Robust effects of syntactic structure on visual word processing

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A series of experiments explored the effect of the syntactic structure of a sentence fragment on the processing of a subsequent target word. In both a naming and a lexical decision task, modal verb contexts followed by main verb targets and preposition contexts followed by noun targets produced faster response times than did the opposite pairings (i.e., modal/noun and preposition/verb). This syntactic context effect occurred across several different variations in the method of context presentation. Also, unlike some previous findings on syntactic priming, the present effects did not disappear when a naming task was employed. The magnitude of the syntactic priming effect was similar in the naming and lexical decision tasks when the response times were slow, but was larger in the lexical decision task when the response times were faster. The implications of these results for recent discussions of the relationship between task structure and the locus of observed contextual effects are discussed.

Studies of sentence and single-word priming play a major role in the evaluation of theories of reading, word recognition, language processing, and semantic memory (Anderson, 1983; Fischler, 1985; Fodor, 1983; Foss, 1982; Henderson, 1982; Neely, 1977; Stanovich, 1980; Stanovich & West, 1983; Tanenhaus & Lucas, in press). For example, it is not surprising that models of context effects on visual word recognition are heavily dependent on the results from such paradigms. Despite some continuing controversies, recent priming experiments have resulted in a considerable convergence of ideas on how context affects word recognition (de Groot, 1984, 1985; Ehrlich & Rayner, 1981; Forster, 1979, 1981; Seidenberg, 1985; Seidenberg, Tanenhaus, Leiman, & Bienkowski, 1982; Seidenberg, Waters, Sanders, & Langer, 1984; Stanovich & West, 1983; Zola, 1984). One reason that the literature in this area has acquired some coherence is that investigators have become more sensitive to the fact that the specific processing requirements of the tasks that are used to assess priming can influence the magnitude of the effects observed. The suggestion that any inference regarding the locus and size of contextual effects must involve a careful task analysis was most forcefully articulated by Forster (1979). West and Stanovich

(1982; Stanovich & West, 1983) and Seidenberg et al. (1984) empirically demonstrated the importance of this idea and used it to explain some of the discrepancies in the literature on context effects. The experiments reported here were designed to investigate whether a similar task comparison could help to elucidate recent research on syntactic priming effects.

Goodman, McClelland, and Gibbs (1981) conducted an experiment in which a syntactic priming effect was observed. Lexical decision times to a target word were faster when it was preceded by a syntactically appropriate word (e.g., *he-said*) than when it was preceded by a syntactically inappropriate word (e.g., *the-said*). Lukatela, Kostic, Feldman, and Turvey (1983) reported a similar result. Seidenberg et al. (1984) discussed how these results relate to theoretical discussions about the modularity of the lexicon (see also Tanenhaus & Lucas, in press). Although the latter investigators replicated the syntactic priming effect when using a lexical decision task, they found that it did not occur when a naming task was employed. Building on the theoretical arguments of Forster (1979) and West and Stanovich (1982), Seidenberg et al. (1984) assumed that the lexical decision task was more prone to reflect postlexical processes. Therefore, they concluded that the standard associative priming effect resulted from activation spreading through lexical memory, whereas the syntactic priming effect was due to a postlexical decision of grammatical acceptability.

The syntactic priming effect observed by Goodman et al. (1981) was small in absolute magnitude and did not occur when the syntactic priming trials were mixed with semantic priming trials. Recently, however, Wright and

This research was supported by NSF Grant No. BNS80-20594 to K. E. Stanovich and by a James Madison University faculty research grant to R. F. West. The authors wish to thank Kathy Larkin for her assistance in data collection and Ruth Nathan, Mark Seidenberg, and Mike Tanenhaus for their comments on the manuscript.

