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Syntactic Prominence Effects on Discourse Processes

GAIL MCKOON, ROGER RATCLIFF, AND GREGORY WARD

Northwestern University

AND

RICHARD SPROAT

AT&T Bell Laboratories

We propose that the meaning of a text is determined in part by syntactic structures that affect the relative prominence given to the concepts in the text. This proposal was tested in four experiments; the data showed that concepts placed in syntactically prominent positions have increased accessibility in short-term memory during reading and also increased accessibility later in long-term memory. We speculate on how such effects might be understood in terms of current theories of text processing and memory retrieval.

It is often assumed that little or no syntactic information is represented in long-term memory for discourse; once syntactic information has served its purpose of organizing different pieces of information into their relative roles of subject and object, pronoun and antecedent, given and new, and so on, it is quickly forgotten. The generally accepted rule is that memory for the verbatim surface forms of sentences lasts only a few seconds. In contemporary psycholinguistics, this assumption had its roots in demonstrations by Sachs (1967; see also Jarvell, 1971; Caplan, 1972) that only the meaning of sentences is remembered, and the assumption has been incorporated into models of memory for text (cf. Anderson & Bower, 1973; Kintsch, 1974; Kintsch & Van Dijk, 1978). The assumption is still current, as evidenced by the absence of discussion of syntactic structures in recent theoretical work on discourse processes (cf. Kintsch, 1988; McKoon & Ratcliff, 1992a). Despite the fact that syntactic information has been intensively studied within the context of comprehension for single sentences (cf. Boland, Tanenhaus, & Garnsey, 1990; Fodor, 1989; Fodor, in press; Frazier & Rayner, 1982; McKoon, Ratcliff, & Ward, 1993; Rayner & Morris, 1991), its possible role in controlling the semantic interpretation of larger discourse units has received little attention. In this article, we attempt to begin to fill this gap by investigating the role of syntax in determining the relative prominence, or salience, of different parts of a discourse.

Despite the wide acceptance of the idea that syntactic information is not remembered, there have been several empirical demonstrations to the contrary. Keenan (1975) and Anderson (1974) showed relatively long-term memory for the exact wording of sentences read in an experimental situation, and Keenan, MacWhinney, and Mayhew (1977) and Kintsch and Bates (1977) showed such memory for spoken discourse from more natural situations. Begg and Wickelgren (1974) found that syntactic information was not forgotten at a faster

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rate than semantic information. However, perhaps surprisingly, none of these demonstrations changed the prevailing theoretical view. The reason for this may lie in the (sometimes implicit) belief that memory for surface information resides in a different form or kind of representation than memory for meaning. Putting verbatim surface information in a different kind of memory makes it plausible that it can, on rare occasions like the studies just mentioned, last longer than the usual few seconds, but still have no influence on meaning. This notion of a different kind of memory for surface form was suggested by Kolers (1976; Kolers & Roediger, 1984), who proposed that the procedures with which information is acquired are remembered not as objects in memory but rather are evidenced in facilitation when those same procedures are reexecuted at a later time. The notion of a different kind of memory for surface form is also part of Kintsch's models (van Dijk & Kintsch, 1983; Kintsch, Welsch, Schmalhofer, & Zimny, 1990); in these models, surface information is encoded into a different level of representation from other kinds of discourse information. In this article, we do not take issue with the view that surface information is represented separately. What we do claim is that, in addition to whatever separate memory may exist for surface information, there are also direct effects of syntactic surface information on the representation of meaning.

The generally accepted role of syntactic information is to connect pieces of information together in their syntactically specified roles. Consider the sentences *The student had to clean up his apartment. He crammed his closet with boxes.* Syntactic processes would identify *the student* as subject of the verbs *clean* and *cram, student* as the referent of *he,* and perhaps, for the second sentence, *he* as old information and *crammed his closet with boxes* as new information (cf. Chafe, 1976; Clark, 1977). Such connections control meaning in only a minimal way, and they are not represented in the long-term memory representation of a text in most current theories. The same propositions would appear in the long-term memory representation for a variety of different surface structures. For example, the representation of the propositions (*clean, student, apartment*) and (*cram, student, closet, boxes*) would be the same, whether the sentences had been stated as above or as *The apartment had to be cleaned up by the student. He crammed boxes into his closet.* We propose in this article that surface form is not always lost in this fashion, but instead can be preserved in the meaning of a text.

Before proceeding, it should be noted that there is already one, often overlooked, way in which the surface form of sentences in a discourse has been taken to affect memory for meaning in the manner we have in mind. Many researchers use Kintsch's (1974) propositional scheme for representing discourse information, and in that scheme, propositions are ordered in terms of importance relative to a topic proposition. The choice of topic proposition is heavily influenced by surface form aspects of the text: the proposition is usually taken from the main clause of the first sentence in the text, and it usually represents the main verb of that clause and its arguments. Surface form affects the choice of the topic proposition, and that choice, in turn, affects the overall organizational meaning of the other propositions in the text. In short, surface form points to the most salient proposition in the text. What we test in the experiments described below is whether surface form also makes other aspects of the text (that are not the topic proposition) more or less salient.

