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Adjunct Attachment Is Not a Form of Lexical Ambiguity Resolution

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Three eye-tracking experiments investigated ambiguity resolution in sentences containing adjunct modifiers. The experiments tested readers' response to sentences that began with a noun phrase complex containing two nouns and a preposition (*of* or *with*). A prepositional phrase or relative clause modified one of the noun phrases. The sentences were either temporarily or fully ambiguous as to which noun phrase was modified. The first and third experiments used semantic plausibility to disambiguate attachment (when disambiguation was possible). The second experiment used gender agreement to disambiguate attachment. The type of modifier, prepositional phrase versus relative clause, affected processing of the modifier as did the type of preposition in the noun phrase complex, theta-assigning versus non-theta-assigning. The data challenge the idea that syntactic ambiguity resolution is a form of lexical ambiguity resolution achieved via competition (MacDonald, 1994; MacDonald, Pearlmutter, & Seidenberg, 1994; Spivey-Knowlton & Sedivy, 1995).

Some contemporary views of how readers and listeners understand a sentence claim that readers begin by building a syntactic structure based on their knowledge of grammatical principles and guided by at least the lexical categories of the words in the sentence (Frazier, 1979, 1987; Frazier & Clifton, 1996). Other views claim that readers and listeners determine the sentence's structure in essentially the same way as they determine the meaning of a word. MacDonald, Pearlmutter, and Seidenberg (1994, p. 682) observe "... recent types of theorizing eliminate the strong distinction between accessing a meaning and constructing a syntactic representation, which was central to previous accounts." These contrasting views of how sentence structure is perceived have been tested most extensively in the domain of ambiguity resolution. Both syntactic ambiguity and lexical ambiguity have been extensively studied and it has been suggested that they reflect many of the same phenomena (MacDonald et al., 1994). In the present paper, we report three experiments on a particular kind of syntactic ambiguity resolution involving modifier attachment that are designed to determine whether a well-documented phenomenon of lexical ambiguity resolution holds true for syntactic ambiguity resolution.

To explain why syntactic ambiguity resolution might resemble lexical ambiguity resolution, we must first describe lexical ambiguity

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resolution. The phenomenon that serves as our starting point was investigated by Rayner and Duffy (1986). Rayner and Duffy measured fixation times on ambiguous words that had either one frequently occurring and one infrequently occurring meaning (biased words) or two equally frequent meanings (balanced words). In this study, words were treated as balanced if their most frequent meaning occurred between 47 and 67% of the time (mean = 58%), based on a mixture of published and locally generated norms. Words were treated as biased if their most frequent meaning occurred greater than 81% of the time (mean = 87%). Compared to unambiguous control words, readers spent more time fixating balanced words. By contrast, biased words produced fixation times equal to unambiguous control words. Rayner and Duffy proposed that the two meanings of balanced words become available at the same time, thereby forcing the reader to do additional processing to select a single meaning.

A further study investigated context effects on the processing of balanced and biased ambiguous words (Duffy, Morris, & Rayner, 1988). Balanced words were preceded by context that made one of two meanings appropriate. Biased words were preceded by context that made the subordinate meaning appropriate. Fixation times on balanced words preceded by biasing context did not differ from unambiguous control words. By contrast, readers spent more time fixating biased ambiguous words than unambiguous words when context supported the less-frequent meaning of the ambiguous word. Duffy et al. provided two explanations for these findings. The first proposes that word meanings are delivered for integration in a serial fashion. On this view, frequency and context interact to determine when different meanings become available. The second proposes that all of the meanings of an ambiguous word are activated simultaneously, but with different amounts of evidence favoring the different meanings. According to Duffy et al. (p. 441), "Selection (of a single meaning for integration) would be relatively fast when the evidence clearly supported one meaning; it would be slow when equal amounts of evidence accrued for both meanings." Thus, sources of information, context and lexical frequency in this case, interacted to determine the response to a word.

MacDonald et al. (1994) proposed a system that operates in accordance with Duffy et al.'s (1988) second explanation of frequency and context effects. In MacDonald et al.'s system, word meanings compete with one another for activation in a distributed network. The outcome of this competitive process determines what meaning the processor integrates into the discourse representation. When the reader encounters a word, all of the semantic primitives associated with the word receive some activation. When two word meanings occur equally frequently, the patterns of primitives that encode different meanings receive equal amounts of activation and feed equal amounts of inhibition to one another and it takes longer for the system to settle into a stable pattern of activation. Contextual information influences this competition by enhancing the activity of some primitives and decreasing the activation of others.

MacDonald et al. (1994) proposed that syntactic analysis proceeds in a similar fashion. At the syntactic level, choosing a syntactic analysis involves activating a particular set of x-bar structures, and different sources of information interact to adjust the activation of these structures. When the activation of one structure sufficiently exceeds the activation of all other structures, disambiguation has occurred. In some situations, all relevant sources of information are present by the time the syntactic analysis begins. This is true in the cases of lexical ambiguity discussed earlier, and it is true in some much-studied cases of syntactic ambiguity (see Tanenhaus, Spivey-Knowlton, & Hanna, in press). In these cases, processing time is slowed to the extent that the alternative analyses are closely matched in terms of the activation they receive from competing information sources. Spivey-Knowlton and Sedivy (1995) used such an analysis to account for increased processing times associated with some prepositional phrase attachment ambiguities. They proposed (p. 260) that "Near equal activation levels of the two alternatives will result in lengthy

competition, hence greatly slowed reading times at the point of ambiguity."

Accounts like these constitute a general class called *constraint satisfaction* accounts (e.g., MacDonald, Pearlmutter, & Seidenberg, 1994; Spivey-Knowlton & Sedivy, 1995; Trueswell, 1996; Trueswell, Tanenhaus, & Kello, 1993). These accounts propose that people compute more than one analysis for syntactically ambiguous fragments. The parser consults all relevant sources of information, including subcategorization preferences, semantic plausibility, and discourse context, to rank the different analyses. As described above, when all relevant sources of information are already available at the point of ambiguity, reading will be slowest when the various sources of information result in the most equal activation of the alternative interpretations. Constraint satisfaction accounts have also been applied to the case where information arriving later in a sentence conflicts with information that was used earlier. Disruption occurs when a previously favored analysis becomes disfavored on the basis of newly encountered text. It takes time for the system to reorder its preferences, and the more evidence there was for the initially preferred analysis, the more difficult it will be for the system to do this. Considered together, these mechanisms of *simultaneous* and *successive* competition provide an explanation of differential difficulty at the point of syntactic disambiguation on the basis of subcategorization information (e.g., Trueswell et al., 1993; but cf. Ferreira & Henderson, 1990), animacy (e.g., Trueswell, Tanenhaus, & Garnsey, 1994), and referential context (e.g., Altmann & Steedman, 1988). They also claim to accommodate individual differences in parsing (e.g., MacDonald, Just, & Carpenter, 1992; Pearlmutter & MacDonald, 1995; but see Waters & Caplan, 1997), variations in parsing across languages, changes in parsing preferences within individuals over time, and syntactic priming (e.g., Cuetos & Mitchell, 1988; Cuetos, Mitchell, & Corley, 1996; Branigan, Pickering, & Stewart, 1997). None of these experiments, however, provides unambiguous evidence for unrestricted use of information during initial parsing nor for competition between alternative syntactic analyses (see, e.g., Frazier, 1995; Frazier & Clifton, 1996, pp. 7–23).

In contrast with constraint satisfaction accounts, Frazier's (1979) *garden path* account proposes that comprehenders compute syntactic analyses one at a time. When faced with a temporary syntactic ambiguity, the parser adopts only the first available analysis. General principles like *late closure* and *minimal attachment* determine which analysis becomes available first. Crucially, nonstructural information, like semantic plausibility or preceding context, has no influence in the choice of an initial analysis. After an initial choice has been made, a thematic processor uses a broad range of information, including semantic plausibility and pragmatics, to assess the quality of the resulting interpretation (e.g., Rayner, Carlson, & Frazier, 1983). If the thematic processor finds the initial analysis deficient in some way, it may trigger syntactic reanalysis. This model accounts for disruption of processing observed in numerous experiments (Ferreira & Clifton, 1996; Frazier & Rayner, 1982, 1987; Mitchell, 1987; Mitchell & Holmes, 1985; Rayner et al., 1983; Rayner & Frazier, 1987; Rayner, Garrod, & Perfetti, 1992; Traxler & Pickering, 1996a), but has been challenged by data suggesting that late closure does not apply universally (Brysbaert & Mitchell, 1996; Carreiras & Clifton, 1993; Cuetos & Mitchell, 1988) or that the parser can access nonstructural information very rapidly during parsing (Altmann, Garnham, & Dennis, 1992; Altmann & Steedman, 1988; Britt, 1994; Britt, Perfetti, Garrod, & Rayner, 1992; Taraban & McClelland, 1988; Trueswell, Tanenhaus, & Garnsey, 1994).

The *construal* hypothesis (Frazier & Clifton, 1996) represents an alternative to both traditional garden path and constraint satisfaction accounts. Construal proposes two classes of relations between constituents in sentences: primary and nonprimary. A primary phrase or relation is defined as the subject or main predicate of any finite clause or a complement or obligatory constituent of a primary phrase. A nonprimary phrase is a phrase that cannot be taken to be a primary phrase. Construal assumes further that text that can be temporarily taken as instan-

tiating a primary relation will be treated as if it does instantiate a primary relation even if the text does not actually instantiate a primary relation. Primary relations are subject to structurally guided parsing principles (like minimal attachment and late closure). Nonprimary relations are subject to the construal principle. The construal principle stipulates that text instantiating nonprimary relations is associated within the active theta domain as opposed to being attached in a determinate fashion to a single node in a phrase marker. The active theta domain is defined as the (extended) maximal projection of the most recent theta-assigner. Text instantiating a nonprimary relation is evaluated using any available information in the association domain. If more than one potential attachment site for a nonprimary relation is available within the active theta domain, the system evaluates potential attachment sites simultaneously. However, at the present time, the construal hypothesis does not provide a precise specification of how this evaluation is carried out. We will propose one way in which the construal mechanism could perform this evaluation in the General Discussion.

In the experiments we present below, we looked for evidence of competition between syntactic analyses in addition to testing predictions made by the construal hypothesis and other syntactic parsing accounts (e.g., the *tuning* hypothesis; Cuetos, Mitchell, & Corley, 1996; Mitchell, Cuetos, Corley, & Brysbaert, 1995). Before describing our experiments in detail, we will briefly describe previous experimental work on sentences similar to those we tested.

RESEARCH ON MODIFIERS FOLLOWING COMPLEX NOUN PHRASES

Cuetos and Mitchell (1988) tested prepositional phrase and relative clause modifiers, using Spanish versions of sentences like (1).

> Someone shot the male servant of the actress who was standing on the balcony *with her husband.* (1)

Readers took longer to process disambiguating material (here the italicized words) when the modifier had to attach to the second noun (*actress*) in the noun phrase complex than when it could attach to either the first or second noun. Cuetos and Mitchell also obtained judgments that suggested that Spanish speakers prefer to attach modifiers to the first noun in a noun phrase complex. They interpreted their on-line and judgment data as indicating a general preference in Spanish to treat modifiers following complex noun phrases as modifying the first noun in the complex. Brysbaert and Mitchell (1996) tested Dutch translations of Cuetos and Mitchell's sentences, and Zagar, Pynte, and Rativeau (1996) tested similar sentences in French and observed faster reading when the first noun was modified than when the second noun was. These data contradict Frazier's (1979) principle of *late closure*, under which modifiers should attach to the second noun phrase.

Other studies on similar constructions in English (Carreiras & Clifton, 1993; Clifton, 1988) and Italian (De Vincenzi & Job, 1993, 1995) produced different results. Carreiras and Clifton used self-paced reading to investigate sentences with relative clause modifiers and did not find a consistent attachment preference (although they showed a first-noun advantage for the Spanish translations of their English sentences). In addition, De Vincenzi and Job tested prepositional phrase and relative clause modifiers in Italian. In questionnaire studies, they found that Italian speakers preferred to attach modifiers to the first noun phrase in noun phrase complexes when the noun phrase complex contained the preposition *of,* which is what Cuetos and Mitchell found for their Spanish speakers. However, De Vincenzi and Job found that when they changed the preposition in the noun phrase complex to *with,* Italian speakers preferred to attach the modifier to the second noun in the noun phrase complex. Despite this difference in off-line preferences, self-paced reading experiments demonstrated that Italian readers were initially faster to read both prepositional phrase and relative clause modifiers that were semantically forced to modify the second noun phrase than ones that modified the first noun phrase.