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Garrett (1984) reported a syntactic priming effect that seems to be much more robust. This effect was much larger in magnitude than that observed by Goodman et al. (1981), and it was obtained under several methodological and stimulus variations. Wright and Garrett (1984) employed sentence fragments as primes and manipulated the syntactic acceptability of the target words that followed. In order to rule out the possibility of semantic effects, none of the critical target words were predictable from, or associatively related to, the preceding sentence fragment. An example of the stimuli used in their Experiment 1 is provided by the following four sentence fragments (target words are italicized):

1. MV: The man spoke but could *compete*
2. MN: The man spoke but could *entries*
3. PV: Just at the time of *compete*
4. PN: Just at the time of *entries*

The target word is an acceptable continuation in Fragment 1 (the MV condition: a main verb following a modal verb) and Fragment 4 (the PN condition: a preposition followed by a plural noun), but an unacceptable continuation in Fragment 2 (the MN condition: a modal verb followed by a plural noun) and Fragment 3 (the PV condition: a preposition followed by a main verb). Wright and Garrett (1984) thus predicted an interaction between the prime condition (modal vs. preposition) and target word (verb vs. plural noun), and a strong interaction was indeed observed in their experiment. However, they employed the lexical decision paradigm in their studies. The work of West and Stanovich (1982) and Seidenberg et al. (1984) raises the question of whether this syntactic effect, like that of Goodman et al. (1981), should be interpreted as arising from a postlexical grammaticality check. Such a hypothesis predicts that the effect would interact with task (naming vs. lexical decision) because the naming task is less prone to detect postlexical effects. This hypothesis was tested in Experiment 1.

EXPERIMENT 1

Method

Subjects. The subjects were 64 students recruited through an undergraduate psychology subject pool. Thirty-two of the subjects performed in the lexical decision condition, and the remaining 32 subjects performed in the naming condition.

Stimuli and Apparatus. The stimuli used in this experiment were the same as those used in Experiment 1 of Wright and Garrett (1984). The complete list of stimuli is presented in their Appendix A. The critical stimuli consisted of 48 incomplete sentence contexts and 24 word targets. The targets consisted of 12 main verbs (e.g., *formulate*) and 12 plural nouns (e.g., *batteries*). The verb (V) and noun (N) target word sets were matched on length, number of syllables, and approximate Kučera and Francis (1967) frequency. Twenty-four of the contexts consisted of sentence fragments that ended in modal verbs (e.g., "If your bicycle is stolen, you must"). Sentence fragments ending in modal verbs (M) may be continued by main verbs (the modal-main verb, or MV, condition), but not by plural nouns (modal-noun, or MN condition). The remaining 24 contexts consisted of sentence fragments that ended in prepositions (e.g., "For now, the happy family lives with"). Sen-

tence fragments ending in prepositions (P) may be continued by plural nouns (preposition-noun, or PN condition), but not by main verbs (preposition-verb, or PV condition). The modal and preposition sentence fragments were matched on the length and number of their constituent words. In the lexical decision condition, the 48 sentence fragments preceded words and nonwords equally often. The 24 nonwords that were preceded by the critical sentence fragments conformed to normal orthographic conventions and matched the word targets in length. Thirty additional incomplete sentence contexts that ended in word targets were used as fillers to decrease the proportion of MN, MV, PN, and PV trials. The target words in these filler trials were always acceptable continuations, and in 24 cases, the presentation of the target word resulted in a complete sentence. The lexical decision condition included an additional 30 filler contexts that ended in nonword targets.

The 32 subjects who made lexical decisions each received 6 practice trials, followed by a random ordering of 108 experimental trials, 54 with word targets and 54 with nonword targets. The 54 word trials consisted of 6 trials under each of the four experimental conditions (MV, MN, PV, PN) and 30 filler trials. The assignment of targets was counterbalanced across subjects so that each was presented equally often under each of the two context conditions. No subject saw the same target or sentence context more than once in the course of the experiment. Each subject received the same filler trials. The 32 subjects who participated in the naming task received an identical set of 54 word trials. For them, the nonword trials were deleted.