The proposal that surface syntactic structure interacts with discourse meaning is based in part on current work in linguistics, where the "information packaging" functions of syntactic constructions have been widely studied (Chafe, 1974, 1976; Givon, 1976; Kuno, 1986; Prince, 1978; Wilson & Sperber, 1979; Ward, 1985). In every lan-

guage, speakers have choices about how to convey or package information, and it is a central tenet of studies in functional syntax that these choices are not random. Different syntactic constructions have different discourse functions, and knowing which constructions are appropriate or felicitous or most useful in a given context constitutes part of a speaker's general linguistic competence.

One of the functions often claimed in linguistics for syntactic constructions, the one that is relevant to the research described here, is to vary the relative "status" of the concepts in a discourse. There have been at least two suggestions about how syntax might accomplish this function: within a proposition, differences in relative status might be due to the linking of the arguments of a verb to different syntactic positions, and across propositions, differences in relative status might be due to the assignment of concepts to "foregrounded" versus "backgrounded" syntactic positions.

Within a proposition, the arguments of a verb can be assigned to several different syntactic positions, including subject, direct object, and indirect object. It has been pointed out that an argument may be understood to be more affected by the verb if it is placed in one syntactic position rather than another (cf. Rappaport, Laughren, & Levin, 1987). For example, consider the following two sentences:

1. Bees are swarming in the garden.
2. The garden is swarming with bees.

When *garden* is in the subject position, it is understood to be more affected than when it is in an object position; in other words, it is more likely that the whole garden is swarming with bees with sentence 2 than with sentence 1. Consistent with this intuition, the clause *but most of the garden has no bees in it* is odd when added to the end of sentence 2 but less so when added to sentence 1 (examples from Anderson, 1971). Similarly, in sentences 3 and 4, the entity *wall* is more affected as a direct object than as an indirect object: it is more likely that the whole wall is covered with paint with sentence 4 than with sentence 3. We hypothesize that the more affected a discourse entity is by the action of the verb, as indicated by its syntactic position relative to the verb, the more prominent or salient will be its position in the discourse model. This hypothesis is based on the assumption that, all other things being equal, more affected entities are more central to the meaning of the discourse. Sentence 2 is more likely to be part of a discourse about the garden than sentence 1, and sentence 4 is more likely to be part of a discourse about the wall than sentence 3. It must be stressed that other discourse considerations may override affectedness. In a discourse about insects, we might want to use sentence 1, even though the more affected interpretation of sentence 2 was intended and we would have to continue the sentence with *they fill every corner*. Nonetheless we propose that, in general, entities in positions associated with greater affectedness are more salient.

3. John smeared paint on the wall.
4. John smeared the wall with paint.

Different syntactic positions are also associated with different degrees of prominence when considered in the context of discourse units larger than a single proposition. Pragmatically, a speaker or writer can choose whether to place some specific piece of information in the foreground of a discourse or the background, and the choice is manifested by syntactic structure. Notions of foregrounding have been discussed by many linguists, using a variety of terms to describe distinctions in prominence. Examples most directly related to our research come from Wilson and Sperber (1979). They propose that the syntactic positions of propositions order them in terms of importance, and that the more important a proposition, the more relevant it is to the discourse as a whole. For example, the proposition *admire, I, Bergstrom* is said to have more importance pragmatically in sentence 6 than in sentence 5, and therefore

the proposition is more relevant to its discourse context if it is expressed in sentence 6 instead of sentence 5 (examples from Wilson and Sperber, 1979, p. 305).

5. I have invited Bergstrom, who I admire, to give the opening address.

6. I admire Bergstrom, and I have invited him to give the opening address.

Similarly, Wilson and Sperber point out the reduction in importance associated with a proposition being expressed in a modifying phrase instead of a main clause, as in sentences 7 and 8 where *boring, book* is expressed either as a clause or a modifier.

7. This book is boring, and it is expensive.

8. This boring book is expensive.

The goal of the research described in this article was to test the psychological hypotheses implicit in these linguistic claims. We thought that a reader might use the syntactic position in which a discourse entity is expressed to guide processing for that entity during comprehension. An argument expressed in a more affected position relative to its verb would be perceived as more salient by the reader than an argument in a less affected position, and a proposition in a more important syntactic position would give greater salience to its arguments than a proposition in a less important syntactic position. We hypothesized further that, during reading, more salient entities would be more likely to remain in short-term memory longer for more processing than other entities, and that because of this extra processing, they would be more accessible in the long-term memory representation of the discourse. Experiments 1 through 4 tested these hypotheses.

Experiment 1

George is having second thoughts about his new job.

His critical boss is demanding. or *His demanding boss is critical.*

George is thinking of quitting.

