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Similarity-Based Interference During Language Comprehension: Evidence from Eye Tracking During Reading

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The nature of working memory operation during complex sentence comprehension was studied by means of eye-tracking methodology. Readers had difficulty when the syntax of a sentence required them to hold 2 similar noun phrases (NPs) in working memory before syntactically and semantically integrating either of the NPs with a verb. In sentence structures that placed these NPs at the same linear distances from one another but allowed integration with a verb for 1 of the NPs, the comprehension difficulty was not seen. These results are interpreted as indicating that similarity-based interference occurs online during the comprehension of complex sentences and that the degree of memory accessibility conventionally associated with different types of NPs does not have a strong effect on sentence processing.

Keywords: language, comprehension, memory, parsing, interference

The challenges that people face in trying to understand complex sentences have provided a very fruitful way of understanding the nature of the working memory processes that are used during language comprehension. Beginning with Miller and Chomsky (1963), there has been substantial agreement that embedded syntactic structures, which are effectively unambiguous, can be difficult to impossible to understand because of the need to keep track of multiple noun phrases (NPs) before those NPs can be integrated syntactically or semantically with other expressions in a sentence. Although memory constraints have not universally been seen as the cause of these sentence complexity effects (e.g., MacDonald & Christiansen, 2002; MacWhinney, 1977), most recent analyses have agreed that there is solid evidence indicating that memory constraints contribute strongly to the processing difficulty observed for complex sentences (Caplan & Waters, 1999; Gibson, 1998; Gordon, Hendrick, & Johnson, 2001; Just & Carpenter, 1992; Just & Varma, 2002; Lewis, 1999; Warren & Gibson, 2002). That evidence has been used to support different theories of the interaction of language processing and memory limitations during language comprehension.

In previous work (Gordon et al. 2001; Gordon, Hendrick, & Johnson, 2004; Gordon, Hendrick, & Levine, 2002), we have argued that a critical limitation of language processing is the susceptibility of memory representations to similarity-based interference while these representations are active in working memory. This research has focused on how the difficulty of understanding complex sentences depends on the types of NPs they contain (Bever, 1974). Our theoretical emphasis on similarity-based interference contrasts with the emphasis of Gibson and Warren (Gibson, 1998; Warren & Gibson, 2002) on the information status of NPs in complex sentences. The empirical basis for our theoretical position and for a great deal of other research on complex sentences (e.g., King & Just, 1991; Wanner & Maratsos, 1978) has come from tasks that contrast subject-extracted constructions such as the relative clause (RC) in Sentence 1 and the cleft in Sentence 2 with their object-extracted counterparts in Sentences 3 and 4. In these examples, we have underscored positions from which NPs have been extracted.

1. The lawyer that ___ criticized the doctor has an office on First Avenue.
2. It was the lawyer that ___ criticized the doctor.
3. The lawyer that the doctor criticized ___has an office on First Avenue.
4. It was the lawyer that the doctor criticized ___.

Sentences that have extracted objects, such as Sentences 3 and 4, pose greater comprehension difficulty than do their counterparts, such as Sentences 1 and 2, which have extracted subjects. During the reading of sentences with extracted objects, two NPs must be stored in working memory temporarily before either of them can be syntactically and semantically integrated with a verb. When the verbs do appear, the correct NPs (or referents) must be retrieved and assigned to their proper syntactic and semantic roles in relation to the verbs. In contrast, subject-extracted structures (and canonical subject–verb–object structures) never create a situation in which two unintegrated NPs must be held in working memory before a verb is encountered. This difference in memory storage and retrieval demands is, in one way or another, central to memory-based accounts of the difficulty in understanding sentences with complex embeddings.

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The central thesis of our similarity-based interference model is that this difference in the demands on memory storage and retrieval is greatly increased when the two unintegrated NPs that are temporarily stored in object-extracted constructions have similar representations. As discussed in Gordon et al. (2002), a range of well-established findings about human memory support the idea that the ease of memory retrieval (speed and/or accuracy) is reduced when the available memory traces are similar. In sentences containing RCs, the gap indicating the locus of the extracted phrase is an indication that an NP must be retrieved from memory to fill a syntactic and/or semantic requirement of the associated verb. This characterization of similarity-based interference differs from the formulation developed by Lewis (1996), which seeks to explain why sentences cannot be understood when they have more than one or two central embeddings. Lewis (1996) postulates a very limited memory capacity (two or maybe three) for simultaneously keeping track of syntactic dependencies. He explicitly notes that his model does not offer a mechanism that explains why the ease of understanding doubly embedded sentences is influenced by the types of NPs they contain.

Direct support for the operation of similarity-based interference during language comprehension comes from studies of how the mix of NPs in object-extracted and subject-extracted structures (RCs and clefts) affects the object–subject difference with respect to ease of processing. For example, in an examination of cleft sentences such as Sentences 5 and 6, we manipulated whether the logical subject and object were proper names or definite descriptions (Gordon et al., 2001; see also Warren & Gibson, 2005).

5. It was the barber/John that saw the lawyer/Bill in the parking lot.

6. It was the barber/John that the lawyer/Bill saw in the parking lot.

The results showed the usual object–subject difference: object extractions like Sentence 6 led to higher error rates in comprehension and longer reading times than did subject extractions. In addition, the study presented two other significant findings. First, performance suffered more when the two critical NPs were matched in type (two descriptions, e.g., *barber* and *lawyer*, or two names, e.g., *John* and *Bill*) than when they were unmatched (one name and one description). Second, the object–subject difference was more pronounced with matched NPs. These two findings provide evidence for the view that similarity of NP types in memory representations is a significant factor mediating the standard observation that structures with object extractions are more difficult than their corresponding subject-extracted structures.

Additional evidence comes from a memory-load experiment in which individuals were required to remember a list of words while performing a sentence processing task (Gordon et al., 2002). The similarity of the NP types in the memory load and the critical NP types in the sentence were manipulated, as was sentence complexity (object extracted vs. subject extracted). The results showed a significant interaction of matched versus unmatched NP type and sentence complexity, as evidenced by poorer performance on comprehension questions related to the material in the sentence processing task when the items in the memory loads matched the critical NPs of the sentences.

Attempts to understand the dimensions of similarity that create interference have developed from Bever's (1974) examples of how a mixture of descriptions and different types of pronouns influences sentence complexity. Subsequent research has focused on names as well (Gibson, 1998; Gordon et al., 2001; Warren & Gibson, 2002), with the findings of Gordon et al. (2001, 2002) providing evidence that it was the similarity of the NPs that affected complexity rather than inherent characteristics of the NPs (cf. Gibson, 1998; Warren & Gibson, 2002). Gordon et al. (2004) varied a number of characteristics of NPs in an attempt to understand the dimensions of similarity that create interference when comprehending an object-extracted construction with two descriptive NPs. They found that interference in the comprehension of object-extracted RCs containing two descriptive NPs occurred regardless of whether one of the NPs differed from the other in number (singular vs. plural) or definiteness (definite vs. indefinite and definite vs. generic). In reviewing the differences in similarity between NPs that had been shown to reduce the difficulty of comprehending complex sentences, Gordon et al. (2004) concluded that the only single dimension that could explain the pattern of results was the common noun status of the two critical NPs. Two NPs were dissimilar if one contained a common noun and the other did not. This generalization suggests that the critical dimension of similarity is referential, with the predication of the common noun achieving reference in a manner that is psychologically distinct and more complex than the more direct reference given by names and pronouns (Heim & Kratzer, 1998; Kamp & Reyle, 1993).

Of course, it is possible that multiple dimensions of similarity between NPs affect the ease of understanding complex sentences and that some of those dimensions are correlated with the common noun–noncommon noun dimension discussed by Gordon et al. (2004). Acheson and MacDonald (2005) presented evidence that the phonological similarity of expressions in a complex sentence influenced ease of comprehension. Van Dyke and McElree (2006) showed greater interference from a memory load when it contained words that were plausible arguments for a verb with an extracted NP. These two examples suggest that multiple dimensions of similarity between NPs may contribute to memory interference during the processing of sentences; determining what those dimensions may be is an active area of research.

Here, we focus on the established difference in similarity between descriptions and names, seeking answers to four questions related to how language and memory interact during the comprehension of complex sentences. First, does similarity-based interference occur online during the initial interpretation of NPs as arguments of verbs. Second, under what, if any, circumstances does similarity-based interference affect sentence processing after readers have had the opportunity to interpret NPs as arguments of verbs? Third, does linear proximity between NPs contribute to similarity-based interference? Finally, does the effect of type of NP on ease of sentence comprehension in English occur because type of NP is typically a good cue about what information is accessible to speakers and hearers from memory? These questions are addressed in three experiments that use eye tracking during the reading of sentences with embedded clauses and also of simple sentences.

Experiment 1

In this experiment, subjects read sentences containing RCs while their eye movements were recorded. Both subject-extracted and object-extracted RCs were used as stimuli, and the NP in the RC could either be a description or a name. Thus, there were four types of experimental sentences as shown below in Sentences 7 and 8:

7. The banker that praised the barber/Sophie climbed the mountain just outside of town.

8. The banker that the barber/Sophie praised climbed the mountain just outside of town.

Our previous work (Gordon et al., 2001) showed that the object–subject difference, as measured by both self-paced reading time and question-answering accuracy, is reduced when the NP embedded in the RC is a name as compared to when it is a description (and the NP that is the subject of the sentence is a description). By using eye tracking to study this effect, the current experiment overcomes limitations of the methods we (Gordon et al., 2001, 2002, 2004) and others (Bever, 1974; Gibson, 1998; Warren & Gibson, 2002) used to measure the online effects of NP type on sentence complexity.