A further study compared Spanish and English speakers' preferences in experiments that manipulated the type of preposition and the semantic relation between the two nouns in the

noun phrase complex (Gilboy, Sopena, Clifton, & Frazier, 1995). In questionnaire studies, Gilboy et al. found that the relationship between the nouns in the complex affected attachment preferences for both Spanish and English speakers. Further, they demonstrated that there were some kinds of complex noun phrases which resulted in first noun modification preferences in both Spanish and English and other types of complex noun phrases which resulted in second-noun modification preferences in both languages. These findings challenge the assumption that readers treat all sentences containing noun phrase complexes followed by a modifier in the same fashion. Gilboy et al. proposed that Cuetos and Mitchell's (1988) results reflect the specific characteristics of their test sentences rather than a difference in parsing between English and Spanish. However, they did not present any on-line data, and additional evidence is needed to clarify these issues.

Some on-line data are available from a study of relative clause and prepositional phrase modifier attachment in German (Hemforth, Konieczny, & Scheepers, in press). Hemforth and her colleagues reported that German speakers showed a preference to attach relative clause modifiers to the first noun phrase in a noun phrase complex in both questionnaire and eye-tracking studies. By contrast, German speakers preferred to attach prepositional phrase modifiers to the second noun phrase in the complex. Thus, German speakers appear to treat relative clause and prepositional phrase modifiers differently.

In this article, we contrast different accounts of human sentence processing by investigating attachment of modifiers to noun phrase complexes like *the servant of the actress.* Three eye-tracking experiments provide a test of several claims associated with constraint satisfaction parsers (e.g., MacDonald et al., 1994; Spivey-Knowlton & Sedivy, 1995; Trueswell et al., 1993) and structurally guided parsers (e.g., De Vincenzi & Job, 1995; Frazier, 1979). In addition, we tested several predictions made by the *construal* hypothesis (Frazier & Clifton, 1996) that also follow from Gilboy et al.'s (1995) questionnaire findings. Experiment 1 tested the claim that readers process prepositional phrase modifiers differently than relative clause modifiers. Experiment 2 used a different kind of disambiguation to confirm and extend novel findings from Experiment 1. Experiment 3 tested the claim that the semantic relationship between nouns in complex noun phrases affects modifier processing.

PROCESSING PRIMARY AND NONPRIMARY RELATIONS

Experiment 1 tested sentences like (2) and (3):

> The driver of the car with the moustache was pretty cool. (2)
> The driver of the car that had the moustache was pretty cool. (3)

Sentences (2) and (3) begin with a noun phrase complex containing two noun phrases. A modifier (a prepositional phrase or relative clause) that must be assigned to one or the other of the noun phrases in the complex follows the noun phrase complex. Semantic plausibility compels the reader to attach the modifier to *The driver* because drivers can have moustaches but cars normally do not. However, before readers interpret either analysis, either noun phrase could serve as the host for the modifier. According to the garden path theory, readers should prefer to follow late closure and attach the modifier to the most recent noun phrase. According to constraint satisfaction, both attachment sites will be considered, but one site may be preferred, depending upon the particular characteristics of the lexical items in the sentence, contextual influences, and individual differences between readers.

According to construal, processing of the modifier depends on whether it is taken as a primary or nonprimary phrase. The construal hypothesis clearly classifies relative clauses as nonprimary phrases. It is less clear about how it classifies prepositional phrases. At one point (p. 153), Frazier and Clifton (1996) state " . . . PPs in the V-NP-PP configuration do not behave on par with relative clauses. PPs are initially minimally attached . . . " However, at another point (p. 41), they state that "A phrase . . . that has no

potential licenser in its local context (e.g., a prepositional phrase attached to a subject NP headed by a noun that assigns no theta role) cannot be taken to instantiate a primary phrase." These two quotes assume environments that differ in the presence of a verb in the position of a possible theta-assigner. However, they reflect a substantial degree of uncertainty within the theory about the exact conditions under which a phrase will be taken as primary. What if the subject noun assigns a theta role—will a following PP be taken to be primary? What if the V in the V-NP-PP configuration assigns no theta role appropriate for the PP? Will the PP then be taken as nonprimary?

In brief, the construal hypothesis provides some justification for potentially distinguishing between the status of prepositional phrases and relative clauses. However, it does not clearly state just how a prepositional phrase will be treated in which environment. One goal of the present experiments was to begin to gather experimental evidence that might be relevant to formulating such a clear statement.

Now consider processing of sentence (3). This sentence differs from sentence (2) only in that the modifier is a relative clause rather than a prepositional phrase. According to construal, relative clauses instantiate nonprimary relations and therefore the modifier should be associated within the current theta domain rather than attached in a determinate fashion. Because the preposition *of* does not assign a theta role to the following noun phrase *the car*, the active theta domain when readers reach the modifier includes both noun phrases in the complex. Because the modifier instantiates a nonprimary relation, and because two host noun phrases are available in the active theta domain, readers should evaluate both noun phrases as hosts for the modifier simultaneously. If processing of the modifier in sentences like (2) differs from processing of the modifier in sentences like (3), then this would suggest that readers treat prepositional phrase modifiers in the configuration *noun phrase of noun phrase prepositional phrase* as primary.

EXPERIMENT 1

Experiment 1 investigated processing of sentences like (2a–2c) and (3a–3c); see Appendix.

The driver of the car with the moustache was pretty cool. (2a)
The car of the driver with the moustache was pretty cool. (2b)
The son of the driver with the moustache was pretty cool. (2c)
The driver of the car that had the moustache was pretty cool. (3a)
The car of the driver that had the moustache was pretty cool. (3b)
The son of the driver that had the moustache was pretty cool. (3c)

The sentences all began with a noun phrase complex containing two noun phrases followed by a modifier that was temporarily or globally ambiguous as to which noun phrase it modified. In sentences (2a) and (3a), semantic plausibility compelled readers to attach the modifying expression to the first noun phrase in the complex. Attaching the modifier to the first noun phrase produced a plausible interpretation; attaching the modifier to the second noun phrase produced an implausible interpretation. In sentences (2b) and (3b), semantic plausibility compelled readers to attach the modifying expression to the second noun phrase in the complex. In sentences (2c) and (3c), either attachment produced a plausible interpretation. Thus, there were three attachment conditions: plausible attachment to the first noun phrase in sentences (2a) and (3a), plausible attachment to the second noun phrase in sentences (2b) and (3b), and plausible attachment to either noun phrase in sentences (2c) and (3c).

Previous eye-tracking studies have found that readers have longer fixations or make more regressive saccades when viewing text that produces an implausible semantic interpretation (Clifton, 1993; Pickering & Traxler, 1998; Rayner et al., 1983; Traxler & Pickering, 1996b). Thus, differences in the eye movement record between attachment conditions should reveal which attachments readers make when processing sentences like (2a–2c) and (3a–3c).

Experiment 1 also manipulated modifier type: prepositional phrase versus relative

clause. The construal hypothesis suggests that these types of modifiers might be processed differently.

Participants

Forty-eight native (British) English speakers from the University of Glasgow were paid to participate in the eye-tracking phase of the study. All of them had normal vision or wore corrective lenses. All were naive with respect to the aims of the experiment. Some had participated in previous eye-tracking experiments. The participants were randomly assigned to one of two groups of 24 participants each. The first group read sentences containing prepositional phrase modifiers. The second group read sentences containing relative-clause modifiers.

Items

The items constituted two sets of 24 sentences. The first group of items contained sentences like (2a–2c), where the modifier was a prepositional phrase. The second group of items contained sentences like (3a–3c), where the modifier was a relative clause. One version of each item was randomly assigned to one of three lists of items. The items were rotated across lists such that each item occurred in each of its conditions. Each participant saw only one version of each item.

Because the nouns in the noun phrase complexes differed between conditions, we counterbalanced for animacy. Across items, animate and inanimate nouns occurred in the first and second positions equally often. Note that not all items had subject noun phrases with one animate and one inanimate noun. Some of the items had animate–animate pairs and some had inanimate–inanimate pairs.

There were also 84 filler items. Twenty-eight of these items contained an unreduced complement that could temporarily be taken to be a relative clause (e.g., *We explained to the school that the man founded the library next.*) that were part of another experiment. The other fillers were of varying syntactic types.

Plausibility Norming

To determine the plausibility of the noun phrase + modifier combinations, 20 raters assigned ratings to 127 sentences like (4a–4c) and (5a–5c):

The driver with the moustache was pretty cool. (4a)	(mean rating = 6.1)
The car with the moustache was pretty cool. (4b)	(mean rating = 1.0)
The son with the moustache was pretty cool. (4c)	(mean rating = 5.8)
The driver that had the moustache was pretty cool. (5a)	(mean rating = 6.0)
The car that had the moustache was pretty cool. (5b)	(mean rating = 1.0)
The son that had the moustache was pretty cool. (5c)	(mean rating = 5.7)

Raters assigned each sentence a score from 0 (makes no sense) to 7 (makes perfect sense). All of the items in the plausible conditions (4a and 4c) and (5a and 5c) received mean ratings of 5 or above. Further, there were no differences in mean plausibility between the two plausible conditions (4a and 5c; 5a and 5c). All of the items in the implausible conditions (4b) and (5b) received mean ratings of 2 or below. We included in the experiment all of the sets of items where all of the different versions satisfied the plausibility criteria.

Attachment Preferences

Readers' ultimate decision about where to attach the modifier should be affected by the plausibility of the result. Thus, readers should decide ultimately to attach the modifier to the first noun phrase in the complex in sentences (2a) and (3a) and to the second noun phrase in the complex in sentences (2b) and (3b). To determine what preference, if any, readers had in the fully ambiguous sentences (2c) and (3c), we undertook two separate norming studies. In the first, two groups of 20 raters read a randomized list of the fully ambiguous versions of the experimental sentences. Testing a semantically ambiguous condition is a commonly used methodology to test for syntactic preferences (e.g.,

Cuetos & Mitchell, 1988; Gilboy et al., 1995). One group read sentences containing prepositional phrase modifiers and the other group read sentences containing relative-clause modifiers. After reading each sentence, the readers answered a question like (6) by circling one of two options.

Who had a moustache? the son the driver (6)

The order of the options was counterbalanced across participants and items. In sentences with prepositional phrase modifiers, readers indicated that the modifier attached to the second noun phrase in the complex 74% of the time. In sentences with relative-clause modifiers, readers indicated that the modifier attached to the second noun phrase in the complex 68% of the time. One-way ANOVAs including modifier type (prepositional phrase vs relative clause) as a within-items factor produced a marginal difference in strength of the attachment preference between the prepositional phrase modifiers and the relative-clause modifiers in the items analysis [$F2(1,23) = 4.22$, $p = .051$, $MS_e = .006$] but not in the participants analysis [$F1(1,39) < 1$, NS]. Note that the preference to attach to the second noun phrase differs reliably from no preference for both relative clause and prepositional phrase modifiers. Sixteen of 20 participants and 21 of 24 items produced a preference for attachment to the second noun phrase (critical value of $\chi_1 = 15$, $p < .05$; critical value of $\chi_2 = 18$, $p < .01$). For the prepositional phrase modifiers, 16 of 20 participants and 21 of 24 items produce a preference for attachment to the second noun phrase ($p_1 < .05$, $p_2 < .01$).

In the second norming study, 38 participants read sentence fragments that constituted the beginnings of the sentences that appeared in the eye-tracking experiment, in the same order, and including filler sentences. The experimental sentences were cropped just before the head of the modifier. That is, if the experimental sentence were *The son of the driver with/that had the moustache was pretty cool*, then the participant would see *The son of the driver that had the* . . . . The filler sentences were cut off at various points so that they appeared similar to the experimental items. The participants were instructed to write down the first grammatical and meaningful continuation that they could think of. They were then given a second booklet containing the experimental fragments and two paraphrase fragments (e.g., *The son had* . . . and *The driver had* . . .), balanced for order across questionnaires, and were told to indicate which of these fragments best corresponded to their completion. Some studies have shown that completion data correlate with reading measures, so that locally ambiguous sentences that continue with a syntactically more frequent type of completion are easier to process than ones that continue with a syntactically less frequent type, though others have not found this relationship (e.g., Clifton, Kennison, & Albrecht, 1997; Trueswell, 1996).

Some constraint-satisfaction theorists have proposed that sentence completion norms provide the best estimate of the relative initial activation of competing analyses and hence the best predictor in a constraint satisfaction framework (McRae, Spivey-Knowlton, & Tanenhaus, in press; Tanenhaus et al., in press). This sentence completion technique has a number of problems, however, that do not apply to the forced-choice task. As noted by Trueswell (1996), the completion task involves production and therefore rests on the highly debatable assumption that production and comprehension draw upon the same sources of information in the same way. Second, sentence completion may not reflect normal production processes. For example, participants may try to finish off sentences with as few words as possible, in which case they might favor a shorter type of completion over a more frequent one. Finally, one problem specifically associated with our experiment is that many of the completions will be syntactically ambiguous. Scoring of these responses would therefore be subject to the same biases as the forced-choice task. Under these conditions, we concluded that the least bad option was for the participants to score their own responses after finishing the completion task and without prior warning. We excluded all trials on which participants said that they did not know which paraphrase was correct (1.2%).