The first sentence of this short discourse introduces George. The second sentence is made up of three propositions: (*his, boss*), (*critical, boss*), and (*demanding, boss*). For the latter two propositions, there is a choice about how to represent them syntactically. Both could be main clauses, or one or the other could be modifying phrases. In the two versions that we used for Experiment 1, one modifier was given a main clause position (a predicate modifier) and the other was mentioned as a prenominal modifier. In the first case (. . . *boss is demanding*), *demanding* was given the more prominent syntactic position and in the second case (. . . *demanding boss* . . .), it was given the less prominent syntactic position. We hypothesized that the increased prominence for *demanding* as a predicate modifier would lead to more processing during reading, and therefore more accessibility in short-term memory and/or a longer period of time in short-term memory.

We tested this hypothesis by presenting subjects with short texts like the George paragraph to read. Immediately after each text, a test word was given for recognition. Subjects were instructed to indicate as quickly and accurately as possible whether the test word had or had not appeared in the text. For the George text, *demanding* was tested after the third sentence, and we expected that responses to it would be faster and/or more accurate if the text had mentioned *demanding* in the predicate modifier position as opposed to the prenominal modifier position.

Method

Materials. Each of 24 experimental texts had two versions, with two modifiers switched between the predicate and the prenominal positions in each version, as shown by example above. Each text began with a lead-in sentence (mean length, 7.9 words) and ended with a third sentence (mean length, 7.5 words). The middle sentence was always five words in length: a possessive pronoun or article, followed by a modifier, followed by a noun, followed by a form of the verb *to be*, followed by a mod-

ifier. The two modifiers were both used as test words for the experimental texts. The texts were always displayed in three lines on the CRT screen.

There were two sets of filler texts, each text with one test word. One set of 44 texts averaged 52 words and six lines as presented on the CRT screen; for these texts, 9 had positive test words and 33 had negative test words. The other set of 24 fillers averaged 67 words and five lines on the CRT screen; the test word for each of these was positive.

Procedure. For all four experiments described, all stimuli were presented on a CRT screen, and all responses were collected on the CRT's keyboard. The CRT was controlled by a real-time microcomputer system.

Experiment 1 began with a short list of lexical decision test items, used to give subjects practice with the response keys. After this, six practice filler paragraphs were presented and then the remaining filler paragraphs and the modifier paragraphs were presented in random order. Each paragraph began with an instruction to *Press the space bar* on the CRT keyboard when ready to begin reading. Subjects read the paragraphs one line at a time, pressing the space bar to advance from each line to the next. After the last line, the paragraph was erased from the CRT screen and a single test word was presented. Subjects were instructed to respond as quickly and accurately as possible, pressing the */* key if the word had been in the paragraph just read and pressing the *z* key if it had not. For 44 of the filler texts, a true/false test statement followed the test word. Subjects were instructed to read each paragraph carefully so that they would be able to respond correctly on a true/false test. If the response on the true/false test was incorrect, the word *ERROR* was displayed for 2000 ms. After the test word (and the true/false test if there was one) and a 1000-ms pause, the instruction to press the space bar for the next paragraph was displayed.

Design and subjects. For each of the modifier texts, either the first or the second of the two modifiers was tested (which was designated first and which second was decided arbitrarily), and either the first or the second modifier was presented in the predicate position (the other modifier was presented in the prenominal position). Crossing these two variables resulted in four conditions, which were crossed with groups of subjects (21 per group) and sets of paragraphs (six per set). All cells of the Latin square were not equally represented across subjects (because of constraints on the design of an unrelated experiment involving one of the sets of fillers) so paragraphs were paired for analyses of results (making 12 pairs). A different random order of presentation of the paragraphs was used for each second subject. The 84 subjects participated in the experiment for credit in an Introductory Psychology class.

Results

For all the experiments, means were calculated for each subject and each item in each condition; these means were analyzed by analyses of variance across both subjects and items, $p < .05$.

As predicted, responses were faster and more accurate when the modifier (e.g., *demanding*) was presented in the predicate position (*his critical boss was demanding*), 978 ms and 4% errors, than when it was presented in the prenominal position (*his demanding boss was critical*), 1036 ms and 5% errors. The difference in response times was significant, $F1(1,83) = 11.5$ and $F2(1,11) = 6.0$. One of the two test words (which was labeled first and which was labeled second was arbitrarily designated when the paragraphs were written) had slower response times than the other, by 46 ms. This difference was significant, $F1(1,83) = 4.7$ and $F2(1,11) = 5.1$. However, the predicate position was facilitated over the prenominal position for both test words: the interaction between test word and modifier position was not significant,

F's < 1.0. The standard error of the mean response times was 10.1 ms. No differences in error rates reached significance, all F's < 2.4.

Reading times for the sentences containing the modifiers and reading times for the sentences that followed the modifier sentences (the sentences that immediately preceded the test word) did not differ significantly across experimental conditions. The mean reading time for the modifier sentences was 1784 ms (standard error of the mean was 19.0 ms) and the mean reading time for the final sentences was 1739 ms (standard error of the mean was 14.3 ms).