Judgments of acceptability (Bever, 1974) and ratings of ease of understanding (Warren & Gibson, 2002) are metalinguistic tasks. Although potentially informative about language processing, they clearly are not online measures of the sort that are generally considered to provide information about language processing as it occurs. Correctly answering a question about a sentence (Gordon et al., 2001, 2002, 2004; Warren & Gibson, 2002) is a performance measure that indicates that the sentence must have been successfully processed, but if a question is not answered correctly, it is possible that factors operative after online processing, such as forgetting, are responsible for the mistake.

Self-paced reading time methodology (Gordon et al., 2001, 2002, 2004; Warren & Gibson, 2002) provides a measure of processing as it occurs, but it results in slower-than-normal reading times. This slower-than-normal reading limits the methodology's usefulness for understanding the time course of processing, a limit that is compounded by the inability of readers in a self-paced reading task to look back at earlier words. This inability to look back also heightens the memory demands of comprehension beyond what is required in normal reading, a consequence of particular concern in studies that focus on the nature of memory in language processing. In contrast, eye-tracking methodology provides a measure of processing as it occurs during normal reading and has been successfully exploited to study many issues in language processing (Rayner, 1998).

The current use of eye tracking provides evidence about whether similarity-based interference occurs online during the initial interpretation of NPs as verbal arguments and therefore is not solely a postinterpretive process. In addition, determining the locus of such an online interference effect could provide important information about the nature of memory interference during sentence processing. In memory research, interference is generally characterized as a phenomenon that occurs during memory retrieval. During the processing of complex sentences, memory retrieval would be expected to occur at the verbs because this is where it first becomes necessary to retrieve NPs from memory to fill syntactic/semantic roles.

Method

Participants. Thirty-six students at the University of North Carolina at Chapel Hill served as participants in the experiment. They were native English speakers and received credit for an introductory psychology course for their participation. All had normal or corrected-to-normal vision.

Materials. Each run of the experiment presented 24 experimental sentences and 44 filler sentences to a participant. Other than changes to the NPs, the sentences were the same as those used in Gordon et al. (2001). Half of the experimental sentences contained an object RC, and the other half contained a subject RC. The subject of the sentence, which was also the NP that the RC modified, was always a definite description (e.g., *the clerk*, *the editor*, *the conductor*). Half of the NPs embedded in the RC were definite descriptions, and the other half were names. Thus, the sentences that contained subject RCs were similar to Sentence 7, and the sentences that contained object RCs were similar to Sentence 8. The sentences that contained two descriptions were designed so that the plausibility of either of the descriptions being the agent or patient of the critical verbs of the sentence was equal. In additionally, this characteristic of the stimuli was tested by having participants perform plausibility ratings on the forms used in this experiment and on forms created by reversing the positions of the descriptions in the sentence, and it was found that the stimuli did not show plausibility biases for certain descriptions performing the actions specified by the verbs (see Gordon et al., 2004). The names varied in length from five to nine characters so that they would be comparable in length to the definite descriptions. The conditions of RC type and NP type were combined so that there were four experimental conditions (object/description, subject/description, object/name, subject/name). Appendix A shows the stimuli in their object-extracted form. After the presentation of each sentence, a comprehension question related to the content of the sentence was presented to the participant. For the experimental stimuli, two thirds of the comprehension questions referred to the actions described by the verb embedded in the RC, and one third referred to the action described by the matrix verb. Half of the comprehension questions were true and half were false. The filler sentences conveyed complex ideas but did not contain RCs.

Design and procedure. Four counterbalanced lists were created such that each experimental sentence appeared in only one condition in a list. Across lists, every experimental sentence occurred in all conditions (the four conditions were created by the combination of the factors of RC type and embedded NP type). Each experimental run consisted of four blocks. The first block contained 14 filler sentences. The next three blocks each contained 10 filler sentences and 8 experimental sentences. The order of presentation of sentences was randomized within each block. To end the presentation of each sentence, participants pressed the space bar when they were finished reading and comprehending the sentences. To end the presentation of each comprehension question, participants pressed either a key labeled for a *true* response or a key labeled for a *false* response once they had determined their answer.

Throughout the entire experimental run, each participant wore an Eye-Link system eye-tracking device that was manufactured by Sensorimotoric Instruments (Boston, MA). The eye tracker sampled pupil location at a rate of 250 Hz. In addition, the system parsed the samples into fixations and saccades. After undergoing a routine that calibrated the eye tracker, participants began the experimental run. The stimuli of the sentence were presented on a computer screen. Each trial began with the presentation of a fixation point on the screen at the location where the first word of the sentence would later be presented. The presentation of this fixation point served both to direct the gaze of the participant to the location of the beginning of the sentence and to maintain the calibration of the eye tracker. During the presentation of the fixation point, the experimenter used another computer to monitor the location of the direction of gaze of the participant. When the gaze of the participant was judged to be sufficiently steady on the fixation point the experimenter pressed a button that made the fixation point disappear and the sentence of the trial appear. After the participant read the sentence and pressing the spacebar to signify completion, the sentence disappeared and the comprehension question relating to that sentence appeared. Then, after the participant pressed the button corresponding to his or her answer, the trial ended, and the fixation point for the next trial appeared. During each trial, the experimenter could see the location of the fixation of the participant relative to the location of the words of the trial. If the calibration of the eye tracker appeared inadequate, the experimenter would recalibrate the eye tracker between trials.

Results

In this and in the subsequent experiments, we report multiple behavioral measures of sentence processing and comprehension. First, we report accuracy rates on the comprehension questions related to the information in the sentences. Next, and most relevant to the hypotheses at hand, we report certain online measures of processing of critical regions of the sentences. Specifically, we report gaze durations, right-bounded reading times, rereading times, first-pass regression ratios, and regression path reading times. Finally, we report the total fixation times on the noncritical regions, those that occur before and after the critical regions. Below, we describe these measures on the basis of the characterizations provided in a number of authoritative reviews (Inhoff & Radach, 1998; Liversedge, Paterson, & Pickering, 1998; Rayner, 1998; Rayner & Pollatsek, 2006).

Gaze duration refers to the sum of the durations of the initial fixations on a region, provided that no material downstream in the sentence has been viewed. The gaze duration on a region terminates when the gaze is first directed away from the region of interest (regardless of whether the subsequent fixation is progressive or regressive in relation to the region of interest).[1] *Right-bounded reading time* is similar to gaze duration except that the termination of right-bounded reading time does not occur until a region of the sentence progressive to the region of interest is fixated; the general reviews cited above do not discuss right-bounded reading time, but this measure has been used in a number of eye-tracking studies of reading (Calvo, 2001; Pickering, Traxler, & Crocker, 2000; Sturt & Lombardo, 2005; Traxler, Morris, & Seely, 2002).[2] *Rereading time* is computed by subtracting the gaze duration on the region from the total time spent fixating the region. *First-pass regression ratios* are the percentages of saccades from the word of interest following the reader's first pass through the material (as defined by the gaze duration measure) that are regressive. *Regression path duration* (also called *go-past duration*) is the sum of all fixations from the first fixation on the target word up to, but excluding, the first fixation downstream from the target word (if the word is skipped during first-pass reading, then the regression path duration is 0).

Comprehension question accuracy. The comprehension questions were designed to test whether participants had acquired a correct understanding of the relationship between the critical NPs and the verbs in the sentences. The proportions of correct responses to comprehension questions related to information in the sentences were as follows. For sentences using descriptions, the accuracy rates were .88 (SEM = .02) for objects and .86 (SEM = .02) for subjects. For sentences using names, the accuracy rates were .94 (SEM = .02) for objects and .94 (SEM = .02) for subjects. There was a main effect of NP type on comprehension question accuracy such that questions related to sentences with embedded names were answered more accurately (proportion correct = .94) than questions related to sentences with embedded descriptions (proportion correct = .87), $F_1(1, 35) = 17.86$, $MSE = 0.06$, $p < .001$, and $F_2(1, 23) = 5.89$, $MSE = 0.18$, $p < .025$. There was no effect of RC type on question accuracy, $F_1(1, 35) = 0.06$, $MSE = 0.08$, $p > .80$, and $F_2(1, 23) = 0.02$, $MSE = 0.29$, $p > .90$, and no interaction between RC type and NP type on question accuracy, $F_1(1, 35) = 0.61$, $MSE = 0.07$, $p > .43$, and $F_2(1, 23) = 0.19$, $MSE = 0.22$, $p > .66$.

Regions of interest. Our analyses focus on two regions: the RC and the matrix verb. We analyze the RC as a region, rather than as a series of individual words, because the NPs and verbs are in different positions in subject and object RCs. Analyzing the RC as a region means that the measures apply to the same words, only in a different order in the object and subject RCs. The matrix verb is identical across all conditions, therefore it can be analyzed on its own. In addition, the analysis of the matrix verb focuses on the regression path duration and regression ratio measures, rather than the measures of focus presented for the RC region. The measures of focus for the RC region reflect reading durations local to that region. In contrast, the measures of focus for the matrix verb reflect the more integrative processes that would be expected to occur upon the reader encountering the word that completes the integration of the critical noun–verb relationships in the sentence rather than measures that reflect only reading times on that region.

Analyses of the RC region. The RC region of the sentences in Experiment 1 consisted of all words after the complementizer *that* and before the matrix verb. Table 1 shows reading time measures for the RC region of the sentence. Gaze duration can be taken to be the measure of earliest processing of the region in our study. There was a main effect of NP type on gaze duration on the RC region, such that longer gaze durations (664 ms) were observed for sentences with embedded descriptions than for sentences with embedded names (530 ms), $F_1(1, 35) = 38.06$, $MSE = 74{,}084$, $p < .001$, and $F_2(1, 23) = 21.68$, $MSE = 121{,}554$, $p < .001$. There was no effect of RC type on gaze duration on the RC region, $F_1(1, 35) = 0.00$, $MSE = 144{,}250$, $p > .97$, and $F_2(1, 23) = 0.01$, $MSE = 109{,}026$, $p > .92$. There was a trend toward an interaction between NP type and RC type on the RC region, such that the

[1] *First-pass reading time* has been recommended as an alternative label for gaze duration when the region of interest is greater than a single word (Rayner & Pollatsek, 2006), though *gaze duration* is sometimes used for short multiword regions (Rayner, Warren, Juhasz, & Liversedge, 2004). However, because the present analyses use both single-word and multiword regions, we use the label *gaze duration* for both so as to avoid using different labels when the same measure is applied to different types of regions.