Whatever shortcomings the two types of

norming task may have had, they produced nearly identical estimates of participants' attachment preferences. In the second norming study, participants preferred to attach relative clause modifiers to the second noun phrase in the complex 71% of the time (vs 68% for the previous norming test). Prepositional phrase modifiers produced 79% attachment to the second noun phrase (vs 74% for the forced-choice task). ANOVAs including modifier type (prepositional phrase vs relative clause) showed little difference in strength of the attachment preference between the prepositional phrase modifiers and the relative clause modifiers in the sentence completion data [$F1(1,36) < 1$, NS, $MS_e = 0.056$; $F2(1,23) = 2.87$, $p = .10$, $MS_e = .027$].

Further ANOVAs tested whether the type of norming task affected the degree of attachment preference. Test type (forced choice vs completion task) and sentence type (prepositional phrase vs relative clause modifier) were treated as within items and between subjects. These ANOVAs produced no main effects or interactions with test type (all $F < 1$), demonstrating that attachment preference was the same across the two tests.

Procedure

An SRI Dual-Purkinje Generation 5.5 eye-tracker monitored readers' eye movements. The tracker has angular resolution of 10′ arc. The tracker monitored only the right eye's gaze location. A PC displayed items on a VDU 70 cm from readers' eyes. The VDU displayed four characters per degree of visual angle. The tracker monitored readers' gaze location every millisecond and the software sampled the tracker's output to establish the sequence of eye fixations and their start and finish times.

Before the experiment started, readers read an explanation of eye-tracking and a set of instructions. The instructions told them to read at their normal rate and comprehend the texts as well as they could. The experimenter then seated the participant at the eye-tracker and used bite bars and forehead restraints to minimize head movements. Next, readers completed a calibration procedure. Before each trial, a small "+" symbol appeared near the upper left-hand corner of the screen. Immediately after readers fixated the "+" symbol, the computer displayed an item, with the first character of the text replacing the "+" on the screen. The "+" symbol also served as an automatic calibration check, as the computer did not display the item until it detected stable fixation on the "+" symbol. If readers did not rapidly fixate the "+" symbol, the experimenter recalibrated the eye-tracker. When readers finished reading each item, they pressed a key, and the computer either displayed a comprehension question, on about half of the trials, balanced across conditions, or proceeded to the next trial. Half of these questions had "yes" answers, half had "no." For example, the test sentence *The bishop of the church with the funny eyebrows made us cry.* was followed by the question *Did the bishop make us laugh?* Readers responded to the questions by pressing a button and did not receive feedback on their answers. Their answers were not recorded. After readers completed each sixth of the experiment, the experimenter recalibrated the equipment. Thus, the eye-tracker was calibrated a minimum of six times during the experiment and often more. The computer displayed each experimental list in a fixed random order together with the filler sentences. The first two sentences and the first two after each calibration were fillers. The computer displayed all sentences on a single line.

Regions

We divided the sentences into five regions for statistical analysis (see Appendix for region boundaries). Region 1 included the first noun phrase in the complex. Region 2 included the preposition *of* and the second noun phrase. Region 3 included the beginning of the modifying expression up to the head noun in the modifier. Region 4 included the head noun of the modifier. Region 5 included the rest of the sentence. All of the regions included the character space immediately before the first word in the region.

Measures

We report three measures of processing: first-pass gaze duration, total time, and first-pass regressions. First-pass gaze duration is the sum

total of fixation times starting with the reader's first fixation inside the region until the reader's gaze leaves the region, either to the left or to the right. Total time is the sum of all the reader's fixation times within the region. First-pass regressions include all eye movements that cross the region's left boundary that are initiated during a first-pass fixation in the region. In addition to reporting means based on participants' raw reading times, we also report deviation scores for first-pass and total times. These deviation scores were computed according to the method suggested by Ferreira and Clifton (1986). An automatic procedure computed a regression equation for each participant using all items, including fillers, that the participant read. For each region, the reading time predicted by the participants' regression equation was subtracted from the actual measured reading time. Thus, positive scores indicate slower-than-predicted processing and negative scores indicate faster-than-predicted processing. All of the analyses we report are based on these deviation scores. Analyses using the raw scores produce nearly identical results and so we do not report them.

Analyses

An automatic procedure incorporated fixations of less than 80 ms into the largest fixation within one character. In the next stage, the program eliminated all individual fixations greater than 1000 ms and less than 80 ms. These criteria eliminated 4.0% of the data from Experiment 1. Individual fixations greater than 1000 ms generally reflect instances where the eye-tracker loses track of the reader's gaze location and readers generally do not extract much information during very short fixations (Rayner & Pollatsek, 1989).

Predictions

The garden path account predicts that readers will have more difficulty processing the modifier when the modifier attaches to the first noun phrase in the complex. Thus, readers should process the modifier more slowly in sentences (2a) and (3a) than in sentences (2b and 2c) and (3b and 3c).

Constraint satisfaction accounts predict that on-line processing should reflect off-line preferences. For our sentences, readers prefer to attach modifiers to the second noun phrase in the complex. Thus, for the disambiguated sentences, constraint satisfaction accounts predict that (2a) should be harder than (2b) and (3a) should be harder than (3b). In addition, there is little difference in the strength of the preference between prepositional phrase modifiers and relative clause modifiers. Thus, constraint satisfaction does not predict marked differences in processing between sentences with prepositional phrase modifiers and sentences with relative clause modifiers. Further, for individual items, strength of preference for attaching the modifier to one or the other of the noun phrases in the complex should correlate with fixation times. For example, as the preference for attachment to the second noun phrase increases, fixation times should decrease during processing of the modifier in sentences where the modifier attaches to the second noun phrase.

Additional predictions of the constraint-based account depend on how the normative preference percentages are assumed to map onto the process of settling on a single analysis. If, for example, the 68% figure for relative clauses indicates that they are balanced in the way that ambiguous words with similar distributions of meanings are balanced, then the constraint-based account predicts lengthier response times for the fully ambiguous sentences (2c and 3c) than for the disambiguated sentences (2a and 2b, 3a and 3b) due to competition between alternative interpretations. If, on the other hand, the 68% figure is interpreted as showing a preference for attachment to the second noun phrase, meaning that the sentence corresponds to a biased ambiguous word, then we would expect a faster response to sentences where the modifier can attach to the second noun phrase (2b and 3c, 3b and 3c) than for sentences where the modifier attaches to the first noun phrase (2a and 3a).

The construal account would make the same prediction as the garden path account when the modifier is a prepositional phrase (sentences 2a–2c), if a prepositional phrase following a subject noun phrase is treated as a primary

relation. It makes different predictions for processing relative clauses (sentences 3a–3c). Because relative clauses can only instantiate nonprimary relations, they are subject to the construal principle. Thus, readers should associate the relative clause within the active theta domain and evaluate all attachment sites in the domain simultaneously. In sentences (3a–c), both noun phrases lie within the active theta domain during processing of the modifier, so both sites should be evaluated as hosts for the modifier at the same time. Thus, construal predicts no difference in processing of the modifier between sentences (3a) and (3b) because in both cases *car* and *driver* are simultaneously assessed as potential attachment sites. Without elaborations, construal is mute on whether (3c) should be faster or slower than (3a or 3b).

Results and Discussion

Table 1 presents mean first-pass time, total time, and first-pass regressions by region and condition for Experiment 1, as well as mean first-pass and total time deviation scores. Table 2 presents the results of the statistical analyses on the deviation scores and regressions.

The first-pass and regressions data produced only one reliable main effect (which we discuss below) and no interactions in any of the analyses.

We subjected the total time data from regions 2–4 to 2 (modifier type: prepositional phrase vs relative clause modifier) × 3 (attachment: modifier attaches to the first noun phrase vs second noun phrase vs either noun phrase) × 3 (region: region 2 vs region 3 vs region 4) ANOVAs. Modifier type was a between-participants and within-items factor. Attachment and region were treated as within participants and items. Examining this broad region should give an indication whether readers responded consistently throughout the sentence. The second panel of Table two shows a main effect of attachment. The third and fourth panels show that an effect of attachment is clearly present for relative clause sentences (deviation score means of −2, −16, and −99 ms for first, second, and either noun phrase attachment, respectively) but not for prepositional phrase sentences (deviation score means of −41, −42, and −68 ms).

Next, we further examined the main effect of attachment in the relative clause sentences only across regions 2 through 4. Tests for simple effects showed that readers spent less time processing regions 2–4 when the modifier could attach to either noun phrase than when it had to attach to the first noun phrase [$F1(1,23) = 10.85$, $p < .01$; $F2(1,23) = 7.72$, $p < .01$] or to the second noun phrase [$F1(1,23) = 7.96$, $p < .01$; $F2(1,23) = 5.59$, $p < .03$]. Total times for regions 2–4 across sentences where the relative clause modifier attached to the first noun phrase versus the second noun phrase did not differ (both $F < 1$).

While the interaction between modifier type and attachment did not reach significance when examining the data pooled over regions 2 through 4 (see 1st panel of Table 2), it did reach significance when region 4 (the head noun of the modifier phrase, where disambiguation effects should be strongest) is examined (see 13th panel of Table 2). As was found for the broader region, sentences with relative clause modifiers did produce significant differences among the attachment conditions, while sentences with prepositional phrase modifiers did not (see panels 15 & 16 of Table 2). Total times on the head noun of the modifier in sentences with relative clause modifiers were shorter when the modifier could attach to either noun phrase in the complex than when it had to attach to the first noun phrase [$F1(1,23) = 9.39$, $p < .01$; $F2(1,23) = 9.13$, $p < .01$] or to the second noun phrase [$F1(1,23) = 12.81$, $p < .001$; $F2(1,23) = 12.13$, $p = .001$]. Reading times on the head noun of the modifier in sentences where the modifier attached to the first noun phrase did not differ from reading times on the head noun of the modifier where the modifier attached to the second noun phrase (Fs < 1).

Readers' total reading times in the relative clause sentences did not match the off-line preference for these sentences. Further, readers spent less time processing the modifier when two analyses produced plausible semantic interpretations than when only one analysis produced a plausible semantic interpretation, even

TABLE 1

Experiment 1: Mean Regressions and Reading Times by Region and Condition

Example target sentence:

Region 1 2 3 **4** 5

The driver of the car with the/that had the moustache was pretty cool.

		Region				
Modifier	Modifier attaches to	1	2	3	**4**[a]	5
		First-pass reading time (MS)				
Prepositional	First noun phrase	440	414	358	346	649
Phrase	Second noun phrase	471	430	349	338	687
	Either	465	426	365	335	678
Relative	First noun phrase	447	392	542	324	664
Clause	Second noun phrase	434	415	494	320	643
	Either	422	403	525	314	650
		Total reading time (MS)				
Prepositional	First noun phrase	616	754	562	519	891
Phrase	Second noun phrase	641	772	578	482	929
	Either	629	743	535	489	874
Relative	First noun phrase	636	767	1040	529	1012
Clause	Second noun phrase	702	826	968	547	969
	Either	631	728	869	447	887
		First-pass regressions (%)				
Prepositional	First noun phrase	0	15	11	12	53
Phrase	Second noun phrase	0	13	8	16	44
	Either	0	16	5	12	53
Relative	First noun phrase	0	16	12	26	69
Clause	Second noun phrase	0	22	12	23	67
	Either	0	22	9	17	64
		First-pass reading time (MS deviation from predicted)				
Prepositional	First noun phrase	36	−104	−93	−13	122
Phrase	Second noun phrase	72	−89	−103	−22	161
	Either	65	−96	−88	−24	151
Relative	First noun phrase	51	−115	−19	−26	145
Clause	Second noun phrase	41	−99	−62	−32	128
	Either	31	−109	−27	−38	135
		Total reading time (MS deviation from predicted)				
Prepositional	First noun phrase	25	−28	−99	3	97
Phrase	Second noun phrase	56	−9	−83	−35	102
	Either	44	−43	−135	−27	81
Relative	First noun phrase	−5	−76	90	−21	141
Clause	Second noun phrase	32	−36	−7	−5	107
	Either	−5	−126	−57	−113	22

[a] Region **4** corresponds to the head noun of the modifier.

TABLE 2

Experiment 1: ANOVA Results by Region for Modifier (Prepositional Phrase vs Relative Clause) and Attachment (Modifier Attaches to First vs Second vs Either Noun Phrase)

Example target sentence:

Region	1	2	3	**4**	5

The driver of the car with the/that had the moustache was pretty cool.