The stimuli were presented on a CRT monitor with a refresh cycle of 16.7 msec under the control of an Apple II microcomputer. A Mountain Hardware clock, telegraph keys, and a voice-activated relay were interfaced with the computer to enable the collection of lexical decision and naming times. All letters were uppercase and were presented at a viewing distance of approximately 64 cm. Five-letter words subtended a horizontal visual angle of approximately 1.88°. When the target word was presented, it was in the position it would have occupied had the sentence been continued. Target-word onset was controlled by a button pushed by the experimenter that immediately caused the target to be displayed and simultaneously started the millisecond clock. In the naming task, the voice-activated relay stopped the clock when the subject responded verbally to the target. In the lexical decision task, the clock was stopped when the subject responded by pressing a telegraph key.

Procedure. In this experiment, the subject read the sentence contexts out loud, and the experimenter target-initiation procedure used by Stanovich and West (1983) was employed. Prior to the collection of the data, the experimenter was given practice in synchronizing the pushing of the control button with the articulation of the last word in the context. Of course, some time invariably elapsed between the subject's articulation and the experimenter's buttonpress. However, the experimenter tried to minimize this time by attempting on all trials to synchronize the buttonpress with the articulation of the last context word such that the button was activated as soon as possible after the end of that articulation. The experimenter was instructed to develop a criterion so stringent that occasionally the button was pressed during the articulation of the last context word, thus aborting the trial. There were only a few experimenter-aborted trials, but those that did occur were distributed approximately equally across experimental conditions, indicating that the criterion was consistently applied (see Stanovich & West, 1983, for a discussion of this and alternative procedures).

Subjects were individually tested in a session that lasted approximately 30 min. They were told to look at the CRT and to read aloud the sentence contexts that appeared. In the naming task, subjects were instructed to read the target word aloud as rapidly as possible when it appeared. In the lexical decision task, the subjects indicated each response by pressing one of two telegraph keys. Subjects made "word" responses with the right hand and "nonword" responses with the left hand. The subjects were told that only the

responses to the targets were timed, so they were free to read the contexts at a comfortable pace.

Results

Trials on which some type of experimental malfunction occurred (e.g., the vocal response was too quiet for the relay setting or the experimenter aborted the trial by pushing the button too early) were dropped from the data analysis. Trials on which the subject articulated the wrong word, pressed the wrong key, or had a response time longer than 2,000 msec or longer than two standard deviations above his/her mean for that condition were scored as subject errors and were also dropped from the analysis. The mean reaction times and the mean percentage of subject errors for all of the four experimental conditions are displayed in Table 1. All of the analyses that follow are based on the subject's mean reaction time in each condition.

A $2 \times 2 \times 2$ (task $\times$ target $\times$ context) analysis of variance on the reaction times indicated that the main effect of task (lexical decision vs. naming) was significant [$F(1,62) = 10.4, p < .01$]. Reaction times were slower in the lexical decision task. Neither the main effect of target [verb vs. noun; $F(1,62) = 1.94$] nor context [modal vs. preposition; $F(1,62) < 1$] was significant. The target $\times$ context interaction was significant [$F(1,62) = 34.6, p < .001$]. The main verb targets were responded to more rapidly when preceded by modal contexts than when preceded by the preposition contexts, whereas the plural noun targets were responded to more rapidly when preceded by preposition contexts than when preceded by the modal contexts. However, the expected three-way interaction (task $\times$ target $\times$ context) failed to materialize [$F(1,62) < 1$]. The size of the two-way interaction was as large in the naming task as in the lexical decision task. The mean context effects (PV – MV and MN – PN) were 72 and 88 msec, respectively, in the naming task, and 78 and 94 msec, respectively, in the lexical decision task. Higher error rates were generally associated with longer reaction times, so the interpretation of the results is not obscured by speed-accuracy trade-offs. In the lexical decision task, the mean reaction time to nonwords preceded by M contexts was 761 msec (5.5% error) and the mean

reaction time to nonwords preceded by P contexts was 741 msec (4.4% error).