[2] Traxler et al. (2002) refer to the measure as "quasi-first pass reading time."

Table 1
Various Reading Time Measures for the Relative Clause (RC) Region in Experiment 1

Reading measure	RC type	NP2	Time (ms) *M*	Time (ms) *SEM*
Gaze duration	Object	Description	665	29
	Subject	Description	624	25
	Object	Name	508	20
	Subject	Name	552	22
Right-bounded reading[a]	Object	Description	907	29
	Subject	Description	741	24
	Object	Name	667	21
	Subject	Name	677	21
Rereading[a]	Object	Description	1,312	79
	Subject	Description	916	57
	Object	Name	874	51
	Subject	Name	751	53

Note. The RC region of the sentences was defined to be all words after the complementizer *that* and before the matrix verb (i.e., the embedded NP and the embedded verb). NP2 = second noun phrase.
[a] Significant interaction at the $\alpha = .05$ level.

object–subject difference was greater when the NPs were both descriptions, but it did not reach traditional significance levels, $F_1(1, 35) = 3.78$, $MSE = 105856$, $p > .06$, and $F_2(1, 23) = 2.20$, $MSE = 161438$, $p > .15$.

Right-bounded reading of a region can also be considered to be a relatively early measure of processing. There was a significant effect of RC type on right-bounded reading times on the RC region such that the right-bounded time of object RCs (786 ms) was longer than the right-bounded time of subject RCs (708 ms), $F_1(1, 35) = 13.20$, $MSE = 100{,}688$, $p < .002$, and $F_2(1, 23) = 15.68$, $MSE = 80{,}253$, $p < .002$. In addition, there was an effect of NP type on right-bounded reading times on the RC region. RCs with embedded descriptions were read more slowly (823 ms) than RCs with embedded names (672 ms), $F_1(1, 35) = 48.07$, $MSE = 105{,}431$, $p < .001$, and $F_2(1, 23) = 38.44$, $MSE = 122{,}133$, $p < .001$. Most important, there was a significant interaction between RC type and NP type with respect to right-bounded reading times of the RC region. The difference between object and subject RCs was larger for RCs with descriptions than for RCs with names, $F_1(1, 35) = 19.63$, $MSE = 88{,}086$, $p < .001$, and $F_2(1, 23) = 12.06$, $MSE = 129{,}251$, $p < .003$.[3]

Rereading time can be considered a relatively late measure of processing of a region. Object RCs were read more slowly (1,093 ms) than subject RCs (834 ms) during rereading of the RC region, $F_1(1, 35) = 20.90$, $MSE = 695{,}544$, $p < .001$, and $F_2(1, 23) = 10.51$, $MSE = 1{,}383{,}612$, $p < .005$. RCs with descriptions were read more slowly (1,114 ms) than RCs with names (813 ms) during rereading of the RC region, $F_1(1, 35) = 21.69$, $MSE = 905{,}576$, $p < .001$, and $F_2(1, 23) = 35.52$, $MSE = 552{,}987$, $p < .001$. Moreover, there was an interaction between RC type and NP type for the RC region such that the difference in rereading times for object and subject RCs was larger for RCs with descriptions than for those with names, $F_1(1, 35) = 4.30$, $MSE = 930{,}478$, $p < .05$, and $F_2(1, 23) = 8.58$, $MSE = 466{,}593$, $p < .009$.

Analyses of the matrix verb. Of the reading time measures used in the analysis of the RC region (gaze duration, right-bounded reading time, and rereading time), only rereading time showed any significant differences across experimental conditions for the matrix verb. Rereading times of the matrix verbs following object RCs were longer (356 ms) than rereading times of the matrix verbs following subject RCs (281 ms), $F_1(1, 35) = 7.92$, $MSE = 119{,}295$, $p < .01$, and $F_2(1, 23) = 8.38$, $MSE = 123{,}030$, $p < .01$. Other than that result, none of the measures that were used in the analysis of the RC region showed an effect of RC type, NP type, or an interaction between RC type and NP type for the matrix verb.

Table 2 shows the first-pass regression ratios for the matrix verb. For the matrix verb, there was a trend toward a main effect of RC type on regression ratios for the matrix verb such that more first-pass regressions were made for object RCs than for subject RCs (.29 for object RCs, .21 for subject RCs). This trend was significant by subjects but not by items, $F_1(1, 35) = 5.97$, $MSE = 0.16$, $p < .025$, and $F_2(1, 23) = 3.18$, $MSE = 0.29$, $p > .085$. There was no effect of NP type on first-pass regression ratios from the matrix verb, $F_1(1, 35) = 0.22$, $MSE = 0.16$, $p > .63$, and $F_2(1, 23) = 0.02$, $MSE = 0.18$, $p > .85$, and there was no interaction between RC type and NP type for first-pass regression ratios from the matrix verb, $F_1(1, 35) = 1.88$, $MSE = 0.21$, $p > .17$, and $F_2(1, 23) = 3.25$, $MSE = 0.25$ $p > .08$.

Table 2 also shows the regression path durations for the matrix verb of the sentence. Regression path durations from the matrix verb showed an effect of RC type such that they were longer for sentences with object RCs (597 ms) than for sentences with subject RCs (458 ms), $F_1(1, 35) = 8.54$, $MSE = 331{,}831$, $p < .007$, and $F_2(1, 23) = 10.18$, $MSE = 278{,}092$, $p < .005$. There was no effect of NP type on regression path durations from the matrix verb, $F_1(1, 35) = 0.12$, $MSE = 277{,}309$, $p > .72$, and $F_2(1, 23) = 0.09$, $MSE = 265{,}813$, $p > .77$, but RC type and NP type interacted such that the difference in regression path duration between object and subject RCs was smaller when the second NP was a name than when it was a description, $F_1(1, 35) = 9.24$, $MSE = 295{,}644$, $p < .005$, and $F_2(1, 23) = 8.57$, $MSE = 355{,}703$, $p < .009$.

Global measures of noncritical regions. Table 3 shows total fixation times for the sentence beginning (all words before the RC region) and the sentence end (all words after the matrix verb), regions that are not likely to show interesting effects but are examined to check the possibility of effects that conflict with those shown in other measures, a pattern that would suggest processing tradeoffs across regions. There was a main effect of RC type on total fixation time on the sentence beginning such that the beginnings of sentences with object RCs were read more slowly (1,399 ms) than the beginnings of sentences with subject RCs (1,223 ms), $F_1(1, 35) = 26.79$, $MSE = 245{,}981$, $p < .001$, and $F_2(1, 23) = 6.67$, $MSE = 1{,}012{,}861$, $p < .02$. There was no main effect of embedded NP type on time spent fixating the sentence beginning

[3] A parallel set of analyses was conducted in which reading time was adjusted by the length of the region (i.e., by dividing by the number of characters). Note that length is the same for object and subject RCs, though it differs for names and descriptions. Critically, length is not confounded with the Type of RC $\times$ Type of NP interaction. In any case, performing the analyses on adjusted reading time did not lead to meaningful changes in levels of statistical significance that would alter the characterization of the statistical significance of the effects discussed. Comparable analyses were performed on the next two experiments and also did not lead to meaningful changes in the results.

Table 2
First-Pass Regression Ratios and Regression Path Durations From the Matrix Verb in Experiment 1

	Desc-Object		Desc-Subject		Name-Object		Name-Subject	
Matrix verb	*M*	*SEM*	*M*	*SEM*	*M*	*SEM*	*M*	*SEM*
Regression path	641	54	396	19	511	67	526	40
Regression ratio	.32	.03	.17	.03	.26	.03	.25	.03

Note. Shown are the proportions of eye movements from the matrix verb that were regressive, rather than progressive. Also shown are the regression path durations from the matrix verb of the sentences. Desc = definite description.

and no interaction between RC type and embedded NP type on the total fixation time on the sentence beginning. In addition, there was no main effect on sentence end fixation time of RC type or embedded NP type and no interaction between RC type and embedded NP type with regard to fixation time on the sentence end. These results provide no suggestion of processing tradeoffs across regions.

Discussion

The results of the experiment show that object-extracted RCs are read more slowly than subject-extracted RCs. More important, the results show very clearly that the magnitude of this object–subject difference during the comprehension of an RC is reduced when the NP in the embedded clause is a name as compared with when it is a description. Two measures show this effect clearly: right-bounded reading of the RC and regression path duration on the matrix verb. These effects are observed during the initial period in which readers must represent the critical NPs and integrate them with the embedded and matrix verbs. As such, they provide clear evidence that the type of the embedded NP affects the interpretation of the sentential NPs in relation to the verb, as predicted by the similarity-based interference account. The finding that interference during initial reading occurs in close proximity to the embedded and matrix verbs is consistent with the idea that the similarity-based interference occurs at the time of memory retrieval, as has also been indicated by work manipulating memory load during self-paced reading (Van Dyke & McElree, 2006).

Table 3
Total Reading Times of Sentence Beginning and End in Experiment 1

		Sentence beginning		Sentence end	
RC type	NP2	*M*	*SEM*	*M*	*SEM*
Object	Description	1,433	60	1,712	75
Subject	Description	1,272	52	1,712	72
Object	Name	1,366	47	1,756	90
Subject	Name	1,172	47	1,689	76

Note. The total times spent reading noncritical regions are presented to show that spillover effects were not observed in this experiment. RC = relative clause; NP2 = second noun phrase.