Source	*F*1	df1	*F*2
Modifier × attachment, regions 2, 3, and **4**[a] combined			
First-pass deviation	<1 (3594)	2, 92	<1 (4604)
Total time deviation	2.14 (23225)	2, 92	1.92 (27075)
Regressions	<1 (135)	2, 92	<1 (168)
Attachment, regions 2, 3, and **4** combined			
First-pass deviation	<1 (4325)	2, 92	<1 (5128)
Total time deviation	7.06* (23225)	2, 92	3.72* (45390)
Regressions	1.30 (135)	2, 92	<1 (278)
Prepositional phrase sentences, attachment, regions 2, 3, and **4** combined			
First-pass deviation	<1 (2863)	2, 46	<1 (4118)
Total time deviation	1.09 (15389)	2, 46	<1 (27091)
Regressions	<1 (118)	2, 46	<1 (165)
Relative clause sentences, attachment, regions 2, 3, and **4** combined			
First-pass deviation	<1 (4325)	2, 92	<1 (5128)
Total Time Deviation	6.35** (31060)	2, 92	4.50* (45374)
Regressions	1.16 (153)	2, 92	<1 (281)
Modifier × attachment, region 2			
First-pass deviation	<1 (6021)	2, 92	<1 (6926)
Total time deviation	<1 (18420)	2, 92	1.07 (25263)
Regressions	<1 (180)	2, 92	<1 (168)
Attachment, region 2			
First-pass deviation	<1 (6021)	2, 92	<1 (6998)
Total time deviation	2.50 (18420)	2, 92	1.07 (44993)
Regressions	<1 (180)	2, 92	<1 (195)
Prepositional phrase sentences, attachment, region 2			
First Pass Deviation	<1 (7126)	2, 46	<1 (6883)
Total Time Deviation	<1 (15860)	2, 46	<1 (29716)
Regressions	<1 (220)	2, 46	<1 (106)
Relative clause sentences, attachment, region 2			
First Pass Deviation	<1 (4916)	2, 46	<1 (7041)
Total Time Deviation	2.32 (20980)	2, 46	1.25 (40541)
Regressions	1.73 (141)	2, 46	<1 (257)
Modifier × attachment, region 3			
First-pass deviation	<1 (3597)	2, 92	<1 (4275)
Total time deviation	3.05* (16557)	2, 92	2.84 (18470)
Regressions	<1 (131)	2, 92	<1 (96)
Attachment, region 3			
First-pass deviation	2.82 (3597)	2, 92	1.35 (8067)
Total time deviation	6.14** (16557)	2, 92	3.80* (27583)
Regressions	1.76 (131)	2, 92	<1 (203)

TABLE 2—*Continued*

Source	*F*1	df1	*F*2
Prepositional phrase sentences, attachment, region 3			
First-pass deviation	<1 (2371)	2, 46	<1 (4573)
Total time deviation	1.49 (11473)	2, 46	1.43 (11964)
Regressions	2.15 (93)	2, 46	1.37 (127)
Relative clause sentences, attachment, region 3			
First Pass Deviation	2.53 (4823)	2, 46	1.72 (7770)
Total Time Deviation	6.24** (21641)	2, 46	4.11* (34089)
Regressions	<1 (170)	2, 46	<1 (172)
Modifier × attachment, region **4**			
First-pass deviation	<1 (2124)	2, 92	<1 (2023)
Total time deviation	4.35* (9403)	2, 92	4.89* (8788)
Regressions	1.40 (135)	2, 92	<1 (278)
Attachment, region **4**			
First-pass deviation	<1 (2080)	2, 92	1.11 (2348)
Total time deviation	4.03* (10734)	2, 92	3.25* (14249)
Regressions	1.75 (196)	2, 92	1.75 (187)
Prepositional phrase sentences, attachment, region **4**			
First-pass deviation	<1 (1738)	2, 46	<1 (2269)
Total time deviation	1.24 (17878)	2, 46	1.11 (9386)
Regressions	<1 (144)	2, 46	<1 (176)
Relative clause sentences, attachment, region **4**			
First-pass deviation	<1 (2510)	2, 46	<1 (2103)
Total time deviation	7.49** (10929)	2, 46	7.16** (11790)
Regressions	2.08 (244)	2, 46	2.40 (200)
Modifier × attachment, region 5			
First-pass deviation	<1 (14775)	2, 92	<1 (15744)
Total Time Deviation	1.29 (26138)	2, 92	<1 (31131)
Regressions	1.76 (225)	2, 92	2.14 (256)
Attachment, region 5			
First-pass deviation	<1 (14775)	2, 92	<1 (15174)
Total time deviation	2.32 (26138)	2, 92	1.95 (19262)
Regressions	1.76 (225)	2, 92	2.65 (197)
Prepositional phrase sentences, attachment, region 5			
First-pass deviation	<1 (16105)	2, 46	1.06 (10985)
Total time deviation	<1 (22451)	2, 46	1.89 (24300)
Regressions	3.21* (203)	2, 46	5.07* (192)
Relative clause sentences, attachment, region 5			
First-pass deviation	<1 (13445)	2, 46	<1 (18932)
Total time deviation	3.01 (29825)	2, 46	1.89 (24300)
Regressions	<1 (246)	2, 46	<1 (262)

Note. ANOVAs treated attachment as a within-participants and within-items factor. Modifier type was treated as a between-participants and within-items factor. Degrees of freedom for participants analyses are as indicated. Degrees of freedom for items analyses are (2, 46).

[a] Region **4** corresponds to the head noun of the modifier.

* $p < .05$; ** $p < .01$; *** $p < .001$. MS_e appear in parentheses.

when the preferred attachment produced a plausible interpretation. Both of these findings challenge constraint satisfaction accounts. On the one hand, readers' on-line processing should have reflected the operation of constraints (as determined by off-line measures). In this case, the off-line data predicted shorter reading times when the modifier attached to the second noun, and this did not occur. On the other hand, readers should have taken longer to process the modifier when more attachment sites produced plausible semantic analyses because of competition, and this also did not occur. Finally, there should have been no reliable differences between sentences with prepositional phrase modifiers and relative clause modifiers (because the off-line preferences for the two types of sentences were nearly the same), but there were.

It is possible that no competition occurred in the fully ambiguous sentences tested in this experiment because readers preferred too strongly to attach modifiers to the second noun phrase in the complex. If the preexisting structural preference was too strong, no competition would occur, according to constraint satisfaction models because the preferred interpretation would quickly out-compete the dispreferred interpretation. Note, however, that this would still leave unexplained long reading times when the modifier had to attach to the second noun phrase. If this account is correct, then response times in the fully ambiguous sentences should have increased as the structural bias weakened. To test this possibility, we separated the relative clause sentences into two groups: one where the off-line preference to attach to the second noun phrase in the complex was 65% or greater (biased items); and one where the off-line preference to attach to the second noun was between 35 and 60% (balanced items). Using these criteria, 18 of the items were biased toward attaching to the second noun phrase, and 6 of the items were balanced. By chance, the 6 balanced items were distributed across experimental lists in such a way that each of the participants was missing data in one cell. Participants 1–8 saw no balanced items where the modifier attached to the first noun, participants 9–16 saw no balanced items where the modifier attached to the second noun, and participants 17–24 saw no balanced items where the modifier could attach to either noun. Thus, in the following analyses, missing data in the participant means were replaced by the grand mean (collapsing across conditions) for the region (Cohen & Cohen, 1975).

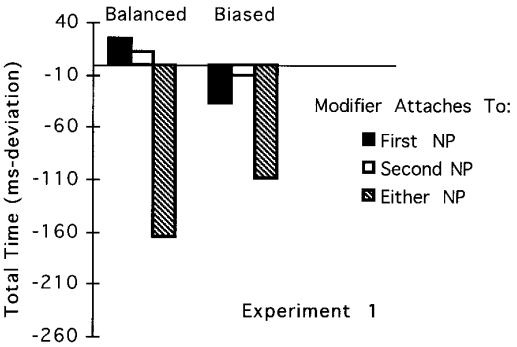

FIG. 1. Experiment 1, relative clause sentences. Mean total time (deviation) scores on Region 4 for balanced and biased items by condition. The set of bars on the left represents mean total time (deviation) for balanced items; the set of bars on the right represents mean total time (deviation) for biased items.

If the more neutral items produced greater competition, then the difference between the fully ambiguous items and the other types should be smaller in the balanced items than in the biased items. Figure 1 shows results separately for balanced and biased items. Total times on the head noun of the modifier across the two types of items are nearly identical. Item type (balanced vs biased) and attachment did not produce reliable interactions ($F1 < 1$, $F2 = 1.22$, NS). When the balanced items were analyzed separately, the main effect of attachment remained [$F1(2,46) = 3.25$, $p < .05$, $MS_e = 30623$; $F2(2,10) = 3.82$, $p < .06$, $MS_e = 13242$]. As in the entire set of items, this main effect occurred because total times for the fully ambiguous sentences were less than total times for sentences where the modifier had to attach to the first noun phrase in the complex [$F1(1,23) = 5.74$, $p < .02$, $MS_e = 30623$; $F2(1,5) = 6.57$, $p < .05$, $MS_e = 13242$] or the second noun phrase in the complex [$F1(1,23) = 3.82$, $p < .06$, $MS_e = 30623$; $F2(1,5) = 4.98$, $p < .05$, $MS_e = 13242$]. Total times on the two types of

disambiguated sentence did not differ (Fs < 1). Thus, balanced items behaved much the same as biased items. Reading times on the fully ambiguous materials did not increase as the items became more neutrally biased (the numerical difference, though not statistically significant, was in the opposite direction).

Next, we performed a correlational analysis to test a further prediction of constraint satisfaction accounts. According to such accounts, processing time should reflect off-line preferences. Thus, for each item, we subtracted the total time (deviation) on the head noun of the modifier when the modifier attached to the second noun phrase from the total time (deviation) when the modifier attached to the first noun phrase. We then attempted to predict this difference using the strength of the preference for attachment to the second noun phrase. The preference data used in the first regressions reported here came from the forced-choice test. We performed all of the regressions a second time using the completion test to generate the predictions. According to the constraint satisfaction account, the difference in processing time for attachment to the first versus second noun phrase should increase as the preference for attachment to the second noun phrase increases. The obtained r values, however, were $-.003$ using the forced-choice data as the predictor variable [$t(22) = -0.14$, NS] and 0.65 using the completion data [$t(22) = 0.31$, NS]. Thus there was no evidence that strength of preference affected processing.

Finally, one effect in the regressions data requires comment. The prepositional phrase sentences produced a main effect of attachment in the regressions data from region 5, the final region in the sentence. This main effect occurred because readers made fewer regressions when the modifier attached to the second noun phrase than when it attached to the first [$F1(1,23) = 4.65$, $p < .04$; $F2(1,23) = 7.58$, $p = .01$] or when it could attach to either noun phrase [$F1(1,23) = 4.96$, $p < .04$; $F2(1,23) = 7.64$, $p = .01$]. Readers made the same number of regressions when the modifier had to attach to the first noun phrase as when it could attach to either (both Fs < 1). This result needs to be interpreted with caution, as it comes from a region where readers are presumably engaging in sentence wrap-up processes (cf. Rayner & Pollatsek, 1989) and because the greater number of regressions from sentences like (2a) and (2c) did not lead to greater total reading times for those sentences. Still, the regressions effect might indicate that readers had less difficulty processing sentences where the prepositional phrase modifier attached to the second noun phrase, which would be consistent with all current accounts. However, the fact that sentences like (2c) produced an elevated number of regressions is consistent with an account in which competition between attachment to the first noun phrase and the second noun phrase disrupts processing.

The implications of some other aspects of the data from Experiment 1 also remain unclear. First, while prepositional phrases were not processed like relative clauses (as seems to be the case in German; Hemforth et al., in press), prepositional phrases did not show a clear preference for modifying the second noun in the complex noun phrase, as had been predicted by all theories. This finding may reflect some insensitivity of the experiment or it may reflect the absence of an on-line preference for the first versus second noun attachment in prepositional phrase modifiers in English.

Second, the clearest effects observed for the relative clause sentences occurred in the total time measure, not on first-pass time. Disruption due to syntactic processing and disruption effects due to other factors are sometimes observed in first-pass time or even first fixation time (Frazier & Rayner, 1982), but precisely how it appears seems to depend on a variety of factors. Rayner, Sereno, Morris, Schmauder, and Clifton (1989), Rayner and Sereno (1994), and Traxler, Bybee, and Pickering (1997) lay out some of the considerations. When material that disambiguates a temporary ambiguity toward an unexpected interpretation appears, the eye can remain fixated longer than usual, regress back to an earlier region, or move forward in search of material to resolve the expectation violation. Further, how quickly the eye responds to the disambiguation depends on the

clarity of the disambiguation. When the disambiguation is carried by grammatical information (e.g., a part of speech inconsistent with the preferred interpretation), the response can be very quick. But when disambiguation requires inferencing or resolution of semantic interpretation, the response can be slowed. In such cases, the eye may even move on to the next region and then return to the disambiguating region (or earlier regions), resulting in total time rather than first-pass time effects. Our materials apparently fell in the category of such slow disambiguation, which is reasonable enough given that semantic interpretation of a nonprimary phrase was involved. The lack of first-pass time and regressions effects may also reflect the fact that disambiguating material was unavailable until near the end of the noun phrase.[1] Finally, our critical region contained only a single word, which makes them rather shorter than many studies which produce effects in first-pass gaze duration data (e.g., Trueswell et al., 1993).