The results of an item analysis mirrored the subject analysis in all critical aspects. There was a significant main effect of task [$F(1,22) = 93.1, p < .001$], but not of context or target ($F < 1$ in both cases). The target $\times$ context interaction was significant [$F(1,22) = 24.9, p < .001$], but the three-way interaction was not ($F < 1$).

EXPERIMENT 2

In Experiment 1, both main verbs and plural nouns were responded to faster when preceded by an appropriate syntactic context. The syntactic effects observed in the lexical decision task were even somewhat larger in size than those observed by Wright and Garrett (1984). However, contrary to expectation, the magnitudes of the effects in the naming task were similar. Thus, the lexical decision results are not problematic, since they replicate the findings of the former investigators. The sizes of the effects in the naming task were surprisingly large, however, given some reasonable extrapolations from the results of Seidenberg et al. (1984) and West and Stanovich (1982). However, there was one aspect of Experiment 1 that might have led to artifactually large effects in the naming task. The methodology employed in that experiment was adapted from the experiments of Stanovich and West (1983) and involved having the subjects read the contexts out loud. Perhaps in the inappropriate conditions (MN and PV), the articulation transitions between the end of the last context word and the beginning of the target word were unusually difficult ones (a reasonable conjecture given that the words were syntactically inappropriate; see also Campbell & Besner, 1981). This might have slowed responses in these conditions in the naming task, leading to a syntactic effect, but one arising for completely different reasons than that observed in the lexical decision task (if we assume that the latter is due to a postlexical grammaticality check). Again, such an effect in the naming task would reflect not an effect of syntax on lexical access, but a postlexical response effect, and thus would be more analogous to the postlexical grammaticality effect in the lexical decision task. This explanation of the naming results was tested in Experiment 2, where the subject read the contexts silently. If difficult articulation transitions are the reason for the syntactic effect observed in the naming task, then the effect should be eliminated, or at least severely attenuated, when the context is read silently. In contrast, the pattern of effects in the lexical decision task should remain unchanged. Thus, this experiment provides an environment more conducive to observing the expected three-way interaction.

Method

The subjects were 56 undergraduate students recruited through an undergraduate psychology subject pool. Twenty-four of the subjects performed in the lexical decision condition, and the remaining 32 subjects performed in the word naming condition. The stimuli

Table 1
Mean Reaction Times (in Milliseconds) and Mean Percentages of Errors in Experiment 1

Final Word of Context	Target Type			
	Verb		Noun	
	RT	PE	RT	PE
Lexical Decision Task				
Modal	659	1.3	764	2.6
Preposition	737	2.9	670	1.3
Naming Task				
Modal	561	1.0	643	2.4
Preposition	633	1.8	555	0.5

Note—PE = percentage of errors.

and apparatus were the same as in Experiment 1, except that target-word onset was under the control of the computer rather than the experimenter. The target word appeared 3,500 msec after the onset of the sentence context. The subjects were instructed to read the sentence contexts silently and then respond appropriately when the target appeared. With one exception, all other aspects of the procedure were as in Experiment 1. In Experiment 2, the subject's reaction time in milliseconds was displayed in the upper left corner of the display after each trial. No specific instructions were given regarding this feedback, but it did serve to emphasize the importance of speed. Previous pilot and published work with the fixed-interval procedure has indicated that it tends to yield slower reaction times than does the experimenter-initiation procedure (cf. Experiment 1 of Stanovich & West, 1983, with Experiment 8 of that paper and with Experiment 2 of West & Stanovich, 1982).