In addition to the early effects on processing, this experiment showed a significant interaction between type of extraction and type of NP for rereading of the critical region of the sentence, a finding that shows that similarity-based interference may continue beyond the time when readers have acquired enough information from the sentence to interpret the NPs in relation to the verbs. Another finding of note is that no differences were observed in error rates for question answers either as a main effect of type of extraction or in the interaction of type of extraction with type of NP. This contrasts with our previous experiments, which have generally shown clear effects of these factors (Gordon et al., 2001, 2002, 2004). The absence of effects on errors suggests that the self-paced reading task, with its limitation on rereading earlier parts of a text, may indeed impose higher memory demands than normal reading and thus may impair comprehension.

Experiment 2

Experiment 1 showed that the sentence complexity effect, manifested in the object–subject difference, was strongly influenced by the similarity of the types of NPs in a sentence beginning in relatively early stages of processing and persisting through later stages of processing. Experiment 2 addresses two competing explanations of this finding: The first explanation is that interference due to the similarity of NPs occurs as a consequence of the memory retrieval of two unintegrated NPs. The retrieval of the unintegrated NPs must occur when the verbs with which they are to be integrated are encountered. It is possible that similarity-based interference occurs only when two or more unintegrated NPs are held in memory before either of them is integrated with a verb. According to this explanation, the integration of an NP with a verb precludes it from interfering with other NPs in memory. A test of this explanation can be made by asking whether similarity-based interference of two NPs is observable during the processing of simple sentences made up of single clauses in which the first NP can be integrated with a verb (e.g., assigned a syntactic and thematic role) before the second NP is encountered. If the integration of the first NP with a verb prevents it from interfering with another NP, then we would expect no similarity-based interference to occur in such simple sentences.

The second explanation is that linear proximity of two NPs is the basis for similarity-based interference. In object-extracted constructions the two critical NPs are separated by a single word, whereas in subject extracted constructions they are separated by two words, which raises the possibility that linear proximity could be a main source of the similarity-based interference. This explanation stands in contrast to the account that attributes the effect to the interaction between the types of NPs held in working memory and their integration with a verbal predicate. Double-object constructions, as shown in Sentence 9, make it possible to address these questions. In this type of construction, the critical NPs occur on opposite sides of the verb, making it possible to integrate one of the critical NPs with the verb before the other NP is encountered. In addition, the two critical NPs are separated by only a single word, allowing a test of whether linear proximity is responsible for the similarity effect.

The experiment used double-object constructions, as shown in Sentence 9. The type of NP for the subject and indirect object was varied between descriptions and names, yielding two types of matched NP sentences (description–description and name–name) and two types of nonmatched NP sentences (description–name and name–description). If similarity-based interference can occur in this type of sentence, then greater processing difficulty should be observed for the matched NP sentences than the nonmatched NP sentences, even though the two types of sentences manipulate NPs in exactly the same sentential positions. Moreover, if similarity-based interference is observed in this type of sentence, then the occurrence of such interference may be attributed to the linear proximity of the critical NPs, rather than to the state of integration with verbs of the NPs.

9. After the meeting the banker/Mark gave the manager/Brad the notebook in the hallway.

Method

Participants. Thirty-six students at University of North Carolina at Chapel Hill served as participants. They were native English speakers and received credit for an introductory psychology course for their participation. All had normal or corrected-to-normal vision.

Materials. Forty-eight experimental sentences and 58 filler sentences were created. Each experimental sentence had four versions created by the combination of NP type (description or name) for the first and second NPs. The experimental sentences are shown in Appendix 2. Thus, the sentences were similar to Sentence 9. After the presentation of each sentence, a comprehension question related to the content of the sentence was presented to the participant. The questions related to the experimental sentences asked about the relationship of the subject to its direct and indirect objects.

Design and procedure. Four counterbalanced lists were created such that each experimental sentence appeared in only one condition in a list. Across lists, every experimental sentence occurred in all conditions. There were 10 initial warm-up filler sentences followed by 48 experimental and 48 filler sentences. Besides the number of sentences presented, the procedure was identical to that of Experiment 1.

Results

The analyses and eye-tracking measures were identical to those of Experiment 1.

Comprehension question accuracy. The comprehension questions were designed to test whether participants had acquired a correct understanding of the relationship between the critical NPs and the verbs in the sentences. Proportions of correct responses to comprehension questions related to information in the sentences were as follows: For matched sentences, the accuracy rates were .91 (*SEM* = .01) for description–description NPs and .90 (*SEM* = .01) for name–name NPs. For nonmatched sentences, the accuracy rates were .91 (*SEM* = .01) for description–name NPs and .90 (*SEM* = .01) for name–description NPs. There were no significant differences for the accuracy rates across the NP type conditions.

Analyses of the critical regions. We defined three critical regions to test for the presence of similarity-based interference. The first critical region consisted of the subject and the verb, and the second critical region consisted of the verb and indirect object. These two regions each included a verb and an NP and in that way were analogous to the critical region in Experiment 1. A third critical region consisted of the subject, verb, and indirect object, thereby including all of the critical words in the double-object construction. The three regions overlap, and therefore analyses of these regions are not independent; their definitions were chosen to maximize the chance of finding similarity-based interference.

Table 4 shows reading time measures for the three critical regions of Experiment 2. For the first critical region (the subject and the verb), the early-reading measure of gaze duration was influenced by the type of the first NP (the subject of the sentence), such that this region was read more slowly if the first NP was a description (641 ms) than if it was a name (513 ms), $F_1(1, 35) = 55.74$, $MSE = 111{,}783$, $p < .001$, and $F_2(1, 47) = 60.69$, $MSE = 101{,}766$, $p < .001$. In addition, there was a preview effect such that gaze duration on this region was longer if the second NP (the indirect object) was a name (599 ms) than if it was a description (554 ms), $F_1(1, 35) = 9.99$, $MSE = 75{,}092$, $p < .01$, and $F_2(1, 47) = 6.42$, MSE, $= 114{,}169$, $p < .05$. However, there was no indication of an interaction of the first NP type with the second NP type on gaze duration, $F_1(1, 35) = 0.53$, $MSE = 60{,}260$, $p > .45$, and $F_2(1, 47) = 0.37$, $MSE = 70{,}353$, $p > .54$. The same pattern emerged for right-bounded reading time of the first critical region, with significant effects for the first NP type (711 ms for descriptions and 578 ms for names), $F_1(1, 35) = 54.06$, $MSE = 124{,}260$, $p < .001$, and $F_2(1, 47) = 58.29$, $MSE = 115{,}122$, $p < .001$, and for the second NP type (672 ms for names and 614 ms for descriptions), $F_1(1, 35) = 20.96$, $MSE = 67{,}686$, $p < .001$, and $F_2(1, 47) = 15.50$, $MSE = 91{,}630$, $p < .001$, but no significant interaction between the first and second NP types, $F_1(1, 35) = 0.66$, $MSE = 82{,}378$, $p > .42$, and $F_2(1, 47) = 0.93$, $MSE = 58{,}499$, $p > .33$. Rereading of the first critical region showed an effect only of first NP type, again, such that it was read more slowly when the first NP was a description (495 ms) than when it was a name (421 ms), $F_1(1, 35) = 9.14$, $MSE = 256{,}089$, $p < .01$, and $F_2(1, 47) = 10.03$, $MSE = 234{,}352$, $p < .01$. The type of the second NP had no effect on rereading of the first critical region, $F_1(1, 35) = 0.21$, $MSE = 169{,}541$, $p > .645$, and $F_2(1, 47) = 0.14$, $MSE = 252{,}547$, $p > .70$, and there was no interaction between first NP type and second NP type on rereading of the first critical region, $F_1(1, 35) = 1.81$, $MSE = 184{,}990$, $p > .18$, and $F_2(1, 47) = 1.16$, $MSE = 289{,}749$, $p > .28$. Analysis of the second critical region (the indirect object and the verb) revealed consistent effects of the type of the second NP (the indirect object), such that this region was read more slowly if the second NP was a description than if it was a name for gaze duration (672 ms for descriptions and 526 ms for names), $F_1(1, 35) = 87.94$, $MSE = 92{,}689$, $p < .001$, and $F_2(1, 47) = 49.53$, $MSE = 164{,}654$, $p < .001$; right-bounded reading time (727 ms for descriptions and 590 ms for names), $F_1(1, 35) = 96.19$, $MSE = 60{,}237$, $p < .001$, and F_2(1,

Table 4
Various Reading Time Measures of Critical Regions in Experiment 2

Match and sentence type	Subj + Verb		Subj + Verb + Iobj		Iobj + Verb	
	M	*SEM*	*M*	*SEM*	*M*	*SEM*
			Gaze duration			
Match						
Desc–desc	614	15	991	21	659	16
Name–name	531	14	766	17	521	13
Nonmatch						
Desc–name	667	18	891	20	530	18
Name–desc	494	16	872	21	684	14
			Right-bounded reading			
Match						
Desc–desc	669	16	1,117	23	710	17
Name–name	592	15	881	19	587	14
Nonmatch						
Desc–name	753	19	1,037	22	592	15
Name–desc	559	16	1,027	24	744	19
			Rereading			
Match						
Desc–desc	504	25	780	36	461	25
Name–name	439	22	570	28	369	19
Nonmatch						
Desc–name	485	25	625	31	316	19
Name–desc	402	19	701	30	471	25

Note. A definition of each critical region is given in the heading of each column containing reading time measures. Subj = subject; Iobj = indirect object; Desc = definite description.

47) = 37.50, *MSE* = 154,657, $p < .001$; and rereading time (466 ms for descriptions and 343 ms for names), $F_1(1, 35) = 21.00$, *MSE* = 313,983, $p < .001$, and $F_2(1, 47) = 27.61$, *MSE* = 238,521, $p < .001$. However, none of these measures of reading time was significantly influenced by the first NP type, and none of these measures revealed a significant interaction between the first NP type and the second NP type.