What is clear, given the observed differences in processing between *the car of the driver that had the moustache* and *the son of the driver that had the moustache,* is that readers must have evaluated the attachment of the relative clause to the first noun, even when attachment to the second noun was plausible. This evaluation slowed reading only when it resulted in an implausible analysis. Sheer competition between two plausible analyses did not result in slow reading. Note that these conclusions are not based on the absence of an effect, but rather on a reliable difference between two types of sentence where attachment of the modifier to the second noun phrase produces a plausible semantic interpretation.

One might object to these conclusions because this experiment produced no reliable differences in measures other than total time measures. That is, if syntactic parsing theories are really accounts of initial processing preferences, then all current syntactic parsing theories—including constraint-based lexicalist accounts—are safe from these data. If the effects in this experiment were caused by subjects rereading some kinds of sentences more than other kinds of sentences, then these data tell us nothing about the early events in the syntactic parsing of such sentences. What this line of reasoning lacks, though, is an answer to the question: Why were subjects compelled to reread some kinds of sentences more than other kinds of sentences? According to constraint-based accounts, processing can be disrupted when incoming data compel readers to reevaluate previously established parsing preferences. The degree of disruption depends on both the strength of the preexisting preferences and the amount of evidence the incoming data provides against those preexisting preferences. This logic has been used to account for the results of a number of experiments (see, e.g., Trueswell et al., 1993, 1994). Applying this logic to the current experiment leaves a number of questions unanswered: Why, if readers prefer initially to attach modifiers to first noun phrases, would readers be compelled to reread sentences where attachment to the first noun phrase produces a semantically plausible interpretation? If, on the other hand, readers prefer to attach modifiers to second noun phrases, why are they compelled to reread sentences where attachment to the second noun phrase produces a semantically plausible interpretation? Finally, if modifier attachment results from competition between alternative analyses, why are readers less inclined to reread sentences where two alternatives produce semantically plausible interpretations?

In sum, Experiment 1 provides evidence that readers did not consistently attempt to attach modifiers to either of the possible attachment sites (if they did, we would not have observed

[1] Carreiras and Clifton (submitted) report an eye-tracking experiment using gender-disambiguated relative clauses in English which found faster first-pass reading times when the relative clause modified the second noun-phrase than when it modified the first. There are many possible reasons for the difference between this result and the results reported in the present article, including the fact that Carreiras and Clifton's materials used the complex noun phrase as object of the main verb while the present materials used it as subject of the sentence. It is possible that interpretation takes place more quickly once the main verb provides the thematic roles expressed in a sentence.

greater disruption in the disambiguated sentences than in the fully ambiguous sentences). In particular, the finding of slow reading times when a relative clause must modify the second noun phrase in a complex, compared to when it can modify either one, seems to have strong theoretical implications. Because of this, we attempted to replicate the finding using different materials.

EXPERIMENT 2

Experiment 2 investigated processing of sentences like (7a–7c):

The daughter of the colonel who shot herself on the balcony had been very depressed. (7a)
The daughter of the colonel who shot himself on the balcony had been very depressed. (7b)
The brother of the colonel who shot himself on the balcony had been very depressed. (7c)

These sentences differ from sentences (3a–3c) from Experiment 1 in that the relative clause modifier includes a reflexive pronoun that disambiguates attachment to the first noun phrase in the complex (7a) or the second noun phrase in the complex (7b), and the relative clause begins with the relativizer *who* rather than *that.* In (7c) the relative clause modifier could attach to either noun phrase in the complex. Thus, whereas sentences (3a–3c) in Experiment 1 used plausibility to disambiguate, these sentences used gender agreement. Sentences (7a–7c) resemble sentences (3a–3c) from Experiment 1 in that they begin with a noun phrase complex, the complex contains two noun phrases, the noun phrases are connected by a non-theta assigning preposition, and the modifier is a relative clause. Thus, the processing implications are the same for sentences (3a–3c) and (7a–7c).

Frazier and Clifton (1996, pp. 79–80) briefly report an advantage when reflexive pronouns disambiguate attachment to the second noun in a noun phrase complex. They do not offer an explanation for why reflexive pronouns produce such a preference in their experiment, whereas other sentences in English with the same syntactic structure do not. Thus, it would be useful to have further data on the processing of reflexive pronouns following noun phrase complexes. Experiment 2 provided further evidence about processing of relative clause modifiers when two attachment sites were available in the active theta domain.

Participants

Thirty-six native (British) English speakers from the same pool as the previous experiment were paid to participate in the eye-tracking phase of the study. Some had participated in previous eye-tracking experiments. We removed from all of the analyses three subjects who made substantially more than the average number of regressions (collapsed across conditions).

Items

We constructed 36 sets of sentences like (7a–7c); see Appendix. All of the sentences began with a noun phrase complex containing two noun phrases connected by the non-theta-assigning preposition *of.* All of the sentences continued with a relative clause modifier that began with *who.* All of the relative clause modifiers contained a reflexive pronoun (*himself* or *herself*) that disambiguated attachment of the modifier to the first noun phrase in the complex or the second noun phrase in the complex or permitted attachment to either noun phrase in the complex. We counterbalanced whether the first or second noun phrases contained nouns that referred to male or female entities between items. There were also 86 filler items. Sixteen of these of these sentences contained a complement clause that could temporarily be taken as the direct object of a preceding verb (e.g., *Mike supposed you and the others would come to the party.*) These sentences were part of a further experiment containing 32 items in all.

Attachment Preferences

We determined readers' preferences as to where the modifier should attach using the forced-choice procedure from Experiment 1 in which raters saw ambiguous sentences like (7c). Overall, raters preferred to attach the modifier to the second noun phrase 70% of the time (compared to 68% for comparable sentences from the previous experiment).

Procedure

The experimental procedure was identical to Experiment 1 with one exception: The test sentences in Experiment 2 were longer than those in Experiment 1. Thus, they were displayed on two lines separated by a blank line. The line breaks always occurred within or after the fifth region (the region following the reflexive pronoun). Line breaks occurred as indicated in the Appendix.

Regions

The sentences were divided into six scoring regions for statistical analysis (see Appendix for region boundaries). The first scoring region included the first noun phrase in the complex. The second region included the preposition and the second noun phrase in the complex. The third region included the beginning of the modifying expression up to the head noun in the modifier. The fourth region included the reflexive pronoun. The fifth region included a short one- to three-word adverbial or prepositional phrase. The sixth and final region included the rest of the sentence.

Analyses

We employed the same procedures for analysis as in the previous experiment. A small percentage (6.5%) of the data were removed due to track loss or extremely short fixations.

Predictions

The garden path theory and constraint satisfaction accounts predict that readers will take less time to process the modifier in (7b) when it attaches to the second noun phrase in the complex than in (7a) when it attaches to the first. Construal predicts no difference in processing of the modifier between (7a and 7b) because both noun phrases are available in the current theta domain when the reader encounters the nonprimary relation expressed by the relative clause modifier. The constraint satisfaction account predicts longer reading times for (7c) than (7b) on the assumption that the 70% preference for attaching the modifier to the second noun phrase corresponds to a balanced ambiguity. If instead the 70% figure corresponds to having a biased ambiguity, then the constraint-based prediction is that (7b and 7c) should cause less difficulty than (7a).

Results and Discussion

Table 3 presents mean first-pass time, total time, and first-pass regressions by region and condition for Experiment 2. Table 4 presents the results of the statistical analyses.

In Experiment 2, unlike in Experiment 1, the sharpest results were observed in the analysis of frequency of first-pass regressions. Region 5, which immediately followed the reflexive pronoun, produced a main effect of attachment (in Table 4). Sentences where the modifier attached to the first noun phrase evoked more regressions than sentences where the modifier could attach to either noun phrase [$F1(1,35) = 6.45$, $p = .01$; $F2(1,29) = 9.62$, $p < .01$]. There was some evidence that sentences where the modifier attached to the second noun phrase also evoked more regressions than sentences where the modifier could attach to either noun phrase [$F1(1,35) = 2.49$, $p = .11$; $F2(1,29) = 5.01$, $p < .03$]. Sentences where the modifier attached to the first noun phrase did not differ from sentences where the modifier attached to the second noun phrase in number of regressions (Fs < 1).

The patterns in the first-pass and total times are very similar to the comparable conditions in the previous experiment. As in the previous experiment, reliable effects occurred in the total reading time deviation scores. Across regions 2–4, the analyses revealed a main effect of attachment (modifier attaches to the first vs second vs either noun phrase; see Table 4). Reading times were fastest when the relative clause could attach to either noun phrase, intermediate when it had to attach to the first noun phrase, and slowest when it had to attach to the second noun phrase (mean deviation times of −87, −59, and −34 ms respectively). The contrast between the ambiguous and the second noun phrase conditions was significant [$F1(1,35) = 8.29$, $p < .01$; $F2(1,29) = 8.86$, $p < .01$], while the contrast between ambiguous and first noun phrase did not reach significance [$F1(1,35) =$

TABLE 3

Experiment 2: Mean First-Pass and Total Reading Time, and First-Pass Regressions by Region and Condition

Example target sentence:

Region 1 2 3 **4** 5 6

The daughter of the colonel who shot herself on the balcony had been upset.

	Region					
Modifier attaches to:	1	2	3	**4**[a]	5	6
			First-pass reading time (MS)			
First noun phrase	462	412	361	251	438	903
Second noun phrase	463	422	358	243	457	868
Either	433	426	366	243	436	891
			Total reading time (MS)			
First noun phrase	723	740	576	376	650	1250
Second noun phrase	714	793	581	392	692	1228
Either	666	702	556	349	632	1249
			First-pass regressions (%)			
First noun phrase	0	13	9	11	16	60
Second noun phrase	0	12	9	10	13	58
Either	0	10	8	9	9	57
			First-pass reading time (MS deviation from predicted)			
First noun phrase	71	2	−38	−129	−153	212
Second noun phrase	72	11	−42	−136	−135	183
Either	46	15	−33	−136	−151	201
			Total reading times (MS deviation from predicted)			
First noun phrase	107	100	−50	−225	−210	261
Second noun phrase	80	153	−45	−209	−176	253
Either	49	62	−70	−252	−224	261

[a] Region **4** corresponds to the reflexive pronoun.

2.33, $p > .13$; $F2(1,29) = 2.42$, $p > 13$]. The contrast between the first noun phrase and second noun phrase conditions also was not significant [$F1(1,35) = 1.83$, NS; $F2(1,29) = 2.02$, NS].

Table 4 also presents the results of one-way ANOVAs testing for the effect of attachment on the data from regions 2–5 separately. The analyses on the reflexive pronoun (region 4) attained the standard level of significance in the subjects analysis ($p1 < .05$) and nearly in the items analysis ($p2 < .08$). Tests for simple effects revealed that readers had greater difficulty processing region 4 when the modifier could attach to the second noun phrase than when it could attach to either noun phrase [$F1(1,35) = 6.18$, $p < .02$; $F2(1,29) = 5.25$, $p < .03$]. This replicates the difference found in the relative clause sentences in the previous experiment. As in the broader region, sentences where the modifier attached to the first noun phrase and sentences where the modifier could attach to either noun phrase did not differ [$F1(1,35) = 2.36$, $p = .13$; $F2(1,29) = 1.80$, $p > .19$]. The first noun

TABLE 4

Experiment 2: ANOVA Results by Region for Attachment Effect (Modifier Attaches to First vs Second vs Either Noun Phrase

Example target sentence:

Region	1	2	3	**4**	5	6
	The	daughter	of the colonel	who shot	herself	on the balcony had been upset.

Region	*F*1	*F*2
Regions 2, 3, and **4**[a] combined		
First-pass deviation	<1 (2526)	<1 (2526)
Total Time Deviation	4.15* (18367)	4.43* (16781)
Regressions	1.85 (84)	<1 (87)
Region 2		
First-pass deviation	<1 (2862)	<1 (2473)
Total time deviation	3.73* (20422)	4.89** (13212)
First-pass regressions	1.13 (122)	<1 (107)
Region 3		
First-pass deviation	<1 (2478)	<1 (2474)
Total time deviation	<1 (8104)	<1 (9257)
First-pass regressions	<1 (60)	<1 (63)
Region **4**		
First-pass deviation	<1 (971)	<1 (971)
Total time deviation	3.15* (5366)	2.65 (6907)
First-pass regressions	<1 (90)	<1 (72)
Region 5		
First-pass deviation	<1 (5384)	<1 (5384)
Total time deviation	2.03 (10715)	2.63 (9321)
First-pass regressions	3.29* (116)	5.13** (70)

Note. The ANOVAs treated attachment as a within-participants and within-items factor. Degrees of freedom for participants analyses are (2, 70). Degrees of freedom for item analyses are (2, 58).

[a] Region **4** corresponds to the reflexive pronoun.

* $p < .05$; ** $p < .01$; *** $p < .001$. MS_e appear in parentheses.

phrase condition also did not differ from the second noun phrase condition (Fs < 1).