For filler test words, mean response time for correct positive responses was 1255 ms (21% errors) and for correct negative responses, 1083 ms (2% errors). For true test sentences, correct responses averaged 2102 ms (10% errors), and for false test sentences, correct responses averaged 2160 ms (12% errors).

Experiment 2

In Experiment 1, the predicted result was obtained: a modifier presented in a predicate position was more accessible after an intervening sentence than a modifier presented in a prenominal position. This result is consistent with our hypothesis that different syntactic positions are associated with differing degrees of prominence in a discourse, and that these differing degrees of prominence have consequences for how a reader comprehends the discourse. In particular, the result of Experiment 1 suggests that more prominent discourse entities are more accessible in short-term memory during reading or remain longer in short-term memory than less prominent entities.

There is one alternative explanation of the result of Experiment 1 that immediately presents itself, and that is that the predicate modifier is associated with faster response times because it is more recent relative to the test point than the prenominal modifier. In the George paragraph, the prenominal modifier is eight words back from the test point and the predicate modifier is only six words back. However, this alternative would predict that the difference between predicate and prenominal modifiers would appear only in a short-term memory test, not in a long-term memory test. In contrast, our hypothesis that the predicate modifier receives more processing because of its increased salience suggests that the difference should appear on both short-term and long-term memory tests.

We have proposed that discourse entities assigned to different syntactic positions receive different amounts of processing during reading. Most theories of short-term memory assume that the more a concept is processed in short-term memory and the longer it remains in short-term memory, the more likely it is that the concept is encoded into long-term memory (cf. Gillund & Shiffrin, 1984). However, is it not clear whether and how this assumption extends to a concept presented as part of a discourse. While the result of Experiment 1 suggests that a more prominent syntactic position gives more accessibility in short-term memory, it is not clear whether this increased accessibility represents the kind of processing that would increase the probability of representation in long-term memory. As mentioned in the introduction above, it has long been thought that syntactic information is *not* part of long-term memory for discourse.

The purpose of Experiment 2 was to test whether a concept associated with a syntactically more prominent position in its discourse was more accessible in the long-term memory representation of the discourse than a concept associated with a less prominent syntactic position. The same texts were used as in Experiment 1, each with two modifiers that could be switched from prenominal to predicate position. Subjects were given a series of study-test lists. For the study phase of each list, they read a number of short paragraphs (all unrelated to each other). For the test phase, they were given a list of single words; for each

word, they were asked to decide, as quickly and accurately as possible, whether it had appeared in any of the paragraphs they had just read. We predicted that responses to a word that had been read in the more prominent predicate position would be faster and/or more accurate than responses to a word from the less prominent prenominal position.

Method

Materials. The modifier texts were the same as those used in Experiment 1, each text with the same two test words. There were 46 filler texts. One set of 32 fillers had a mean length of 49.2 words (averaging 6.2 lines on the CRT screen), and the other set of 14 fillers had a mean length of 29.1 words (always three lines). For each filler text, there were four test words that had appeared in the text. Negative test words were chosen from a pool of 966 words that did not appear in any text.

Procedure. Experiment 2 began with a short list of lexical decision test items, used to give subjects practice with the response keys. After this practice, there were seven study-test list sequences. For the first study list, 10 filler texts were presented. The remaining six study lists each contained four of the modifier texts, four of the longer fillers, and two of the shorter fillers, all presented in random order except that the modifier texts were never in the first or the last two positions of the study list. Each test list was made up of 64 test words, 32 positive words from texts in the immediately preceding study list and 32 negative test words. Except for the first test list, the 32 positive test words included the two modifiers from each modifier text and 4 test words from each filler text in the study list. For each of the modifier texts, one of the modifiers was tested at some point in the test list after the 20th position, and the other modifier was tested at least 10 positions later in the test list. The test position immediately preceding each modifier was filled by a positive test word from one of the filler texts. Otherwise, the positions of test words were chosen randomly.

In designing this experiment, we debated whether the reading time for each text should be controlled by the experimenter or by the subject. Control by the experimenter reduces variability across subjects and items, but control by the subject allows the subject to read at the right rate for whatever level of comprehension the subject adopts as his or her goal. Moreover, reading rate is affected by the degree of accuracy needed for reasonable performance on the test list. Informing subjects each time they make an error increases accuracy, and making feedback aversive (by presenting an error message for a long amount of time, e.g., 2000 ms) should increase accuracy even more. Over the three long-term memory experiments presented in this article, we tried three different combinations of reading time control and accuracy feedback. In Experiment 2, reading time was controlled by the experimenter, and errors were indicated by a 2000-ms error message.