The analysis of the third region, which was designed to reveal a presence of NP type match effects in double-object constructions (the subject of the sentence, the verb, and the indirect object), also revealed consistent patterns across the different measures. This region was read more slowly when the first NP was a description than when it was a name for the measures of gaze duration (941 ms for descriptions and 819 ms for names), $F_1(1, 35) = 26.39$, *MSE* = 212,385, $p < .001$, and $F_2(1, 47) = 23.23$, *MSE* = 236,351, $p < .001$; right-bounded reading time (1,077 ms for descriptions and 954 ms for names), $F_1(1, 35) = 35.59$, *MSE* = 166,756, $p < .001$, and $F_2(1, 47) = 31.42$, *MSE* = 188,652, $p < .001$; and rereading time (703 ms for descriptions and 636 ms for names), $F_1(1, 35) = 6.28$, *MSE* = 310,291, $p < .05$, and $F_2(1, 47) = 4.08$, *MSE* = 480,160, $p < .05$. This region was also read more slowly when the second NP was a description than when it was a name for the measures of gaze duration (932 ms for descriptions and 829 ms for names), $F_1(1, 35) = 23.30$, *MSE* = 177,448, $p < .001$, and $F_2(1, 47) = 13.09$, *MSE* = 312,700, $p < .001$; right-bounded reading time (1,072 ms for descriptions and 959 ms for names), $F_1(1, 35) = 43.03$, *MSE* = 91,728, $p < .001$, and $F_2(1, 47) = 14.60$, *MSE* = 270,490, $p < .001$; and rereading time (741 ms for descriptions and 598 ms for names), $F_1(1, 35) = 14.44$, *MSE* = 611,518, $p < .001$, and $F_2(1, 47) = 15.98$, *MSE* = 552,184, $p < .001$. However, again, no interactions were observed between the first NP type and the second NP type for any of the reading time measures of the third critical region.

Table 5 shows the first-pass regression ratios and regression path durations from the second NP and direct object of the sentence. In both positions, there were significant effects of second NP such that descriptions showed longer regression path durations than names: second NP (503 ms for descriptions and 358 ms for names), $F_1(1, 35) = 32.12$, *MSE* = 196,120, $p < .001$, and $F_2(1, 47) = 43.60$, *MSE* = 174,706, $p < .001$; direct object (494 ms for descriptions and 445 ms for names), $F_1(1, 35) = 7.32$, *MSE* = 107,338, $p < .01$, and $F_2(1, 47) = 7.97$, *MSE* = 101,593, $p < .01$. There was also a main effect of second NP on regression ratios for the direct object such that more first-pass regressions were made for descriptions (.16) than for names (.12), $F_1(1, 35) = 6.88$, *MSE* = 0.09, $p < .05$; $F_2(1, 47) = 5.53$, *MSE* = 0.14, $p < .05$. No interactions between the first NP type and second NP type were found for either of these measures.

Global measures of noncritical regions. Table 6 shows mean total reading times for the beginnings and ends of sentences. There were no main effects of first NP type or second NP type and no interactions between first NP type and second NP type for both

Table 5
First-Pass Regression Ratios and Regression Path Durations From the Second Noun Phrase (NP) and Direct Object in Experiment 2

Region and reading measure	Desc–desc *M*	Desc–desc *SEM*	Name–name *M*	Name–name *SEM*	Desc–name *M*	Desc–name *SEM*	Name–desc *M*	Name–desc *SEM*
Second NP								
Regression path	500	22	357	18	358	23	505	20
Regression ratio	.14	.02	.16	.02	.11	.02	.16	.02
Direct object								
Regression path	501	26	429	19	461	22	486	22
Regression ratio	.16	.02	.10	.02	.13	.02	.16	.02

Note. Shown are the proportions of eye movements from the second NP and the direct object that were regressive, rather than progressive. Also shown are the regression path durations from the second NP and the direct object of the sentences. Desc = description.

total sentence beginning reading times and total sentence end reading times.

Discussion

The NP type manipulation had highly significant effects on all of our measures of reading times, with names being read more quickly than descriptions. This result may simply reflect the fact that the names in this study were shorter than the descriptions, or it may be a consequence of the different ways that names and descriptions achieve reference. More important, no reading time measures, whether reflecting early processing or later processing, showed a significant effect of whether the two critical NPs in the sentence were of the same type. Thus, the results provide no indication that similarity-based interference affected comprehension of the sentences, which stands in contrast to the highly reliable interaction of NP type and extraction type observed in Experiment 1. The absence of similarity-based interference in this experiment is not consistent with the idea that the greater linear proximity of the critical NPs in the object-extracted RCs as compared to the subject-extracted RCs in Experiment 1 was responsible for the significant interaction of NP type with RC type in that experiment. The NPs in the current experiment were separated by one word, as were the NPs in the object-extracted RCs used in Experiment 1. The results are instead consistent with an explanation of the effect of NP type that draws on the demands placed on the reader by the presence, at least temporarily, of multiple unintegrated NPs in memory.

Table 6
Total Reading Times of Sentence Beginning and Sentence End in Experiment 2

Match and sentence type	Sentence beginning *M*	Sentence beginning *SEM*	Sentence end *M*	Sentence end *SEM*
Match				
Desc–desc	890	18	1,463	25
Name–name	894	19	1,402	27
Nonmatch				
Desc–name	903	18	1,441	25
Name–desc	966	19	1,491	24

Note. The total times spent reading noncritical regions are presented to show that spillover effects were not observed in this experiment. Desc = definite description.

The absence in this experiment of a late effect of similarity-based interference sheds further light on the way in which the presence of such late effects in Experiment 1 should be interpreted. The late effects (i.e., effects on rereading) in Experiment 1 occurred after readers had acquired sufficient information to correctly interpret the NPs as verbal arguments, suggesting two possibilities: (a) Similarity-based interference results from incomplete interpretation of the noun–verb relations even after sufficient information for that interpretation has become available, or (b) the occurrence of similarity-based interference emerges after that interpretation has been successfully performed. The second of these two possibilities is not supported by the results of Experiment 2, because it predicts that similarity-based interference should have been observed in this experiment after the (relatively quick) interpretation of the NPs as verbal arguments.

Experiment 3

Together, Experiments 1 and 2 showed that the mix of NPs in a sentence had a greater impact on the comprehension of complex sentences than simple sentences and that linear proximity did not appear to be a potent factor in similarity-based interference. Instead, the effect of similarity-based interference seemed to be tied to the need to retrieve one of two NPs that are held in working memory in advance of their being integrated with a verbal predicate. The current experiment further investigates the strength of this account by examining the effect of NP type within an object-extracted RC that contains a ditransitive verb, as shown in Sentence 10.1. The use of ditransitive verbs in the RC allowed us to manipulate the types of NPs that occur both as the subject of the RC and as its indirect object. At one level, these manipulations allowed us to combine in a single type of sentence structure the manipulation of NPs that occured across sentences in Experiment 1. The examples in Sentences 10.1 through 10.3 illustrate this point. Again, we have used underscores to show the location in the RC sentences from which the NPs were extracted.

10.1. . . . the notebook that the banker/Mark gave (to) _______the manager/Brad contained . . .

10.2. . . . the lawyer that _______criticized the manager/ Brad had an office . . .

10.3. . . . the lawyer that the banker/Mark criticized _______had an office . . .

The experimental stimuli in the subject-extracted RCs (see Sentence 10.2) manipulate the type of NP that occurs as the object in the RC, whereas those in object-extracted RCs (see Sentence 10.3) manipulate the type of NP that occurs as the subject in the RC. By using ditransitive verbs, as in Sentence 10.1, the present experiment manipulated the types of NPs in both the subject and the indirect object position in the RC. This made it possible to test two alternative views concerning the basis of the interaction of NP type and type of RC extraction that we observed in Experiment 1 and previously (Gordon et al., 2001). These two views differ with respect to whether memory representations are responsible for the results of Experiment 1 or whether the results can be equally well explained by properties of linguistic representations, assumed by speakers and hearers, that influence the accessibility of these representations in memory.

The first view, which has been the focus of our research, is that object-extracted RCs are processed more easily with names than descriptions because of the memory demands of retaining and retrieving two adjacent NPs that are similar (two descriptions) prior to integration with a verbal predicate. No such difference is seen for subject-extracted RCs, because the two critical NPs are separated by the embedded verb, allowing integration of the first NP with the verb before second NP is encountered. As in the last experiment, this view predicts that there should be no interaction between type of NP and position of NP, because the manipulated NPs are separated by the embedded verb. Because the NP modified by the RC is the direct object of the ditransitive verb, and because NPs playing that role in ditransitive verbs are overwhelmingly inanimate, we did not expect similarity-based interference between the modified NP and the animate subject NP of the RC. Research by Traxler et al. (2002) and by Mak, Vonk, and Schriefers (2002) found that having an inanimate matrix NP modified by an RC containing an animate NP is very natural and facilitates the processing of object-extracted RCs.

The second view is that the interaction between NP type and extraction type derives from consideration of how known information, presumed to be accessible in memory, is packaged in linguistic representations. Restrictive RCs tend to include given (or familiar) information, as their semantic purpose is to help identify the NP that they modify, a fact that is born out by corpus studies (Fox & Thompson, 1990; Gordon & Hendrick, 2005). In the case of an object-extracted RC, the first NP that is overtly present in the RC is its subject. The subject of a clause, more so than an object, most frequently refers to given information (Givón, 1984; Prince, 1981), so on the basis of information packaging, subject NPs found in object-extracted RCs should refer to familiar or given information. There is less functional pressure for this preference in subject-extracted RCs because the logical subject of the RC is present as the head noun that is modified by the RC itself. Because the purpose of an RC is to explicitly provide the basis of familiarity or givenness of the noun it modifies, a subject modified by an RC will have less pressure to be familiar than a subject within an RC. On a variety of accounts, both linguistic and psycholinguistic, names are considered more likely to refer to given information or more accessible information than are descriptions (Garrod, Freudanthal, & Boyle, 1994; Warren & Gibson, 2002). Because information is packaged asymmetrically, with familiar information, such as names, being provided earlier in a sentence than less familiar information, an information packaging perspective predicts a greater advantage for names over descriptions in the subject position of an RC than in object position, a pattern that was found between different sentences in Experiment 1.