As in the previous experiment, we divided items into balanced and biased categories on the basis of the rating task, using the same 65% cutoff. Under these criteria, 9 items counted as balanced and 21 items counted as biased. Figure 2 shows total time (deviation) for the reflexive pronoun for balanced and biased items. The balanced items produced little evidence for a main effect of attachment in the total time (deviation) data on the reflexive pronoun [$F1(2,72) = 2.75$, $p < .08$, $MS_e = 29204$; $F2(2,16) = 1.56$, NS, $MS_e = 7842$]. Tests for simple effects also did not detect reliable differences between attachment conditions in the balanced items [N2-attached versus fully ambiguous items produced a trend toward a difference with $p1 < .03$, $p2 < .10$]. However, when we compare the biased and balanced materials, there is no main effect of bias and no interaction of bias with attachment (all $F < 1.32$). Further, reading times on the fully ambiguous materials do not increase as they become more neutrally biased. Finally, as in the previous experiment, we correlated the magnitude of the bias with the difference in reaction time between sentences where the modifier attached to the first noun phrase and sentences where the modifier attached to the second noun phrase. As in the

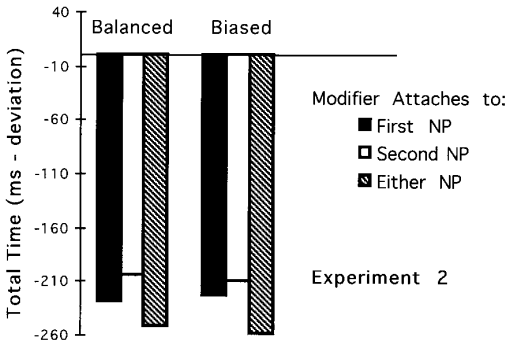

FIG. 2. Experiment 2, mean total time (deviation) scores on Region 4 for balanced and biased items by condition. The set of bars on the left represents mean total time (deviation) for balanced items; the set of bars on the right represents mean total time (deviation) for biased items.

previous experiment, the two were not significantly correlated [$r = .02$, $t(28) < 1$, NS].

This pattern of results, then, confirms the pattern obtained in the previous experiment. In particular, the finding of greater ease of processing of the fully ambiguous sentences was replicated, most clearly in the analysis of first-pass regression frequency. The data thus allow more confident conclusions about the processing of relative clause modifiers in English. The data create difficulty for constraint satisfaction models on two counts. First, ease of processing should reflect off-line preferences, and this did not occur. In particular, readers should have had no difficulty processing the modifier when it attached to the second noun phrase because that was the preferred attachment, but readers did experience difficulty. Second, reading times should be long when context fails to resolve a syntactic ambiguity, and this also did not occur.

These data also provide further evidence for early processing of sentences containing relative clause modifiers. Note that an attachment effect occurred in the first-pass regressions data from the region immediately following the reflexive pronoun. This difference, then, between *The daughter of the colonel who shot himself . . .* and *The brother of the colonel who shot himself . . .* provides further evidence that an implausible attachment to the first noun phrase disrupted processing even when a plausible alternative analysis was available and that participants detected this anomalous attachment rapidly.

The construal hypothesis predicts that in sentences like (7b), readers will associate the modifier within the current theta domain and assess all available attachment sites simultaneously. This prediction is consistent with the current results, if one assumes that a single implausible semantic interpretation can cause disruption. According to this account, sentences like (7a and 7b) produce disruption because readers simultaneously interpret *himself* as being potentially coreferential with *daughter* and *colonel* and coreference between *himself* and *daughter* creates conflict.

The assumption that one implausible analysis is enough to cause disruption would conflict with explanations of previous experimental results (Boland, Tanenhaus, Garnsey, & Carlson, 1995). Boland et al. investigated unbounded dependency constructions containing verbs like *persuaded* that have two available argument slots. Readers did not experience disruption on the matrix verb when the direct object analysis produced an implausible interpretation, as in *That's the movie that John persuaded . . . .* Boland et al. argued that disruption did not occur because readers simultaneously treated *movie* as a direct object argument and as part of an infinitival phrase, as in *That's the movie that John persuaded the children to watch.* Boland et al. suggested that if the direct object analysis produced an implausible result readers foregrounded the alternative infinitival analysis at little or no cost. If the same argument were applied to adjunct modifier attachment, then no disruption should have occurred in sentences like (7a and 7b) from the current experiment, or sentences like (3a & b) from the previous experiment. Therefore, if the pattern we observed in these experiments holds in the resolution of other attachment ambiguities, it may be the case that modifier attachment is handled differently than verb argument assignment.

EXPERIMENT 3

Experiment 3 examined processing of relative clauses in another type of sentence. Gilboy et al. (1995) demonstrated that in an off-line

judgment task Spanish and English speakers' preferences for attaching a modifier depended on whether the noun phrase complex contained a theta-assigning preposition. The construal hypothesis explains this effect by suggesting that when a modifier represents a nonprimary relation, readers associate the modifier to the current theta domain and then evaluate all potential hosts within that domain. In Experiment 3, we tested sentences like (8a–8c), where only one attachment site was available in the active theta domain during processing of the modifier.

The steak with the sauce that was tough didn't win a prize. (8a)
The steak with the sauce that was runny didn't win a prize. (8b)
The steak with the sauce that was tasty didn't win a prize. (8c)

These sentences differ from those in the preceding experiments in the preposition used within the complex noun phrase. In Experiments 1 and 2, the preposition *of* was used. This preposition transmits a theta role from the first to the second noun rather than assigning a theta role itself. In this case, *of* takes a theta role provided by the first noun phrase and assigns it to the second noun phrase. In Experiment 3, the preposition *with* was used. This preposition assigns its own theta role to its object. In other words, no theta role is transmitted from the first to the second noun phrase. Thus, in sentences like (8a–8c), when readers encounter the modifier only the second noun phrase (e.g., *the sauce*) is available within the currently active theta domain.

Gilboy et al. (1995) demonstrated that a relative clause following a noun phrase complex was more likely to modify the second noun when the preposition *with* joined the two nouns than when *of* did. They interpreted this effect as supporting construal's claim that a modifier is associated to the domain of the most recent theta assigner. This domain includes both nouns when the preposition in the noun phrase complex is *of* but only the second noun when the preposition is *with.* This interpretation implies that an on-line experiment should demonstrate a reading-time preference when a relative clause modifies the second noun in the configuration *noun phrase 1 with noun phrase 2 relative clause* compared to when it modifies the first noun.

Participants

Thirty-six native (British) English speakers from the same pool as the previous experiments were paid to participate in the eye-tracking phase of the study. Some had participated in previous eye-tracking experiments.

Items

We constructed 36 sets of sentences like (8a–8c); see Appendix. All of the sentences began with a noun phrase complex containing two noun phrases connected by the theta-assigning preposition *with.* All of the sentences continued with a relative clause modifier that began with *that.* We counterbalanced the positions of the nouns in the noun phrase complex across items to ensure that irrelevant characteristics of the nouns did not influence readers' responses to the relative clause modifiers. The predicate adjectives in the relative clause modifiers were matched for length and frequency [e.g., *tough, runny,* and *tasty* were equally long and occurred equally frequently in the CELEX corpus of spoken and written English (Baayen, Piepenbrock, & van Rijn, 1993)]. There were also 86 filler sentences. Thirty-six of these were from an additional experiment and contained an initial phrase that could be interpreted either as a noun phrase or as a gerund (e.g., *Feeding sharks frightened the visiting biologist in the wetsuit.*). The rest were of various syntactic types. All sentences were displayed on a single line.

Plausibility Norming

To determine the plausibility of the noun phrase/modifier combinations, 20 raters assigned ratings to 228 sentences like (9a–9f):

The steak was tough. (9a)	(mean = 6.8)
The steak was runny. (9b)	(mean = 1.1)
The steak was tasty. (9c)	(mean = 6.2)
The sauce was tough. (9d)	(mean = 0.9)
The sauce was runny. (9e)	(mean = 6.5)
The sauce was tasty. (9f)	(mean = 6.2)

Raters assigned each sentence a score from 0

(makes no sense) to 7 (makes perfect sense). All of the items in the plausible conditions (9a, 9c, 9e, and 9f) received mean ratings of 5 or above. All of the items in the implausible conditions (9b and 9d) received mean ratings of 2 or below.

Attachment Preferences

We determined attachment preferences for the sentences in Experiment 3 using the forced-choice task from Experiment 1 in which raters decided which noun phrase the modifier referred to in fully ambiguous sentences like (8c). Twenty participants indicated that the modifier attached to the second noun phrase in the complex 81% of the time. Eighteen of 20 participants and 33 of 36 items produced a preference for attachment to the second noun phrase ($p_1 <$ .01; critical value of $\chi_2 = 25$, $p < .01$).

Procedure

The experimental procedure was identical to the previous experiment.

Regions

For statistical analysis, we divided the sentences into six scoring regions (see Appendix for region boundaries for each item). The first region included the first noun phrase in the complex. The second region included the preposition and the second noun phrase in the complex. The third region included the following text up to, but not including the predicate adjective in the modifier. The fourth region included the predicate adjective of the modifier. The fifth region included the first two words of the following verb phrase. The sixth and final region included the remainder of the sentence.

Analyses

All factors were treated as within participants and within items. A small percentage (6.8%) of the data were removed due to track loss or extremely short fixation times.

Predictions

According to the construal hypothesis, attachment outside the currently active theta domain should be difficult. Thus, readers should experience more difficulty processing the relative clause modifier in (8a) than in (8b and 8c). The traditional garden path and constraint satisfaction accounts make the same prediction in this case. Garden path theory proposes that late closure applies and so attachment to the second noun phrase in the complex should be easier. The constraint satisfaction prediction is based on the assumption that the items are biased toward attaching the modifier to the second noun phrase.

Results and Discussion

Table 5 presents mean first-pass, total time, and first-pass regressions by region and condition for Experiment 3. Table 6 presents results of the statistical analyses.

As in the previous experiment, the sharpest result occurred in the regressions data from the region immediately following the critical region, in this case the region following the predicate adjective (region 5). This region produced a main effect of attachment (modifier attaches to the first vs second vs either noun phrase). The effect is the result of attachment to the first noun phrase producing more disruption than attachment to the second noun phrase [$F1(1,35) = 13.23$, $p < .001$; $F2(1,35) = 6.86$, $p = .01$] or when attachment to either noun phrase was possible [$F1(1,35) = 14.26$, $p < .001$; $F2(1,35) = 6.57$, $p = .01$]. Readers produced the same number of first-pass regressions when attachment to both nouns was possible and when only attachment to the second noun was possible (both $F < 1$). Note that this effect occurred in the same postcritical region as the regressions effect from Experiment 2.

As in the previous experiments, we examined processing across regions 2–4, as this would indicate whether readers' processing was consistent across a substantial portion of the sentence. Analyses of the total time deviation data revealed a reliable main effect of attachment (see 1st panel of Table 6). This main effect occurred because sentences where the modifier attached to the first noun phrase were more difficult to process than sentences where the modifier attached to the second noun phrase [$F1(1,35) = 9.77$. $p < .01$; $F2(1,35) = 15.7$,

TABLE 5

Experiment 3: Mean First-Pass and Total Reading Time and First-Pass Regressions by Region and Condition

Example target sentence:

Region 1 2 3 **4** 5 6

The steak with the sauce that was tough didn't please the judges.

	Region					
Modifier attaches to	1	2	3	**4**[a]	5	6
			First-pass reading time (MS)			
First noun phrase	379	409	286	271	347	426
Second noun phrase	374	433	284	267	356	428
Either	388	420	282	257	344	433
			Total reading time (MS)			
First noun phrase	527	784	504	461	595	570
Second noun phrase	533	731	436	400	545	548
Either	532	725	470	399	549	591
			First-pass regressions (%)			
First noun phrase	0	11	9	18	22	59
Second noun phrase	0	11	9	16	14	61
Either	0	10	16	14	14	64
			First-pass reading time (MS deviation from predicted)			
First noun phrase	35	−55	−45	−40	−1	59
Second noun phrase	29	−34	−48	−42	13	63
Either	48	−47	−50	−52	−4	65
			Total reading time (MS deviation from predicted)			
First noun phrase	8	32	14	6	72	4
Second noun phrase	13	−23	−55	−54	20	−18
Either	17	−27	−21	−53	23	21

[a] Region **4** corresponds to the predicate adjective in the modifier.

$p < .001$] and sentences where the modifier could attach to either noun phrase [$F1(1,35) = 6.73$, $p = .012$; $F2(1,35) = 9.77$, $p < .01$]. Means in the other two attachment conditions did not differ (Fs < 1).

