Retrieval interference in the processing of RCs: Evidence from the visual-world paradigm

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Although a large literature demonstrates that object-relative clauses (ORCs) are harder to process than subject-relative clauses (SRCs) (see Table 1, Example 1), there is less agreement regarding where during processing this difficulty emerges, as well as how best to account for these effects. Explanatory frameworks that focus on the role of memory retrieval conceptualize the ORC-SRC asymmetry as resulting from the memory demands associated with processing ORCs as compared to SRCs. In contrast, experience-based accounts argue that the asymmetry reflects the fact that ORCs are less frequent than SRCs. Although both accounts may to some extent explain the mechanisms underlying RC processing, the two make very different predictions regarding the matrix verb: whereas memory-based accounts tend to predict processing differences to emerge at the matrix verb, experience-based accounts do not.

Several studies have found robust ORC-SRC effects at the matrix verb (e.g., Gordon et al., 2006; King & Just, 1991; Lowder & Gordon, 2012), but others have not (e.g., Staub, 2010), or have failed to find these effects when a prepositional phrase (PP) intervenes between the RC and the matrix verb (Staub et al., 2017). Notably, the vast majority of previous experiments on the processing of RCs have been conducted in the written domain relying on self-paced reading or eyetracking during reading. In contrast, there is very little work on RC processing in the spoken domain (cf. Kowalski & Huang, 2017), and we are not aware of any previous research that has carefully examined ORC-SRC differences at the matrix verb when sentences are presented aurally. Accordingly, the current visual-world eyetracking experiment was designed to test whether ORC-SRC differences would emerge at the matrix verb during spoken sentence processing. Memory-based accounts posit that the matrix verb cues the comprehender to retrieve the matrix subject (NP1) from memory; crucially, this process is predicted to be easier for SRCs than for ORCs because the embedded noun (NP2) in ORCs creates interference, as it must serve as the subject of the embedded verb. In contrast, experience-based accounts predict processing differences early in the RC and predict no differences at the matrix verb once the word orders of the two sentences are again identical.

Participants (n = 40) listened to sentences containing ORCs and SRCs in which the order of the two noun phrases (NPs) was counterbalanced across lists (see Table 1, Example 2). The visual display consisted of four pictures representing the two NPs (e.g., a cat and a dog) and two unrelated distractors (e.g., a plant and a towel). A PP always intervened between the RC and the matrix verb. This was important to ensure that any processing differences observed at the matrix verb could not be attributed to spillover from the RC. There were 40 sets of critical items, counterbalanced across four lists and mixed with 64 filler trials that did not contain RCs. A written true-or-false comprehension question followed each trial.

Accuracy on the comprehension questions was significantly worse for sentences containing ORCs (M = 82%) than for sentences containing SRCs (M = 91%), $p < .001$, replicating a pattern that has been obtained in many previous reading studies. Fixation plots for the two sentence types are presented in Figure 1. Participants tended to look at NP1 followed by NP2 while listening to the RC (analysis of this region is complicated by the different word orders), with fixations to these two images returning to equal levels during the PP. Crucially, at the matrix verb, the preference to fixate NP1 versus NP2 was larger in the SRC condition than the ORC condition. This observation was confirmed by statistical analyses that tested the magnitude of this preference over 200-ms time bins. The difference was significant beginning at 1400 ms after onset of the matrix verb and lasted until 2200 ms after onset of the matrix verb.

These results are most readily explained under a memory-retrieval account of RC processing; that is, retrieval of the matrix subject (i.e., NP1) was easier with less interference from NP2 in the SRC than the ORC sentences. The findings also highlight the visual-world paradigm as a useful approach for studying the processing of complex syntactic structures.

Table 1. Example sentences.

Example 1
The reporter that attacked the senator admitted the error. (SRC) The reporter that the senator attacked admitted the error. (ORC)
Example 2
The cat that watched the dog in the living room jumped onto the couch. (SRC, Order1) The cat that the dog watched in the living room jumped onto the couch. (ORC, Order1) The dog that watched the cat in the living room jumped onto the couch. (SRC, Order2) The dog that the cat watched in the living room jumped onto the couch. (ORC, Order2)

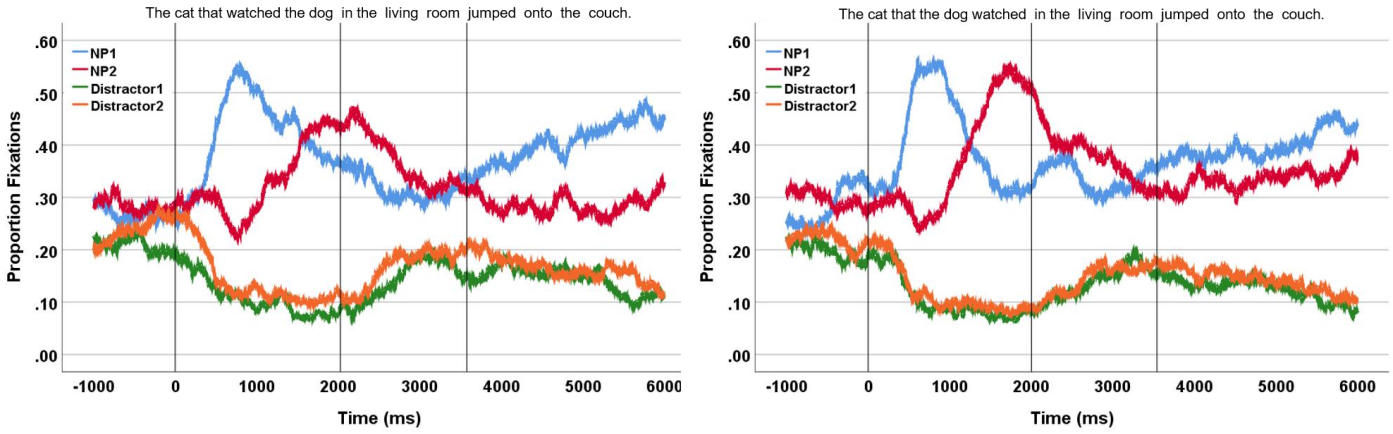

Figure 1. Fixation plots for sentences containing SRCs (left) and ORCs (right). The first vertical line (at time 0) marks the onset of the first noun (e.g., “cat”). The second vertical line represents the mean onset of the prepositional phrase. The third vertical line represents the mean onset of the matrix verb.

References

Gordon, P. C., Hendrick, R., Johnson, M., & Lee, Y. (2006). Similarity-based interference during language comprehension: Evidence from eye tracking during reading. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 32*, 1304-1321.

King, J., & Just, M. A. (1991). Individual differences in syntactic processing: The role of working memory. *Journal of Memory and Language, 30*, 580-602.

Kowalski, A., & Huang, Y. (2017). Predicting and priming thematic roles: Flexible use of verbal and nonverbal cues during relative clause comprehension. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 43*, 1341-1351.

Lowder, M. W., & Gordon, P. C. (2012). The pistol that injured the cowboy: Difficulty with inanimate subject-verb integration is reduced by structural separation. *Journal of Memory and Language, 66*, 819-832.

Staub, A. (2010). Eye movements and processing difficulty in object relative clauses. *Cognition, 116*, 71-86.

Staub, A., Dillon, B., & Clifton, C., Jr. (2017). The matrix verb as a source of comprehension difficulty in object relative sentences. *Cognitive Science, 41*, 1353-1376.