The current experiment manipulated NP match as in Experiment 2, but it did so in sentences such as Sentence 10.1, in which the direct object was extracted and used as the subject of a matrix clause. This NP was modified by an RC containing a ditransitive verb with the two animate NPs as its semantic arguments. In addition, we manipulated the presence of the preposition *to* to see whether this overt cue to the semantic role of the indirect object facilitated integration of sentence meanings. If the asymmetry between familiar and less familiar information was responsible for the greater ease of names than of descriptions in subject position of object-extracted RCs in Experiment 1, we would expect to see such a preference in the current experiment as well.

Method

Participants. Forty-eight students at University of North Carolina at Chapel Hill served as participants. They were native English speakers and received credit for an introductory psychology course for their participation. All had normal or corrected-to-normal vision.

Materials. Experimental sentences from Experiment 2 were adapted and modified. Forty-eight sentences with RC structures were created from the stimuli used in Experiment 2. Each sentence had the same four NP type combinations as those in Experiment 2. Thus, the sentences were similar to Sentence 10.1. In addition to the experimental items, 58 fillers were created. Twenty-four subjects saw sentences with prepositions before the indirect object, and 24 subjects saw sentences without the prepositions. As no significant reading time differences were found between the two preposition conditions, we merged the two sets of data and analyzed them together.

Design and procedure. Four counterbalanced lists were created such that each experimental sentence appeared in only one condition in a list. Across lists, every experimental sentence occurred in all conditions. There were 10 initial warm-up filler sentences followed by 48 experimental and 48 filler sentences. The procedure was identical to that of Experiments 1 and 2.

Results

The analyses and eye-tracking measures were identical to those of Experiments 1 and 2. The analyses showed no effects of the presence of the preposition, therefore we combined the data from the two versions of the experiment in order to maximize its power to show similarity-based interference.

Comprehension question accuracy. The comprehension questions were designed to test whether participants had acquired a correct understanding of the relationship between the critical NPs and the verbs in the sentences. Proportions of correct responses to comprehension questions related to information in the sentences were as follows. For matched sentences, the accuracy rates were

.91 (SEM = .02) for description–description NPs and .95 (SEM = .02) for name–name NPs. For nonmatched sentences, the accuracy rates were .93 (SEM = .01) for description–name NPs and .93 (SEM = .01) for name–description NPs. There were no significant differences for the accuracy rates across the NP type conditions.

Analyses of the critical regions. As in Experiment 2, three critical regions were defined. The first two were again designed to allow for direct comparisons with the results of Experiment 1. The first region was defined as the subject of the RC and the verb of the RC. The second region was defined as the verb of the RC and the indirect object of the RC. The third critical region was designed, as in Experiment 2, to allow for testing for the presence of similarity-based memory interference effect in object RCs with ditransitive verbs.

Table 7 shows reading time measures for the three critical regions of Experiment 3. The pattern of effects for the first critical region (the subject of the RC and the verb of the RC) was similar to that of the subject and verb region in Experiment 2. The measures of early reading showed main effects of both the first NP (the subject of the RC) type and the second NP (the indirect object of the RC) type. The gaze duration on the region was longer if the first NP was a description than if it was a name (548 ms for descriptions and 428 ms for names), $F_1(1, 47) = 48.16$, MSE = 111,897, $p < .001$, and $F_2(1, 47) = 84.61$, MSE = 86,830, $p < .001$, and if the second NP was a name than if it was a description (468 ms for descriptions and 505 ms for names), $F_1(1, 47) = 7.71$, MSE = 82,540, $p < .01$, and $F_2(1, 47) = 10.79$, MSE = 88,177, $p < .001$. This pattern was also observed for right-bounded reading times for the first NP (658 ms for descriptions and 540 ms for names), $F_1(1, 47) = 70.23$, MSE = 97,183, $p < .001$, and $F_2(1, 47) = 84.85$, MSE = 85,401, $p < .001$, and for the second NP (550 ms for descriptions and 602 ms for names), $F_1(1, 47) = 14.53$, MSE = 44,288, $p < .001$, and $F_2(1, 47) = 10.78$, MSE = 56,822, $p < .001$. No significant interactions between first NP type and second NP type were observed for either gaze duration or right-bounded reading time for the first critical region. Rereading times of the first critical region showed the same pattern of effects for the first NP type (619 ms for descriptions and 489 ms for names), $F_1(1, 47) = 33.29$, MSE = 306,181, $p < .001$, and $F_2(1, 47) = 33.02$, MSE = 345,891, $p < .001$, but there was no significant effect of second NP type on rereading times, and there was no significant interaction between first and second NP types on rereading times for this region.

The reading time results were quite consistent for the second critical region (the verb of the RC and the indirect object of the RC) across the different measures. None of the reading time measures for the second critical region showed an effect of the first NP on reading time. The second NP did have an impact on reading time measures of the second critical region, such that this region was read more slowly if the second NP was a description than if it was a name when it was analyzed by gaze duration (617 ms for descriptions and 506 ms for names), $F_1(1, 47) = 49.92$, MSE = 130,316, $p < .001$, and $F_2(1, 47) = 56.65$, MSE = 112,150, $p < .001$; right-bounded reading time (693 ms for descriptions and 572

Table 7
Various Reading Time Measures of Critical Regions in Experiment 3

Match and sentence type	Subj + Verb		Subj + Verb + Iobj		Iobj + verb	
	M	*SEM*	*M*	*SEM*	*M*	*SEM*
Gaze duration						
Match						
Desc–desc	530	11	826	17	613	12
Name–name	450	12	656	14	508	11
Nonmatch						
Desc–name	566	13	762	16	503	11
Name–desc	406	11	710	14	621	12
Right-bounded reading						
Match						
Desc–desc	641	13	1097	20	691	15
Name–name	531	10	834	15	572	13
Nonmatch						
Desc–name	674	13	979	17	572	15
Name–desc	459	10	902	17	694	12
Rereading						
Match						
Desc–desc	615	23	1162	37	713	25
Name–name	509	25	697	28	416	20
Nonmatch						
Desc–name	623	19	837	32	425	20
Name–desc	464	21	978	32	693	25

Note. A definition of each critical region is given in the heading of each column containing reading time measures. Subj. = subject; Iobj = indirect object; Desc = definite description.

ms for names), $F_1(1, 47) = 33.76$, $MSE = 107{,}223$, $p < .001$, and $F_2(1, 47) = 28.51$, $MSE = 125{,}116$, $p < .001$; and rereading time (703 ms for descriptions and 416 ms for names), $F_1(1, 47) = 104.87$, $MSE = 443{,}148$, $p < .001$, and $F_2(1, 47) = 93.71$, $MSE = 510{,}645$, $p < .001$. None of these measures showed an interaction between first NP type and second NP type on reading time of this region.

The analysis of the third region, which was designed to reveal a presence of NP type match effects in object RC constructions that contain a ditransitive verb (the subject of the sentence, the verb, and the indirect object), also revealed consistent patterns across the different measures. This region was read more slowly when the first NP was a description than when it was a name for gaze duration (794 ms for descriptions and 683 ms for names), $F_1(1, 47) = 26.66$, $MSE = 239{,}086$, $p < .001$, and $F_2(1, 47) = 32.46$, $MSE = 203{,}756$, $p < .001$; right-bounded reading time (1,038 ms for descriptions and 868 ms for names), $F_1(1, 47) = 52.51$, $MSE = 194{,}043$, $p < .001$, and $F_2(1, 47) = 81.69$, $MSE = 126{,}679$, $p < .001$; and rereading time (1,000 ms for descriptions and 878 ms for names), $F_1(1, 47) = 20.79$, $MSE = 791{,}738$, $p < .001$, and $F_2(1, 47) = 19.82$, $MSE = 901{,}421$, $p < .001$. This region was also read more slowly when the second NP was a description than when it was a name for gaze duration (768 ms for descriptions and 709 ms for names), $F_1(1, 47) = 6.59$, $MSE = 273{,}328$, $p < .05$, and $F_2(1, 47) = 7.09$, $MSE = 259{,}046$, $p < .05$; right-bounded reading time (1,000 ms for descriptions and 907 ms for names), $F_1(1, 47) = 24.88$, $MSE = 133{,}069$, $p < .001$, and $F_2(1, 47) = 22.25$, $MSE = 145{,}506$, $p < .001$; and rereading time (1,070 ms for descriptions and 767 ms for names), $F_1(1, 47) = 86.82$, $MSE = 635{,}738$, $p < .001$, and $F_2(1, 47) = 51.18$, $MSE = 1{,}136{,}440$, $p < .001$. However, again no interactions were observed between the first NP type and the second NP type for any of the reading time measures of the third critical region.

Table 8 shows the of first-pass regression ratios and regression path durations from the second NP and the matrix verb of the sentence. Descriptions showed longer regression path durations than names (494 ms for descriptions and 359 ms for names), $F_1(1, 47) = 35.06$, $MSE = 201{,}016$, $p < .001$, and $F_2(1, 47) = 48.80$, $MSE = 187{,}216$, $p < .001$, from the second NP, and descriptions showed more first-pass regressions from the second NP (.20 for descriptions and .14 for names), $F_1(1, 47) = 11.18$, $MSE = 0.19$, $p < .01$, and $F_2(1, 47) = 13.96$, $MSE = 0.16$, $p < .001$. No effects of first NP type and second NP type were found in the regression path durations and first-pass regression ratios for the matrix verb, and no interactions between the first and second NP types were found in either the second NP, $F_1(1, 48) = 0.00$, $MSE = 115{,}227$, $p > .97$, and $F_2(1, 47) = 0.00$, $MSE = 117{,}185$, $p > .98$, or the matrix verb, $F_1(1, 48) = 1.69$, $MSE = 182{,}498$, $p > .19$, and $F_2(1, 47) = 0.46$, $MSE = 112{,}711$, $p > .45$. The absence of an interaction between the types of the subject and indirect object NPs on the regression-path duration of the matrix verb differs greatly from Experiment 1, in which the types of the subject and object NPs had a strong impact on the reading times of sentences with object-extracted RCs.