The total time deviation data produced precisely the same effects when we analyzed the data from regions 2–5 individually (only the participants analyses for region 2 failed to produce statistically reliable effects). For comparison to the previous experiments, the head noun of the modifier (region 4) produced a reliable main effect of attachment (see 4th panel of Table 6). This occurred because sentences where the modifier attached to the first noun phrase were more difficult to process than sentences where the modifier attached to the second noun phrase [$F1(1,35) = 9.13$. $p < .01$; $F2(1,35) = 12.6$, $p < .001$] and sentences where the modifier could attach to either noun phrase [$F1(1,35) = 8.93$, $p < .01$; $F2(1,35) = 9.51$, $p < .01$]. Means in the other two attachment conditions did not differ (Fs < 1).

If more neutral items produced greater com-

TABLE 6

Experiment 3: ANOVA Results by Region for Attachment Effect (Modifier Attaches to First vs Second vs Either Noun Phrase)

Example target sentence:

Region	1	2	3	**4**	5	6
	The	steak	with the	sauce	that was	tough didn't please the judges.

Region	*F*1	*F*2
Regions 2, 3, and **4**[a] combined		
First-pass deviation	1.18 (1700)	<1 (2132)
Total time deviation	5.59** (20858)	8.60*** (13271)
Regressions	<1 (102)	<1 (109)
Region 2		
First-pass deviation	1.43 (2848)	1.37 (3019)
Total time deviation	2.14 (18528)	3.03* (12971)
First-pass regressions	<1 (45)	<1 (139)
Region 3		
First-pass deviation	<1 (1390)	<1 (1150)
Total time deviation	5.37** (8008)	6.58** (6655)
First-pass regressions	<1 (91)	<1 (73)
Region **4**		
First-pass deviation	1.33 (1221)	<1 (1628)
Total time deviation	6.02** (7081)	7.46** (5821)
First-pass regressions	<1 (121)	<1 (175)
Region 5		
First-pass deviation	1.09 (2581)	1.14 (2320)
Total time deviation	3.17* (9470)	4.07* (7734)
First-pass regressions	9.17*** (86)	4.48* (166)

Note. The ANOVAs treated attachment as a within-participants and within-items factor. Degrees of freedom for all analyses are (2, 70).

[a] Region **4** corresponds to the predicate adjective in the modifier.

* $p < .05$; ** $p < .01$; *** $p < .001$. MS_e in parentheses.

petition, then we should observe longer reading times for fully ambiguous neutrally biased items. As in the preceding Experiment, we identified items where the bias was 65% or less in favor of attachment to the second noun phrase and then examined the total time deviation data from the critical region (Region 4). In this experiment, six items satisfied the criteria for balanced items. Figure 3 shows results separately for balanced and biased items. Item type (balanced vs biased) and attachment did not produce main effects or interactions (Fs < 1). When the balanced items were analyzed separately, the attachment effect was eliminated (Fs < 1) despite the fact that the pattern of means was nearly identical to that in the biased items. This result reflects the loss of sensitivity due to the small number of items included in the analysis.

One final correlational analysis tested a further prediction of constraint satisfaction accounts. According to such accounts, processing time should reflect off-line preferences. Thus, for each item, we subtracted the total time (deviation) on the head noun of the modifier when the modifier attached to the second noun phrase from the total time (deviation) when the modifier attached to the first noun phrase. We then attempted to predict this difference using the strength of the preference for attachment to the

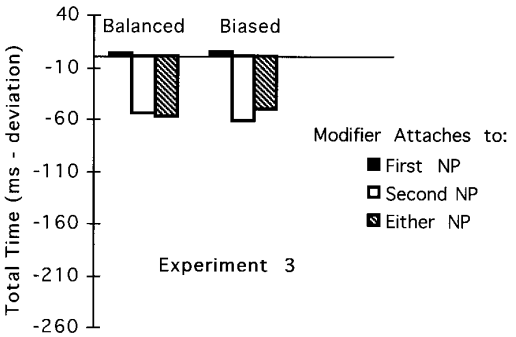

FIG. 3. Experiment 3, mean total time (deviation) scores on Region 4 for balanced and biased items by condition. The set of bars on the left represents mean total time (deviation) for balanced items; the set of bars on the right represents mean total time (deviation) for biased items.

second noun phrase. According to the constraint satisfaction account, the difference in processing time for attachment to the first versus second noun phrase should increase as the preference for attachment to the second noun phrase increases. The obtained correlation, however, was not statistically significant [adjusted $r = -.02$, $t(34) = -.133$, NS].

Readers in Experiment 3 treated relative clause modifiers much differently than readers in the previous two experiments. Here, attaching the modifier to the second noun phrase was accomplished just as readily when the modifier had to attach to the second noun phrase as when the modifier could attach to either noun phrase in the complex. This stands in stark contrast with the previous two experiments. There, processing proceeded most fluently when the modifier could attach to either noun phrase. If attachment to the first noun phrase produced an implausible interpretation, reading was disrupted, even if attachment to the second noun phrase produced a plausible result. This pattern of results, then, suggests that readers in Experiment 3 did not attempt to attach relative clause modifiers to the first noun phrase when attachment to the second noun phrase produced a plausible result; whereas readers in the previous experiments did attempt to attach relative clause modifiers to the first noun phrase when attachment to the second noun phrase produced a plausible result.

In a sense, the results of Experiment 3 are unsurprising because all theories predicted their general outline. However, we believe that they are of value for at least two reasons. First, the prediction made by constraint satisfaction theories was based on the assumption that the off-line bias of individual items would predict the relative difficulty of processing them in the on-line task. This assumption was explicitly contradicted in analyses that explored the effects of off-line biases. We suggest that the observed tendency to take a relative clause as modifying the second noun phrase in Experiment 3 reflects a general structural preference, not the detailed properties of individual items. Second, the results of Experiment 3 are of value simply because they show that the primary result of Experiments 1 and 2, the greater difficulty of reading unambiguous than ambiguous items, does depend on structural details of the sentences being read and is not somehow an artifact of our experimental materials or a general effect of some sort of preference for ambiguity.

GENERAL DISCUSSION

In Experiment 1, readers treated prepositional phrase modifiers differently than relative clause modifiers. In sentences with relative clause modifiers, processing times decreased when two syntactic analyses produced plausible semantic interpretations versus when only one syntactic analysis produced a plausible semantic interpretation. Most strikingly, reading times for sentences where the relative clause modifier had to attach to the second noun phrase were just as high as for sentences where the modifier had to attach to the first noun phrase, despite the fact that readers preferred to attach modifiers to the second noun phrase. Further, processing times in the first experiment for fully ambiguous sentences that had relative clause modifiers did not increase when the off-line attachment preferences for those sentences were more neutral. The second experiment replicated these effects. The third experiment demonstrated that sentences with relative clause modifiers that had to attach to the second noun phrase were processed as rapidly as sentences where attachment to either noun phrase was possible when a theta-

assigning preposition was present in the noun phrase complex. This contrasts with the pattern obtained in the previous two experiments.

Before interpreting these results with respect to current models of parsing, we must first address potential artifactual explanations for the observed pattern of results. First, it is possible that using the relativizer *that* to refer to human referents is infelicitous and may, therefore, have skewed the results of Experiments 1 and 3 in some way. However, if the relativizer *that* had skewed the results of the first experiment, then relative clause modifiers should have behaved differently in Experiment 1 (where *that* sometimes referred to human entities) than in Experiment 2 (where all of the referents were human and where all of the relative clauses began with the relativizer *who*). The fact that relative clause modifiers behaved the same way in both experiments suggests that any infelicity associated with the relativizer *that* did not markedly alter readers' responses. Note further that in the Scottish dialect spoken by the majority of participants in these experiments, referring to animate entities with the relativizer *that* is the preferred form (Romaine, 1982). Thus, Scottish participants should have experienced little difficulty when the relativizer *that* referred to animate entities. One might also suggest that fast response times on the fully ambiguous materials are the result of greater naturalness or felicity of the noun phrase complexes in the fully ambiguous items. This explanation, however, implies that fully ambiguous sentences with prepositional phrase modifiers from Experiment 1 should have been processed more easily than the disambiguated sentences, and they were not.

An account of human sentence processing must explain several findings from these experiments. Most importantly, it must explain why readers experienced less disruption in processing when two analyses produced plausible interpretations than when only one analysis produced a plausible interpretation. It must also explain what causes readers to change their behavior when presented with different kinds of modifiers. Further, it must explain why readers' behavior differs between sentences with non-theta-assigning prepositions and sentences with theta-assigning prepositions in the initial noun phrase complex. Finally, it must explain why readers sometimes experience difficulty when the preferred analysis produces a plausible semantic interpretation.

The standard garden path theory cannot account for the present results. The late closure principle suggests that readers will always attempt initially to attach the modifier to the second noun phrase in the complex in our sentences. Thus, reading times should have been fast when this attachment produced a plausible interpretation and slow when it did not. It should not matter whether attachment to the first noun phrase in the complex produced a plausible interpretation. Late closure fails on both counts. Reading times were not always fast when the second attachment site produced a plausible interpretation; and an implausible interpretation resulting from attachment at the first site sometimes produced disruption.

Constraint satisfaction accounts also do not predict the present pattern of results. According to such accounts, readers should experience difficulty when multiple analyses have nearly equal support from all relevant sources of information or when late-arriving disambiguating information contradicts an initial preference. We assume that the fully ambiguous sentences used in Experiments 1 and 2 qualify as having nearly equal support for both analyses, which should have resulted in extended competition between the closely matched competitors and slow reading time for the fully ambiguous sentences. However, if the off-line bias favoring modification of the second noun phrase was in fact large enough to lead to an initial activation of the analysis in which the second noun phrase was modified, then reading should have been faster when the relative clause modified the second than the first noun phrase. Neither predicted result was observed in Experiments 1 and 2. The advantage for modifying the second noun phrase that was observed in Experiment 3 did not appear to reflect off-line biases when examined on an item-by-item basis, but instead probably reflected general structural effects.

If competition resolves ambiguity at the level of word meanings, but not at the level of syn-

tactic structure, then it may not be accurate or useful to think of processing at one level as a version of the other (MacDonald et al., 1994). Syntactic ambiguity resolution, then, may not be simply described as a form of lexical ambiguity resolution. It may be that different processes are required for resolving lexical ambiguities and some kinds of syntactic ambiguities, simply because the consequences of a mistake are different at the two levels. If a word's lexical identity is not disambiguated, this will have repercussions for other aspects of a sentence meaning and possibly syntactic structure (if, for example, a noun were misidentified as a verb or a transitive verb as an intransitive verb). However, misattachment of a modifier to the first or the second noun phrase in a complex has no implications for the grammatical analysis of the rest of the sentence. This observation might help explain why lexical ambiguities are resolved in a time-consuming fashion while modifier–attachment ambiguities are apparently tolerated. Frazier and Clifton (1996) develop this line of argument further, contrasting the processing of modifier (nonprimary) phrases with the processing of primary phrases whose analysis does have implications for the lexical and grammatical analysis of the remainder of a sentence and which are apparently resolved in a determinate fashion.

Construal can account for the finding that readers process prepositional phrase modifiers differently than relative clause modifiers by assuming that prepositional phrases in the configuration *noun phrase of noun phrase prepositional phrase* are treated as primary relations. The difference in processing between prepositional phrase modifiers and relative clause modifiers would reflect the differing status of primary and nonprimary relations. Construal is straightforwardly compatible with the difference in processing that occurs when non-theta-assigning prepositions are replaced by theta-assigning prepositions in the noun phrase complex. This difference in processing reflects the difficulty of attaching incoming material outside the active theta domain. Construal does not straightforwardly predict fast reading times for the fully ambiguous sentences and thus requires further auxiliary assumptions to account for this result. Further, to the extent that construal is committed to treating prepositional phrases as primary phrases, it incorrectly predicts a late closure advantage for them. This suggests that further work is needed to understand just when and how phrases are identified as primary versus nonprimary.

One assumption that could account for fast reading times in fully ambiguous sentences would be that readers did not resolve the ambiguity. Given this assumption, readers would evaluate both attachment sites (when the modifier was a relative clause) and resolve the ambiguity only when it was possible to discover a single plausible analysis. On this account, resolution in the fully ambiguous condition would not be possible and processing would stop as soon as this became apparent (i.e., as soon as both analyses had been computed). In the other conditions, the same amount of time would be required to compute both analyses, but further processing time would be required to select the plausible analysis (or, possibly, suppress the activation of the implausible analysis).

Alternatively, people may resolve the ambiguity by committing to the first plausible analysis that becomes available. This would be in line with the idea that readers' superordinate goal is to figure out what the sentence means as quickly as possible. This assumes again that all attachment sites in the current theta domain are checked when the modifier instantiates a nonprimary relation. On this account, the modifier would be associated within the current theta domain. Evaluation of potential hosts would proceed in parallel from that point, but there might be some variation in how quickly the different analyses were computed. If the analyses randomly took slightly different times to complete on different trials, then attachment to the first noun phrase would be completed slightly faster some of the time and attachment to the second noun phrase would be completed slightly faster some of the time. This would mean that for the disambiguated materials attachment to the site that produced an implausible interpretation would be computed first some of the time. If the reader committed to that

implausible analysis, extra processing time would be required to get rid of it and finish computing the other analysis. Thus, disruption would occur in these sentences for the same reason it occurs in other garden path sentences. Reanalysis would never be required in the fully ambiguous sentences because the first available analysis would always be plausible, and so readers would never experience difficulty after committing to their initial analysis. If this second account is correct, then the elevated reading times in the disambiguated sentences are produced by reanalysis and not by differences in the speed at which an initial analysis is computed.