Results and Discussion

The data were treated as in Experiment 1. The mean reaction times and the mean percentage of subject errors for the four experimental conditions are displayed in Table 2. All of the analyses that follow are based on the subject's mean reaction time in each condition. A $2 \times 2 \times 2$ (task $\times$ target $\times$ context) analysis of variance on the reaction times indicated that the main effect of task (lexical decision vs. naming) was significant [$F(1,54) = 6.74$, $p < .025$]. Reaction times were slower in the lexical decision task than in the naming task. Neither the main effect of target [verb vs. noun; $F(1,54) = 2.30$] nor the main effect of context [modal vs. preposition; $F(1,54) = 2.25$] was significant. The target $\times$ context interaction was significant [$F(1,54) = 23.4$, $p < .001$]. The main verb targets were responded to more rapidly when preceded by modal contexts than when preceded by the preposition contexts, whereas the plural noun targets were responded to more rapidly when preceded by preposition contexts than when preceded by the modal contexts. Replicating the finding in Experiment 1, the three-way interaction was not significant [$F(1,54) < 1$]. The size of the two-way interaction was as large in the naming task as in the lexical decision task. The mean context effects (PV–MV and MN–PN) were 69 and 43 msec, respectively, in the naming task, and 62 and 36 msec, respectively, in the lexical decision task. None of the reaction-time patterns were obscured by speed-accuracy trade-offs. In the lexical decision task, the mean reaction time to nonwords preceded by M contexts was 701 msec

(4.4% error) and the mean reaction time to nonwords preceded by P contexts was 732 msec (3.1% error).

The results of an item analysis mirrored the subject analysis in all critical aspects. There was a significant main effect of task [$F(1,22) = 34.7$, $p < .001$], but not of context [$F(1,22) = 1.31$] or target ($F < 1$). The target $\times$ context interaction was significant [$F(1,22) = 18.4$, $p < .001$], but the three-way interaction was not ($F < 1$).

The results of Experiment 2 essentially replicated those of Experiment 1. Having the subjects read the contexts silently did not eliminate the target $\times$ context interaction in the naming task. In fact, the interaction was as large in that task as in the lexical decision task. Thus, it seems that a simple explanation in terms of articulation transitions will not suffice. In the next experiment, we focused on exploring further the boundary conditions of the syntactic priming effect in the naming task.

EXPERIMENT 3

In Experiment 2, the context sentence was exposed for a fixed interval during which it was read silently. Although this procedure attenuates the articulation transition problem, it has certain undesirable aspects (see Stanovich & West, 1983, for a further discussion and comparison of silent vs. oral reading in sentence context experiments). Since the context exposure interval is constant (3,500 msec in Experiment 2) and since the sentences vary in length, the fixed-interval procedure virtually guarantees that the time between the reading of the context and the onset of the target word will vary from trial to trial. Perhaps on some trials, the target appears before the context has been completely read. More importantly, on some trials, there will be an unfilled interval between the reading of the context and the onset of the target word. It has frequently been argued (e.g., Mitchell & Green, 1978; Stanovich & West, 1983) that such intervals may induce the subject to employ expectancy strategies that are not normally used when there are continuous processing demands. Thus, the fixed-interval procedure of Experiment 2 may have allowed subjects in the naming condition to use some type of conscious expectancy strategy, or encouraged a postlexical check strategy in this task as well, even though normally such a grammatical check is avoided in naming. In Experiment 3, we attempted to minimize these possibilities by having the subject read the context silently as it was presented one word at a time across the screen (similar to the procedure used by Wright & Garrett, 1984). This procedure, although somewhat more unnatural, provides greater control over the interval between context reading and target onset.