Global measures of noncritical regions. Table 9 shows mean total reading times for the sentence beginnings and sentence ends. There were no main effects of first NP type or second NP type and no interactions between first NP type and second NP type for both total sentence beginning reading times and total sentence end reading times.

Discussion

The results of this experiment are very similar to those of Experiment 2, in which consistent main effects of NP type were observed, but no effects were observed of NP match–mismatch. These results contrast with those of Experiment 1, in which the mix of NPs interacted significantly with sentence structure. The lack of an interaction in this experiment is especially important, because in both this experiment and Experiment 1 the crucial NPs were embedded within an RC. The difference between the experiments is that the nature of the extractions in Experiment 1 created memory-retrieval demands triggered by the need to integrate NPs with a verbal predicate that were not present in this experiment.

Further, the absence in this experiment of an interaction between the types of the two NPs is not consistent with an account of Experiment 1 on the basis of information packaging, in which it is posited that the subject of an RC should refer to previously known information accessible in memory, but that this grounding function in memory is not well served by objects in the RC.

General Discussion

Together the three experiments show that similarity-based interference has highly reliable effects both early and late in pro-

Table 8
First-Pass Regression Ratios and Regression Path Durations From the Second Critical Noun Phrase (NP) and Matrix Verb in Experiment 3

Region and reading measure	Desc–desc		Name–name		Desc–name		Name–desc	
	M	*SEM*	*M*	*SEM*	*M*	*SEM*	*M*	*SEM*
Second NP								
Regression path	497	15	354	11	363	14	491	10
Regression ratio	.18	.02	.14	.02	.14	.01	.22	.02
Matrix verb								
Regression path	337	11	267	9	327	12	317	7
Regression ratio	.10	.02	.11	.02	.09	.02	.07	.02

Note. Shown are the proportions of eye movements from the second NP and the matrix verb that were regressive, rather than progressive. Also shown are the regression path durations from the second NP and the matrix verb of the sentences. Desc = definite decription.

Table 9
Total Reading Times of Sentence Beginning and Sentence End in Experiment 3

	Sentence beginning		Sentence end	
Match and sentence type	*M*	*SEM*	*M*	*SEM*
Match				
Desc–desc	3,002	77	1,119	36
Name–name	2,913	80	1,156	39
Nonmatch				
Desc–name	2,968	78	1,185	36
Name–desc	3,013	79	1,110	38

Note. The total times spent reading noncritical regions are presented to show that spillover effects were not observed in this experiment. Desc = definite description.

cessing when the critical NPs must be held together in memory before either is integrated with a verb but that the similarity of NPs has no effect when one of them can be integrated with a verb before the other enters memory, a finding that holds for NPs in simple sentences and within complex sentences consisting of object-extracted RCs. These results help answer four questions about the interaction of language processes and memory that we raised in the introduction: First, does similarity-based interference occur online during the initial interpretation of NPs as arguments of verbs? Second, under what circumstances does similarity-based interference affect sentence processing after the critical information about argument–verb relations has been seen? Third, can similarity-based interference be explained at least partially by linear proximity of NPs? And fourth, can the effect of NP type on ease of comprehension be explained at least partially by conventional assumptions about the relationship between types of NPs and the accessibility of information from memory?

Experiment 1 provides an answer to our first question, whether similarity-based interference occurs early in processing. It showed that the object–subject difference in reading RC sentences is reduced in relatively early processing when the critical NPs in the sentence are a description and a name as compared with when they are both descriptions. This pattern was seen in right-bounded reading time of the RC and in regression path duration for the matrix verb. These measures reflect reading times of the regions that provide the information necessary for interpreting the NPs as arguments of the verbs. This pattern of results is consistent with our previous results supporting the idea that interference of similar memory representations plays a major role in the robust object–subject asymmetry in RCs (Gordon et al., 2001, 2002, 2004) However, those previous results were obtained with self-paced reading methods that do not provide fine-grained evidence about the time course of sentence processing. The eye-tracking results of Experiment 1 show that similarity-based interference affects early stages of sentence processing.

Experiment 1 also provides evidence bearing on the second question, which concerns the persistence of similarity-based interference after information that is sufficient to determine the arguments of the verbs has been viewed. The interaction of sentence complexity and type of embedded NP was seen not only in measures of early processing, but also in measures of later processing (i.e., rereading). This pattern suggests either that similarity-based interference has effects even after the NPs have been interpreted as arguments of the verbs or that the interpretation process was not always complete even after all the relevant information had been seen. In Experiments 2 and 3, having matched versus nonmatched NP types had no effect on late (or indeed early) measures of processing. The structure of these sentences allowed easy interpretation of the NPs as arguments of the verbs, but the presence of similar NPs could be expected to influence sentence comprehension if similarity-based interference can occur between integrated representations of a sentence. The absence of such an effect in Experiments 2 and 3 suggests that the effects observed in measures of late processing for the RCs in Experiment 1 were due to an incomplete interpretation of the sentence at earlier stages of processing.

The contrast between the results of Experiment 1 and those of Experiments 2 and 3 is also relevant to our third question, whether linear proximity is a sufficient condition for the observation of similarity-based interference. In object-extracted constructions, the critical NPs are separated by a single word (the complementizer), whereas for the subject-extracted constructions, the NPs are separated by two words (the verb and the complementizer). This raises the possibility that the similarity-based interference effect is mediated by linear proximity rather than by the differing memory demands of the two types of constructions. In Experiments 2 and 3, the critical NPs were separated by a single word (a verb), but no similarity-based interference was observed. This shows that proximity in words of the NPs is not the critical factor, but rather it is the type of separating word that is important.

Finally, our fourth question was whether the results that we have interpreted as reflecting similarity-based interference might instead be explainable in part by information packaging considerations. Experiment 3 tested whether information packaging considerations, such as conventionalized assumptions about familiar NPs appearing early in a sentence as its subject, are sufficient to explain the results of Experiment 1. Whereas Experiment 1 found that in object-extracted RCs there was an advantage for names over descriptions as being the subjects of object-extracted RCs, Experiment 3 tested directly whether this preference was the result of the preference for asymmetrically coding familiar information, such as that provided by names, early in the subject of a clause. Experiment 3 found that the magnitude of differences in reading names and descriptions did not vary as a function of position in the sentence. This shows that conventionalized assumptions about the asymmetric coding of familiar information in names and descriptions in English are not responsible for the results found in Experiment 1.

In earlier works we attempted to focus attention on the important implications memory representations have for models of how language and working memory interact. This emphasis contrasts with approaches that emphasize limited memory capacity (Just & Carpenter, 1992; Lewis, 1999) or how NP types are associated with the accessibility of information from memory (Gibson, 1998; Warren & Gibson, 2002). Our emphasis on memory representations is supported by evidence that similarity-based interference, a process based in representational similarity, plays a role in language comprehension. The current results show that these representational effects operate early in the comprehension of sentences and that they are not observed in sentences in which similar NPs, though very close together within the sentence, need not be held together in memory before they can be interpreted as arguments of a verb.

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(*Appendixes follow*)

Appendix A

Stimuli From Experiment 1

The stimuli from Experiment 1 are shown below in their object-extracted forms. The stimuli were also presented in their subject-extracted forms.

1. The banker that the barber/Sophie praised climbed the mountain just outside of town before it snowed.
2. The dancer that the reporter/Angela phoned cooked the pork chops in their own juices on New Year's Eve.
3. The architect that the fireman/Wesley liked dominated the conversation while the game was on television.
4. The waiter that the broker/Janice despised drove the sports car home from work that evening.
5. The detective that the secretary/Trevor disliked clipped the coupons out with the dull scissors.
6. The judge that the doctor/Daniel ignored watched the special about Colombian drug dealers on the nightly news.
7. The robber that the mailman/Stephen insulted read the newspaper article about the fire.
8. The governor that the comedian/Kathryn admired answered the telephone in the fancy restaurant.
9. The actor that the director/Faith thanked worked in many hit movies before 1990.
10. The poet that the painter/Philip inspired wrote an autobiography after their friendship became well known.
11. The chef that the cashier/Justin distrusted called for help after the restaurant closed.
12. The aunt that the child/Kristen amused made paper dolls out of the newspaper.
13. The violinist that the conductor/Michael complimented performed at Carnegie Hall for two weeks.
14. The teacher that the student/Robert questioned wrote a long science fiction novel during the summer vacation.
15. The editor that the author/Jennifer recommended changed jobs after a new merger was announced.
16. The tailor that the customer/Pamela described worked in a small building near the bus station.
17. The admiral that the general/Jeremy advised reminisced nostalgically before the trip got underway.
18. The coach that the referee/Evelyn criticized talked publicly about the incident after the game.
19. The lawyer that the client/Kenneth interviewed had a very small office.
20. The plumber that the electrician/Joanne called drove a grey truck.
21. The salesman that the accountant/Jonathon contacted spoke very quickly.
22. The clown that the magician/Margaret entertained was a star.
23. The clerk that the traveler/Landon helped worked in a large foreign bank.
24. The gardener that the homeowner/Elizabeth envied was very friendly.