Each study list began with an instruction to press the space bar of the CRT keyboard to initiate the list. Then the texts were presented one at a time, for 10 s for filler texts and for 6 s for modifier texts, with a 1-s blank interval between each text. After the 10th text, a row of asterisks was presented for 2 s to signal the beginning of the test list. Then the test words were presented one at a time. A test word remained on the CRT screen until the subject pressed a response key on the keyboard (?/ for positive responses, z for negative responses). If the response was correct, the next test word appeared after a 50-ms blank interval. If the response was not correct, the word *ERROR* was presented for 2000 ms. Subjects were instructed to respond quickly and accurately.

Design and subjects. For each modifier text, one of the two modifier words was tested first in the test list, and it was studied either in the predicate or the prenominal position. Crossing these two variables re-

sulted in four conditions, all presented as the first test word from their text in the test list. Whichever modifier was not tested first was tested later in the test list, resulting in the same four conditions. For example, for the text about George above, *critical* was tested first in two conditions (studied as predicate and studied as prenominal) and *demanding* was tested first in two conditions (studied as predicate and studied as prenominal). The four conditions for each test word were crossed with four sets of texts and four groups of subjects. Order of presentation of materials was random (except for the constraints mentioned above), different for each second subject. The 28 subjects participated in the experiment for credit in an Introductory Psychology class.

The design of Experiment 2 used both modifiers as test words, but only one of them could be the first to access the representation of the text in long-term memory. In other research, the results obtained at a second test position have been shown to be affected by the first test. Dell, Ratcliff, and McKoon (1981) found that evidence of text structure disappeared at a second test: at that point, all test words from a text had about the same response times and error rates. Thus, for Experiment 2, we expected the first test position to show the effect of syntactic salience, but did not know whether the effect would still be obtained at the second test position.

Results

The prediction was that responses for modifier test words would be facilitated when the modifiers had appeared in their texts in the predicate position relative to the prenominal position. This facilitation was obtained for both test positions: 837 ms vs 903 ms (20% errors in each case) for modifiers tested first in the test list and 863 ms vs 891 ms (16% errors vs 21% errors) for modifiers tested second in the test list. The effect was somewhat smaller for one of the test words than the other, although which was designated the first and which the second had been decided randomly.

Analyses of variance on response times showed the main effect of predicate versus prenominal significant, $F1(1,27) = 6.9$ and $F2(1,46) = 7.1$. The interaction between predicate/prenominal and test word approached significance with items as the random variable, $F2(1,46) = 2.0$, and was significant with subjects as the random variable, $F1(1,27) = 4.9$. Both test words showed facilitation of predicate over prenominal sentence position when they were tested first in the test list; for first test positions, the interaction between test word and predicate/prenominal was not significant when those responses alone were analyzed (F's < 2.2). Why the predicate/prenominal effect diminished for one of the test words in the second test position is not clear (see the discussion of Dell et al., 1981, above). Other response time effects in the experiment were not significant (F's < 1.1), except that the effect of test position in the items analysis approached significance, $F(1,46) = 2.7$. The standard error of the response time means was 24 ms. For error rates, none of the main effects or interactions approached significance. Mean response time for positive fillers was 862 ms (24% errors) and mean response time for negative fillers was 976 ms (30% errors).

Experiment 3

Experiments 1 and 2 were designed to test whether the prominence associated with a modifier in a predicate position led to increased accessibility immediately after a discourse was read and whether it led to increased accessibility in the long-term memory representation of the discourse. Both effects were obtained. In Experiment 1, increased syntactic prominence was confounded with recency, but recency should affect only the test of short-term memory. Because the prominence effect was also obtained in the test of long-term memory, recency is probably not the explanation of the result from Experiment 1. Instead, we attribute the results of both Experiments 1 and 2 to syntactically determined salience.

However, the syntactic prominence of

the predicate position was confounded with another, simple variable: the modifier in the predicate position was always the last word of its sentence. The results of Experiments 1 and 2 may reflect, not syntactic prominence, but instead prominence associated with the last word of a sentence as compared with other words in the middle parts of a sentence. In Experiment 3, we eliminated this confound by adding adjunct phrases to the ends of the modifier sentences. The sentences about George became:

George is having second thoughts about his new job.

His critical boss is demanding at times. or *His demanding boss is critical at times.*

With the adjunct phrase added, neither the predicate nor the prenominal modifier appears at the end of the second sentence. Experiment 3 was also designed to generalize the results of Experiment 2 by changes in procedure: The reading time for the texts was controlled by the subjects, not the experimenter, and less emphasis was placed on the accuracy of responses in the test list.

Method

Materials. The same materials were used as in the preceding experiments except that an adjunct phrase was added to the end of each second sentence of the direct object–indirect object texts, as shown above for the George text. The number of words in the adjunct phrases varied from two to four.

For both the modifier texts and the filler texts, only the first two sentences of each text were used in this experiment. Subjects had found Experiment 2 very difficult, and we thought that reducing the length of the texts would make it easier. There was a pool of 66 filler paragraphs, each with two lines as displayed on the CRT screen, averaging 20 words in length. There were two positive test words for each paragraph. Negative test words were drawn from a pool of words that did not appear in any text, the same pool as in Experiment 2.