The data are consistent with a model incorporating a two-stage parser that makes reference to both syntactic and nonsyntactic information to process adjunct modifiers. In an initial stage, evidence accrues for one or more syntactic analyses. When one analysis wins the race to exceed some threshold, it is selected, presumably immediately, after it exceeds threshold. If subsequent input is consistent with the chosen analysis, no difficulty ensues. If subsequent input makes the chosen analysis infelicitous, reanalysis begins, causing measurable disruption in processing.

CONCLUSIONS

We began this article by asking whether syntactic parsing is best described as a process of lexical ambiguity resolution. Whereas alternative lexical representations seem to compete with one another when prior context does not favor one meaning over another, this does not seem to be the case for syntactic structures governing adjunct attachment. If competition between analyses determined adjunct attachment, then we should not have observed faster processing of globally ambiguous sentences. In fact we found no evidence for competition, but rather cases that should produce competition under constraint-based accounts were actually the easiest to process. The relative frequency with which different word meanings occur also seems to play a crucial role in lexical disambiguation. If similar statistics were compiled for the syntactic structures governing adjunct attachment, and if those statistics were accessed during processing, then readers should have had no difficulty processing sentences where the preferred attachment produced a plausible interpretation. Because we did find evidence of difficulty in such cases, we propose that either statistics are not compiled for such structures or they are not routinely employed to guide initial decisions. Thus, in light of the results of the data reported here, we propose that syntactic ambiguity resolution differs from lexical ambiguity resolution in at least two vital respects.

APPENDIX

Note that "|" marks indicate region boundaries and "/" marks indicate where different words appeared in different conditions. Line breaks occurred at the points marked "(cr)" in Experiment 2.

Experiment 1 Stimuli

The driver| of the car| with/that had the| moustache| was pretty cool.
The car| of the driver| with/that had the| moustache| was pretty cool.
The son| of the driver| with/that had the| moustache| was pretty cool.

The car| of the driver| with/that had the two| carburettors| excited us.
The driver| of the car| with/that had the two| carburettors| excited us.
The engine| of the car| with/that had the two| carburettors| excited us.

The chapter| of the author| with/that had the| preface| is causing a stir.
The author| of the chapter| with/that had the| preface| is causing a stir.
The draft| of the contract| with/that had the| preface| is causing a stir.

The writer| of the letter| with/that had the round| spectacles| arrived.
The letter| of the writer| with/that had the round| spectacles| arrived.
The sister| of the writer| with/that had the round| spectacles| arrived.

The house| of the painter| with/that had the small| windows| was large.

The painter| of the house| with/that had the small| windows| was large.
The bedroom| of the house| with/that had the small| windows| was large.

The bishop| of the church| with/that had the funny| eyebrows| made us cry.
The church| of the bishop| with/that had the funny| eyebrows| made us cry.
The sister| of the bishop| with/that had the funny| eyebrows| made us cry.

The church| of the bishop| with/that had the large| spires| faced a lake.
The bishop| of the church| with/that had the large| spires| faced a lake.
The towers| of the church| with/that had the large| spires| faced a lake.

The king| of the mountain| with/that had the| sideburns| impressed Arthur.
The mountain| of the king| with/that had the| sideburns| impressed Arthur.
The minister| of the king| with/that had the| sideburns| impressed Arthur.

The manager| of the factory| with/that had the loud| voice| was efficient.
The factory| of the manager| with/that had the loud| voice| was efficient.
The brother| of the manager| with/that had the loud| voice| was efficient.

The thesis| of the editors| with/that had the| misspellings| was rubbish.
The editors| of the thesis| with/that had the| misspellings| was rubbish.
The chapter| of the thesis| with/that had the| misspellings| was rubbish.

The editors| of the thesis| with/that had the| spectacles| made sense.
The thesis| of the editors| with/that had the| spectacles| made sense.
The father| of the editors| with/that had the| spectacles| made sense.

The tartan| of the clan| with/that had the| stripes| lay in the castle.
The clan| of the tartan| with/that had the| stripes| lay in the castle.
The tartan| of the kilt| with/that had the| stripes| lay in the castle.

The animals| of the forest| with/that had the big| fangs| frightened us.
The forest| of the animals| with/that had the big| fangs| frightened us.
The mouths| of the animals| with/that had the big| fangs| frightened us.

The forest| of the animals| with/that had the big| clearings| pleased us.
The animals| of the forest| with/that had the big| clearings| pleased us.
The valleys| of the forest| with/that had the big| clearings| pleased us.

The valley| of the flowers| with/that had the old| castle| excited a girl.
The flowers| of the valley| with/that had the old| castle| excited a girl.
The village| of the valley| with/that had the old| castle| excited a girl.

The plains| of the tribe| with/that had the rich| topsoil| looked strange.
The tribe| of the plains| with/that had the rich| topsoil| looked strange.
The hills| of the plains| with/that had the rich| topsoil| looked strange.

The director| of the orchestra| with/that had a big| forehead| plays well.
The orchestra| of the director| with/that had a big| forehead| plays well.
The neighbour| of the director| with/that had a big| forehead| plays well.

The solicitor| of the company| with/that had the new| tuxedo| bothered me.
The company| of the solicitor| with/that had the new| tuxedo| bothered me.
The brother| of the solicitor| with/that had the new| tuxedo| bothered me.

The supplier| of the drugs| with/that had the| grimace| killed a kid.
The drugs| of the supplier| with/that had the| grimace| killed a kid.
The uncle| of the supplier| with/that had the| grimace| killed a kid.

The drugs| of the supplier| with/that had a nasty| effect| hurt everyone.
The supplier| of the drugs| with/that had a nasty| effect| hurt everyone.
The chemicals| of the drug| with/that had a nasty| effect| hurt everyone.

The gold| of the miner| with/that had the| impurities| isn't worth much.
The miner| of the gold| with/that had the| impurities| isn't worth much.
The gold| of the batch| with/that had the| impurities| isn't worth much.

The singer| of the song| with/that had long| eyelashes| is pretty stupid.
The song| of the singer| with/that had long| eyelashes| is pretty stupid.
The aunt| of the singer| with/that had long| eyelashes| is pretty stupid.

The restaurant| of the patron| with/that had the blue| tiles| pleased us.
The patron| of the restaurant| with/that had the blue| tiles| pleased us.
The garden| of the restaurant| with/that had the blue| tiles| pleased us.

The inventor| of the machine| with/that had the| goatee| is amazing.
The machine| of the inventor| with/that had the| goatee| is amazing.
The brother| of the inventor| with/that had the| goatee| is amazing.

Experiment 2 Stimuli

The sister/brother| of the actress| who shot| herself/himself| on the balcony| was (cr) under investigation.
The sister/uncle| of the fireman| who criticized| herself/himself| far too often| (cr) was painting the bedroom.
The secretary/companion| of the salesman| who amused| himself/herself| quite a bit| (cr) was writing a letter to the editor.
The mother/father| of the bride| who embarrassed| herself/himself| at the (cr) reception| was complaining to the vicar.
The aunt/uncle| of the bishop| who injured| himself/herself| last summer| was (cr) concerned| about the infection.
The brother/hostess| of the mayor| who complimented| himself/herself| constantly| (cr) was bothered by the reporter.
The niece/nephew| of the waitress| who hurt| herself/himself| on the broken glass| (cr) was shocked by the accident.
The brother/daughter| of the seamstress| who entertained| herself/himself| most (cr) evenings| was reading a book.
The father/sister| of the schoolgirl| who burned| herself/himself| the other day| (cr) was usually very careful.
The uncle/aunt| of the nun| who lost| himself/herself| in thought| was disturbed (cr) by the noise.
The mother/father| of the surgeon| who made a fool of| herself/himself| at the (cr) party| was greatly embarrassed.
The servant/son| of the princess| who scratched| herself/himself| in public| was (cr) terribly embarrassed.
The great-aunt/great-uncle| of the policeman| who treated| herself/himself| after the (cr) accident| was watching the news.
The father/mother| of the prostitute| who killed| himself/herself| last summer| had (cr) lived in Wales.
The sister/husband| of the beautician| who cut| herself/himself| on the broken (cr) glass| phoned for a doctor.
The widow/uncle| of the general| who sacrificed| himself/herself| for the cause| (cr) was the subject of the biography.
The grandmother/bank manager| of the heiress| who bankrupted| herself/himself| last (cr) year| still made risky investments.
The niece/nephew| of the fisherman| who drowned| himself/herself| in the ocean| (cr) didn't know about the tricky current.
The mistress/neighbour| of the actor| who hated| himself/herself| for lying| left (cr) town in a hurry.
The sister/brother| of the count| who crippled| himself/herself| by falling off a (cr) horse| took a long time to get over it.
The wife/son| of the janitor| who educated| herself/himself| at night| loved (cr) going to the theatre.
The niece/nephew| of the commander| who

calmed| himself/herself| after the (cr) tragedy| was waiting for the doctor.

The father/mother| of the ballerina| who found| himself/herself| in a lot of (cr) trouble| phoned the police.

The daughter/assistant| of the chaplain| who drew attention to| herself/himself| all (cr) the time| hated small children.

The grandmother/grandfather| of the stewardess| who treated| herself/himself| to an (cr) ice-cream cone| was waiting at home.

The grand-niece/grand-nephew| of the admiral| who wrote| himself/herself| a note| (cr) admired sailors very much.

The brother/sister| of the butcher| who invited| himself/herself| to the party| (cr) enjoyed it quite a bit.

The sister/nephew| of the baroness| who admired| herself/himself| an inordinate (cr) amount| enjoyed all the attention.

The daughter/brother| of the colonel| who enjoyed| himself/herself| a lot| was out (cr) on the balcony.

The bodyguard/maid| of the baroness| who prepared| himself/herself| very (cr) thoroughly| came from the north.

Experiment 3 Stimuli

The firm| with the solicitor| that was| created/smiling/noticed| made a| lot of money.

The solicitor| with the firm| that was| created/smiling/noticed| made a| big mistake.

The machine| with the engineer| that was| invented/dreaming/replaced| made life| easy.

The engineer| with the machine| that was| invented/dreaming/replaced| made work| fun.

The supplier| with the drug| that was| grinning/powdered/powerful| appeared in| person.

The drug| with the supplier| that was| grinning/powdered/powerful| appeared on| the BBC.

The singer| with the song| that was| distressed/transposed/disgusting| upset the| old lady.

The song| with the singer| that was| distressed/transposed/disgusting| upset our| sister.

The writer| with the book| that was| excited/written/tedious| caused a| big scene.

The book| with the writer| that was| excited/written/tedious| caused an| argument.

The driver| with the car| that was| boastful/repaired/examined| won a| lot of races.

The car| with the driver| that was| boastful/repaired/examined| won the| championship.

The diver| with the ship| that was| annoyed/rusting/leaving| stopped at| the pier.

The ship| with the diver| that was| annoyed/rusting/leaving| stopped near| the port.

The waiter| with the restaurant| that was| eating/closed/rotten| became an| actor.

The restaurant| with the waiter| that was| eating/closed/rotten| became famous.|

The writer| with the note| that was| excited/xeroxed/unusual| irritated the| woman.

The note| with the writer| that was| excited/xeroxed/unusual| irritated us| students.

The meat| with the sauce| that was| tough/runny/tasty| didn't win| the top prize.

The sauce| with the meat| that was| tough/runny/tasty| didn't please| the diners.

The painter| with the house| that was| angry/built/close| made crafts| for us.

The house| with the painter| that was| angry/built/close| made our| street nicer.

The thesis| with the editor| that was| printed/talking/tedious| amazed the| tutor.

The editor| with the thesis| that was| printed/talking/tedious| amazed the| author.

The landlord| with the building| that was| courageous/demolished/horrifying| bothered us.|

The building| with the landlord| that was| courageous/demolished/horrifying| bothered them.|

The sheriff| with the territory| that was| killed/mapped/famous| inspired the| kids.

The territory| with the sheriff| that was| killed/mapped/famous| inspired the| boys.

The child| with the rattle| that was| crying/broken/silent| caught our| attention.

The rattle| with the child| that was| crying/broken/silent| caught our| eye today.

The pilot| with the plane| that was| grinning/repaired/grounded| helped win| the war.

The plane| with the pilot| that was| grinning/repaired/grounded| helped bomb| the city.

The chef| with the food| that was| insane/cooked/horrid| made a| lot of salads.

The food| with the chef| that was| insane/cooked/horrid| made a| lot of people sick.

The pauper| with the bag| that was| angry/empty/dirty| lay on| the street all day.

The bag| with the pauper| that was| angry/empty/dirty| lay in| the gutter today.

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