $p < .001$, ηp2 = .73) and modality ($F(1,31) = 67.2$, p <.001, ηp2 = .68), but no significant interaction (see Figure 2).

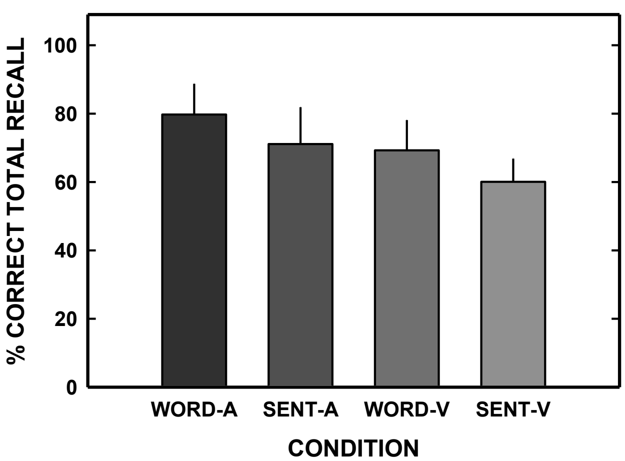

Figure 2: Percent correct total recall for target words in word-level and sentence-level materials during listening and reading tests. Error bars represent SDs.

4 Discussion

Our results clarify the findings of Smith and Pichora-Fuller (2015) by showing that auditory stimuli are easier to recall than visual stimuli even when the linguistic complexity of the stimuli is controlled. Ruchkin et al. [8] suggested auditory recall is easier than visual recall because spoken stimuli have direct access to the phonological loop and therefore may require fewer cognitive resources to process than visually-presented read stimuli, thus facilitating recall. Another interpretation is that reading is cognitively more demanding than listening.

There was a significant correlation between modalities for the sentence-level conditions ($r = .39$, $p = .03$), and a stronger correlation for word-level materials ($r = .58$, $p < .001$). Possibly the lexical cues are more common across modalities, whereas the modality-specific aspects of more complex sentence-level processing differ to a greater extent. As in the previous study, the range of scores was greater for the easiest test of listening to words than for the hardest test of reading sentences; however, both modality and linguistic complexity contributed to the range in scores.

5 Conclusion

These findings may or may not apply to older individuals or people with hearing loss or vision loss. Further research will have to be conducted in order to generalize these findings.

Future research also could explore if the listening memory test is sensitive to intra-individual differences in performance to varying listening condition (e.g., listening is aided vs. unaided or in quiet vs. in noise).

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