Procedure, design, and subjects. The procedure and design were almost the same as those for Experiment 2; there were only the following differences: The study lists each contained four of the modifier texts and eight filler texts. Each test list was made up of 40 test words, 20 positive and 20 negative. For each of the modifier texts, one of the modifiers was placed at some point in the test list after the eighth position, and the other modifier was placed at least eight positions later. Subjects controlled the reading time for each text by pressing the space bar when they had finished reading each text. There was a 1-s blank interval after each text. In the test list, if a response was not correct, the word *ERROR* was presented for 500 ms (as compared to 2000 ms in Experiment 2). The 24 subjects participated in the experiment for credit in an Introductory Psychology class.

Results

It was predicted that response times for a modifier test word would be faster when the modifier had been presented in the predicate position, even though the predicate position was not the last word of its sentence. This is the result that was obtained, but only for the first test position. Because the results were different at the two test positions, we analyzed them separately.

At the first test position, response times for predicate modifiers averaged 733 ms (4% errors) and response times for prenominal modifiers averaged 780 ms (5% errors). This difference was significant, $F1(1,23) = 4.7$ and $F2(1,20) = 7.3$. The effect of which of the two words was tested and the interaction of predicate/prenominal and test word were not significant, F's < 2.2. The standard error of the response time means was 21.2 ms. There were no significant effects on error rates, F's < 1.0.

At the second test position, the standard error of the response times means, 31 ms, was much greater than at the first test position. This larger standard error may have contributed to the failure to find an effect of predicate versus prenominal study position in the second test position. Response times

for predicate modifiers averaged 786 ms (5% errors) and response times for prenominal modifiers averaged 792 ms (7% errors). In the subjects' analysis, one test word was responded to more quickly than the other, $F1(1,23) = 4.7$, but the effect was not significant in the items' analysis, $F2(1,20) = 2.2$. The main effect of predicate/prenominal position and the interaction of predicate/prenominal and test word were not significant, F's less than 2.5.

The mean reading time for the two-sentence modifier texts was 4916.5 ms, with a standard error of 194 ms. The mean response time for positive filler test words was 798 ms (8% errors) and for negative test words, it was 1066 ms (59% errors). Note that subjects had a strong bias to respond *yes*, which led to fast *yes* responses and a high error rate for negative test words. Nevertheless, for the first test position, the predicate/prenominal variable still had a significant effect.

Experiment 4

Experiments 1 through 3 show the effect of syntax on the relative accessibilities of different propositions. The proposition that George's boss is demanding can be made more or less accessible by moving it from one syntactic position (main clause predicate) to another (prenominal modifying phrase). Experiment 4 examined a second syntactic effect, the relative salience associated with the different syntactic positions to which the arguments of a verb can be assigned.

The librarian was furious when she got to work today.

Somebody had inserted some magazines inside some newspapers late last night.

or

The librarian was furious when she got to work today.

Somebody had inserted some newspapers inside some magazines late last night.

In this text, the proposition with the verb *insert* has three arguments: *somebody*, *magazines*, and *newspapers*. In one version, *magazines* is linked to the direct object position, and in the other, it is linked to the indirect object position. In the introduction to this article, we reviewed the linguistic notion that an entity in the direct object position is taken to be more affected by the verb, and we suggested that more affected entities were associated with greater prominence. Greater prominence, in turn, we hypothesized to be associated with greater accessibility in the mental representation of a text.

In Experiment 4, we used texts like the one above about the librarian. Subjects were given a series of study-test lists, as in Experiments 2 and 3, and the direct and indirect objects (*magazines* and *newspapers*) were presented for recognition in the test lists. We predicted faster and/or more accurate responses for the objects when they had appeared in the direct object position than in the indirect object position. For the librarian text, *magazines* would have faster and/or more accurate responses with the first version of the second sentence than the second version. Each of the object sentences ended with an adjunct phrase so that the indirect object was never the final word of its sentence.

Method

Materials. There were 28 paragraphs each with two objects that could be switched between the direct object and the object of preposition positions. Each paragraph began with a lead-in sentence (these averaged 8.75 words) and then continued with a sentence containing the two objects (averaging 10.71 words). This sentence had the form: subject noun phrase, verb, object noun phrase, prepositional phrase, adjunct phrase. The two objects were used as test words. These paragraphs were displayed in two lines on the CRT screen. The same filler paragraphs and pool of negative test words were used as in Experiment 3.

Procedure, design, and subjects. The experiment differed from Experiment 2 only in the following respects: Each of seven study lists contained four of the objects texts and eight filler texts. Each test list was

made up of 40 test words, 20 positive words from texts in the immediately preceding study list and 20 negative words that had not appeared in any studied text. For each of the object texts, one of the objects was tested at some point in the test list after the eighth position, and the other object was tested at least eight positions later in the test list. Subjects controlled the reading time for each text by pressing the space bar when they had finished reading each text. There was a 1-s blank interval between each text. If a response to a test word was not correct, the word *ERROR* was presented for 2000 ms, as in Experiment 2. The 32 subjects participated in the experiment for credit in an Introductory Psychology class.