Appendix B

Stimuli From Experiment 2

1. After the meeting the banker/Mark gave the manager/Brad the notebook in the hallway.
2. In the mall the florist/Audrey did the tailor/Simone a favor by stopping a pickpocket.
3. Last winter the dancer/Mitch sold the reporter/Chuck a stereo at a yard sale.
4. Finally, the waitress/Tina told the customer/Judy the secret while nobody was listening.
5. At the party the doctor/Katie served the nurse/Alice an appetizer before the speeches began.
6. In a dark alleyway the agent/Steven offered the gangster/Harvey a pistol for two hundred dollars.
7. Yesterday the housewife/Doug showed the mailman/Kent a photograph of the grandchild.
8. In the car the detective/Teresa presented the secretary/Angela a package at the stoplight.
9. Before leaving the governor/Beth mailed the demonstrator/Anne a letter in a beige-colored envelope.
10. Suddenly, the actor/Allen sang the director/Kevin a song in the park while everyone looked on in surprise.

11. In the kitchen the poet/Howard made the painter/Dennis a snack out of celery sticks and peanut butter.

12. While working the chef/Sasha guaranteed the cashier/Carol a bonus for all the hard work.

13. Thoughtfully, the violinist/Rhonda grabbed the conductor/Debbie a soda at lunchtime.

14. Outside the schoolhouse the teacher/Hugh brought the student/Todd a note before the buses arrived.

15. From home the editor/Bruce faxed the author/Frank the documents with a number of comments.

16. In the middle of the night, the lieutenant/Kate ordered the general/Mary a sandwich from the diner on the corner.

17. As a favor, the magician/Emily purchased the stagehand/Julia an umbrella because it was raining.

18. This afternoon the plumber/Calvin asked the electrician/Philip the time when they met at the construction site.

19. One cold day the drummer/Eugene fixed the singer/Arnold a lunch with chicken noodle soup and crackers.

20. Hoping to make amends, the runner/Ramona left the cyclist/Alicia some candy on the kitchen table.

21. Before the party the ranger/Dawn built the botanist/Rhea a birdhouse as a birthday present.

22. Eagerly, the roofer/Eddie taught the boxer/Peter a lesson on managing money effectively.

23. Inside the locker room the quarterback/Thomas handed the kicker/Gordon the football after the game.

24. Patiently, the ballerina/Irena knitted the designer/Agnes a sweater using the finest wool available.

25. Early one morning the father/Pamela slid the daughter/Elaine the preserves at the breakfast table.

26. At lunchtime the deputy/Bill brewed the sheriff/Mike some tea in the break room.

27. Confidently, the landlord/Duane passed the tenant/Ralph the contract after the agreement was made.

28. Before the season began the photographer/Ruth secured the model/Gwen a place on the softball team.

29. Considerately, the pharmacist/Norma drew the researcher/Carla a map so there would be no problems getting around.

30. While doing the grocery shopping, the sailor/Justin saved the captain/Wilbur some money by taking the food directly to the ship's kitchen.

31. In the bank the sculptor/Neil paid the translator/Troy the money without first checking the math.

32. By accident, the zookeeper/Leslie sent the politician/Rachel a message that was intended for someone else.

33. Earlier, the driver/Edna poured the passenger/Lori some lemonade at the rest area.

34. While camping, the guide/Simon dug the climber/David a pit in which a fire could be made.

35. Ceremoniously, the intern/Edward awarded the assistant/Nathan a medal for his victory in the annual company race.

36. Beside the pier the surfer/Holly painted the fisherman/Betty a picture of the boats coming in from the sea.

37. Just before dinner the critic/Joanne fed the artist/Maggie the appetizers as a palate cleanser.

38. Once last year the philosopher/Ross loaned the historian/Sean a shirt to wear at a party.

39. On Saturday the plaintiff/Alvin emailed the defendant/Jerry the forms on the brand new computer.

40. Three years ago the writer/Jane bequeathed the publisher/Lynn a house as a token of their friendship.

41. After the blizzard the scientist/Renee sculpted the engineer/Faith a figure out of ice and snow.

42. For dessert, the employee/Andrew bought the president/Daniel a milkshake with whipped cream on top.

43. At the fair the clown/Greg flung the juggler/Tony a prize when the contest was over.

44. For security, the grocer/Denise opened the milkman/Sylvia an account at the local bank.

45. Anxiously, the broker/Rita reserved the investor/Mona a seat on the last train of the day.

46. During the intermission the judge/Larry promised the lawyer/Scott a drink after the trial.

47. Late Sunday night the executive/Trevor prepared the associate/Graham a report to give Monday morning.

48. Last week the psychologist/Vicky read the linguist/Edith a paper about the world of academia.

(*Appendixes continue*)

Appendix C

Stimuli From Experiment 3

1. After the meeting the notebook that the banker/Mark gave (to) the manager/Brad was in the hallway.
2. In the mall a favor that the florist/Audrey did (for) the tailor/Simone was stopping a pickpocket.
3. Last winter a stereo that the dancer/Mitch sold (to) the reporter/Chuck was at a yard sale.
4. Once everyone was gone, the secret that the waitress/Tina told (to) the customer/Judy was overheard by no one.
5. At the party an appetizer that the doctor/Katie served (to) the nurse/Alice was finished before the speeches began.
6. On the streets a pistol that the agent/Steven offered (to) the gangster/Harvey was worth two hundred dollars.
7. Yesterday a photograph that the housewife/Doug showed (to) the mailman/Kent was of the grandchild.
8. In the dark a package that the detective/Teresa presented (to) the secretary/Angela was small and mysterious.
9. Before being sent a letter that the governor/Beth mailed (to) the demonstrator/Anne was in a beige-colored envelope.
10. After the show a song that the actor/Allen sang (to) the director/Kevin was a surprise to everyone in the park.
11. In the kitchen a snack that the poet/Howard made (for) the painter/Dennis was out of celery sticks and peanut butter.
12. On payday a bonus that the chef/Sasha guaranteed (to) the cashier was for all the hard work.
13. Unfortunately a soda that the violinist/Rhonda grabbed (for) the conductor/Debbie was already flat.
14. Outside the schoolhouse, a note that the teacher/Hugh brought (to) the student/Todd was wet from the rain.
15. A week later, the documents that the editor/Bruce faxed (to) the author/Frank were with a number of comments.
16. Because it was late, a sandwich that the lieutenant/Kate ordered (for) the general/Mary was from the diner on the corner.
17. A favor from a friend, an umbrella that the magician/Emily purchased (for) the stagehand/Julia was for keeping the rain off.
18. Apparently the time that the plumber/ Calvin asked (of) the electrician/Philip was when they met at the construction site.
19. One cold day a lunch that the drummer/Eugene fixed (for) the singer/Arnold was chicken noodle soup and crackers.
20. As a gift to make amends, some candy that the runner/Ramona left (for) the cyclist/Alicia was on the kitchen table.
21. Before the party, a birdhouse that the ranger/Dawn built (for) the botanist/Rhea was wrapped as her birthday present.
22. Eagerly learned, a lesson that the roofer/Eddie taught (to) the boxer/Peter was on managing money effectively.
23. Inside the locker room the football that the quarterback/Thomas handed (to) the kicker/Gordon was completely deflated.
24. Incredibly, a sweater that the ballerina/Irena knitted (for) the designer/Agnes was made from the finest wool available.
25. Early one morning the preserves that the father/Pamela slid (to) the daughter/Elaine were spoiled and inedible.
26. Because it was snowing, some tea that the deputy/Bill brewed (for) the sheriff/Mike was already cold.
27. After the meeting, the contract that the landlord/Duane passed (to) the tenant/Ralph was a summary of their agreement.
28. Before the season began a place that the photographer/Ruth secured (for) the model/Gwen was on the softball team.
29. Sketched on an envelope, a map that the pharmacist/Norma drew (for) the researcher/Carla was so there would be no problems getting around.
30. After the grocery shopping, some money that the sailor/Justin saved (for) the captain/Wilbur was by taking the food directly to the ship's kitchen.
31. In the bank the money that the sculptor/Neil paid (to) the translator/Troy was miscounted by the teller.
32. Embarrassingly, a message that the zookeeper/Leslie sent (to) the politician/Rachel was intended for someone else.

33. Earlier, some lemonade that the driver/Edna poured (for) the passenger/Lori was made at the rest area.

34. On the camping trip, a pit that the guide/Simon dug (for) the climber/David was one in which a fire could be made.

35. Ceremoniously, a medal that the intern/Edward awarded (to) the assistant/Nathan was presented for his victory in the annual company race.

36. Drawn beside the pier a picture that the surfer/Holly painted (for) the fisherman/Betty was of the boats coming in from the sea.

37. Just before dinner the appetizers that the critic/Joanne fed (to) the artist/Maggie were intended as a palate cleanser.

38. Once last year a shirt that the philosopher/Ross loaned (to) the historian/Sean was worn at a party.

39. On Saturday the forms that the plaintiff/Alvin emailed (to) the defendant/Jerry were on the brand new computer.

40. Three years ago a house that the writer/Jane bequeathed (to) the publisher/Lynn was respected as a token of their friendship.

41. After the blizzard a figure that the scientist/Renee sculpted (for) the engineer/Faith was covered with ice and snow.

42. For dessert, a milkshake that the employee/Andrew bought (for) the president/Daniel was with whipped cream on top.

43. At the fair a prize that the clown/Greg flung (to) the juggler/Tony was for winning the contest.

44. For security, an account that the grocer/Denise opened (for) the milkman/Sylvia was insured at the local bank.

45. Luckily, a seat that the broker/Rita reserved (for) the investor/Mona was on the last train of the day.

46. To avoid partiality, a drink that the judge/Larry promised (to) the lawyer/Scott was bought after the trial.

47. Late Sunday night a report that the executive/Trevor prepared (for) the associate/Graham was supposed to be given Monday morning.

48. Last week a paper that the psychologist/Vicky read (to) the linguist/Edith was being discussed by everyone in academia.

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