Results

As predicted, responses for object test words were faster when the object had been presented in its text as a direct object than when it had been the object of a prepositional phrase. The facilitation for the direct object was apparent when the object was tested at the first test position in the test list: response times were 679 ms (7% errors) versus 704 ms (6% errors); and when it was tested in the second test position: 661 ms (5% errors) versus 683 ms (4% errors). The amount of facilitation was significant, $F1(1,31) = 6.3$ and $F2(1,27) = 4.6$. The amount of facilitation did not interact either with test position or with which of the two object words was tested, F's < 1.3. Responses for the second test position were faster than for the first, approaching significance, $F1(1,31) = 3.1$ and $F2(1,27) = 3.6$, and the interaction of test position and test word was significant, $F1(1,31) = 5.4$ and $F2(1,27) = 4.1$ (although which test word was designated first vs second had been decided randomly). Standard error of the response time means was 18.8 ms. The only significant effect for error rates was that there were more errors in the first test position, $F1(1,31) = 4.2$ and $F2(1,27) = 4.3$.

Reading times for the two-sentence object texts averaged 5104 ms with a standard error of the mean of 89.8. Responses on positive filler test words averaged 728 ms (6% errors), and responses on negative filler test words averaged 974 ms (49% errors).

General Discussion

The experiments presented in this article were designed from a theoretical view of text processing by which syntactic information is assumed to influence the relative salience of different pieces of text information during reading, and in so doing, helps to determine how much attention is given to different pieces of information. More attention for some concept or proposition translates, we assume, into more processing for a longer period of time in short-term memory.

The experiments presented here test the first and most immediate consequences of this theoretical view. The parts of a text that are expressed in more salient syntactic positions should be more available immediately after they are read, and they should be more accessible in the long-term memory representation of the text. In the first three experiments, we manipulated whether a proposition was placed in a syntactic position of greater prominence—a main clause—or lesser prominence—a modifying phrase. The modifier in the more prominent position was more available immediately after reading, and it was also more accessible in long-term memory. In Experiment 4, we manipulated whether an argument of a verb was placed in the direct object position or an indirect object position, and, as predicted, arguments in the direct object position were more accessible. Like the results of Experiments 1 through 3, this result points to the role of syntax in guiding discourse processing. It also provides experimental evidence to support the linguistic claims about the different degrees of affectedness associated with different syntactic positions for the arguments of a verb.

While differences in accessibility are the most immediate consequences of syntactic variables, the most important conse-

quences may be those that result more indirectly from the extra short-term memory processing given to more prominent pieces of information. Extra processing may affect how the text information is organized and what information is included in the final representation of meaning that is eventually constructed for the text. How this would be accomplished is easy to speculate about (see below), given current models of text processing. But, first, we should consider the sizes of the effects in our experiments.

We need to consider whether the results of our experiments are an example, to put it metaphorically, of the cup being half full or half empty. So far, we have emphasized that the experiments did in fact produce the results that were predicted. However, the effects were small. Across the three long-term memory experiments, the response time differences between syntactically more and less prominent test words were 66, 47, and 25 ms on a baseline of 700–900 ms (for first test positions in Experiments 2, 3, and 4, respectively). Are these effects big enough that a large theoretical structure can be built upon them? Of course, the answer is that we don't know. However, certainly when we speculate theoretically about syntax in discourse processing, the size of the effects should constrain our thinking.

A theory about the role syntax might play in discourse processing can be constructed out of two kinds of already existing models: Kintsch's model (1988) for the processing of propositions and the compound cue models for memory access (Dosher & Rosedale, 1989; Ratcliff & McKoon, 1988; McKoon & Ratcliff, 1992b; Ratcliff & McKoon, 1993). First, consider Kintsch's model for how propositions are processed through short-term memory and encoded into long-term memory. Givon (in press) has proposed that "grammatical devices" are signals that trigger mental operations; he views grammatical signals as "mental processing instructions." This idea can be made concrete in Kintsch's model in order to show how syntactic prominence could come to influence the organization of the propositions of a text. In the model, propositions are processed in cycles. On each cycle, some number of propositions is input to the processing system, where they are connected to each other by argument repetition (i.e., any two propositions that share a common argument are connected to each other). The only connections that are made (without searches of long-term memory) are those between propositions that are in short-term memory at the same time. At the end of a cycle, all but a small subset of the propositions in short-term memory are transferred to long-term memory, and a new cycle with new input propositions begins. Currently, the model chooses which propositions to keep in short-term memory from one cycle to the next according to how closely they are connected to the original topic of the text and how recently they were mentioned in the text. However, it would be straightforward to change the model so that concepts in more prominent syntactic positions were preferentially maintained in short-term memory from one cycle to the next. Preferential maintenance would then allow them to be connected to propositions in the next input cycle, creating connections that would not otherwise be formed. Thus, simply holding syntactically salient information longer in short-term memory (through extra processing cycles) could create an organization of the propositions that would be influenced by syntactic salience. Holding salient information longer would also predict the results of our experiments: a more salient concept would be more accessible a sentence after it was mentioned than a less salient concept (Experiment 1), and a more salient concept would be more strongly represented in long-term memory (Experiments 2, 3, and 4) because it would have had more time to accumulate strength of encoding into long-term memory and/or more time to build its strength of connections to other encoded items (cf. Gillund & Shiffrin, 1984).

It is not only plausible that the organization of the propositions in the final representation of a text would be affected by holding syntactically prominent propositions over from one cycle to the next, but also consistent with other current results. Kintsch (1992) has simulated the effects of adding syntactic preference rules to his model, and the final organization produced by the model does, in fact, change when the rules are added. There is also one empirical finding that is consistent with the notion that syntactic salience affects how propositions are connected together. McKoon, Ward, Ratcliff, and Sproat (1993; see also Ward, Sproat, & McKoon, 1991) examined syntactic salience and pronominal reference with texts from which 1 and 2 below are taken:

1. . . . *lately he's taken up deer hunting. He thinks that they are really exciting to track.*

2. . . . *lately he's taken up hunting deer. He thinks that they are really exciting to track.*

In the second sentences of both examples, the pronoun *they* is intended to refer to *deer*. In the first sentence of 1, *deer* is placed in a modifier position and in the first sentence of 2 it is the object of the verb *hunting*. As indicated by the results of the experiments above, the modifier position should be less prominent and so should make *deer* less salient. In terms of cycles of propositions through short-term memory, decreased salience translates into lower probability of staying in short-term memory. So if a cycle ends after the first sentence of these examples, *deer* will be less likely to be in short-term memory for the beginning of the second sentence in example 1 than in example 2. As a result, understanding the referent of *they* will be more difficult in the first example than the second. This prediction was confirmed by McKoon et al.'s experiments (in press): reading times for the second sentences were longer for the first example than the second, consistent with pronoun resolution taking more time in the first example than the second (see McKoon et al. for experiments that rule out a number of alternative explanations for this result).

The plausibility of the idea that syntactic prominence contributes to preferential maintenance of propositions in short-term memory, as well as the results of Kintsch's (1992) simulations and McKoon et al.'s experiments, all point to the effects of syntactic variables on the long-term memory organization of text information. However, the organization of the propositions given by a text is not the only part of text processing that might be influenced by preferential maintenance in short-term memory. Preferential maintenance might also allow propositions and concepts to be combined in short-term memory in ways that they otherwise might not be, and therefore allow them to form cues for memory retrieval that would not otherwise be formed. Compound cue models of memory retrieval (Dosher & Rosedale, 1989; Ratcliff & McKoon, 1988, 1993) based on the global memory models (e.g., Gillund & Shiffrin, 1984; Hintzman, 1988; Murdock, 1982) claim that a familiar relation between two or more concepts is recognized if and only if the concepts are in short-term memory at the same time. Being in short-term memory at the same time means that the concepts form a compound cue with which they can jointly access memory. For example, the familiar relation between *green* and *grass* would be apparent if they were near enough together in a text that they could be in short-term memory at the same time (see Foss & Speer, 1991, for a discussion similar to this one). In traditional lexical decision priming experiments, words like *green* and *grass* are presented in lists of single words, and the facilitation given by *green* to *grass* is observed only if *grass* immediately follows *green* or they are separated by only one or two other items (McNamara, 1992; Ratcliff, Hockley, & McKoon, 1985; Ratcliff & McKoon, 1978; 1988, 1993). This indicates that, for a list of single items, the compound

cue for memory retrieval contains only two or three of the most recent words. But if the words are not just a list of unrelated concepts but instead form a text, then the compounds for memory retrieval will almost certainly be different. They may contain concepts, semantic propositions, the verbatim words of the text, and so on (see Ratcliff & McKoon, 1988), and which of these are held from one processing cycle to the next will not be determined only by recency, but also by how closely a concept or proposition is connected to the text's topic and, we suggest, by how prominent the concept or proposition is in the syntactic structure of the text. If *green* is placed in a syntactically prominent enough position, it may still be in short-term memory when *grass* is read, even if *grass* appears many words later in the text. The relation between *green* and *grass* that was thus made apparent could potentially change how the text was understood, and so change the encoded meaning of the text.

The syntactic effects on text processing that we have demonstrated in the experiments reported here are small. Concepts linked to syntactically more prominent positions were more accessible in both short-term and long-term memory tests, but not dramatically so. In this discussion, we have speculated that even these small effects might have powerful consequences for the organization and content of the mental representation of discourse. Syntactic "mental processing instructions" (Givon, in press) might, for some pieces of information, mean a little more time spent in short-term memory, and allow a little extra processing, and whether that means a lot for comprehension of a text as a whole is a subject for further research.

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