Method

The subjects were 32 undergraduate students recruited through an undergraduate psychology subject pool. All subjects performed only the naming task. The stimuli and apparatus were the same as in Experiment 2, except that the sentence contexts were presented

Table 2
Mean Reaction Times (in Milliseconds) and Mean Percentages of Errors in Experiment 2

Final Word of Context	Target Type			
	Verb		Noun	
	RT	PE	RT	PE
Lexical Decision Task				
Modal	664	2.1	733	6.3
Preposition	726	4.2	697	5.6
Naming Task				
Modal	586	0.5	649	0.5
Preposition	655	3.1	606	1.0

Note—PE = percentage of errors.

sequentially from left to right across the CRT. A new context word appeared every 400 msec, and each word stayed on the screen as others were added. A plus sign appeared on the screen before the onset of the first context word. The plus sign indicated the position on the screen where the first letter of the target would appear. When all the words of the context and the target were displayed, the location that had been occupied by the plus sign was occupied by the first letter of the target. The subjects were instructed to read silently each word of the context as it appeared and then name the target word as fast as possible when it replaced the plus sign. As in Experiment 2, subjects were given trial-by-trial feedback on their response speeds. All other aspects of the procedure were as in Experiment 2.

Results and Discussion

The mean reaction times and the mean percentage of subject errors for the four experimental conditions are displayed in Table 3. All of the analyses that follow are based on the subject's mean reaction time in each condition. A 2×2 (target $\times$ context) analysis of variance on the reaction times indicated that neither the main effect of target (verb vs. noun) [$F(1,31) < 1$] nor the main effect of context (modal vs. preposition) [$F(1,31) = 2.69$] was significant. The target $\times$ context interaction was significant [$F(1,31) = 7.04, p < .025$]. The main verb targets were responded to more rapidly when preceded by modal contexts than when preceded by preposition contexts, whereas the plural noun targets were responded to more rapidly when preceded by the preposition contexts than when preceded by the modal contexts. The mean context effects (PV–MV and MN–PN) were 50 and 14 msec, respectively. An item analysis revealed a significant main effect of context [$F(1,22) = 4.78, p < .05$], but not of target ($F < 1$). The target $\times$ context interaction was significant [$F(1,22) = 9.54, p < .01$].

Thus, the critical context $\times$ target interaction was obtained in another naming experiment in which the context was read silently in order to attenuate the possible problem of differentially difficult articulation transitions. The word-by-word presentation procedure additionally ensured that there was not a long interval between the reading of the last context word and target onset that would have encouraged the use of expectancies not normally employed during the ongoing word recognition of reading.

The overall naming times were from 70 to 100 msec faster in Experiment 3 than in the previous two experiments, and the error rates were considerably higher. There were, of course, two methodological differences between Experiments 1 and 3 (the presence or absence of response feedback and the oral vs. silent word-by-word method of

context presentation), and one methodological difference between Experiments 2 and 3 (silent fixed-interval vs. silent word-by-word methods of context presentation). Nevertheless, the results indicated that some combination of these methodological changes led to considerably faster responses in Experiment 3.

The overall faster response times in Experiment 3 raised the possibility that the three-way interaction in the first two experiments might have failed to obtain because of the relatively slow reaction times in the naming task. This hypothesis suggests itself because the context effects were correspondingly lower in Experiment 3. The syntactic context effect on the verb targets was 50 msec compared to 72 msec and 69 msec in the first two experiments, and the context effect on the noun targets was 14 msec compared to 88 msec and 43 msec. Thus, the possibility that the three-way interaction would obtain when naming times are faster is explored in Experiment 4, where performance in both tasks is examined using the experimenter-initiation procedure of Experiment 1, but with the addition of the trial-by-trial feedback utilized in Experiments 2 and 3.

EXPERIMENT 4

Although both West and Stanovich (1982) and Seidenberg et al. (1984) argued that postlexical effects were more implicated in lexical decision performance, neither research group argued that such effects were totally absent in the naming task. Their results do not rule out the possibility of creating conditions under which postlexical effects are observed in naming. Although it is probably the signal detection logic of the lexical decision task that primarily accounts for its greater sensitivity to postlexical effects (see Balota & Chumbley, 1984; Seidenberg et al., 1984; West & Stanovich, 1982), a secondary factor might be the sheer amount of time that passes before a response is initiated. As either task is slowed down, more time is available for slower-acting syntactic and message-level processes to become implicated in performance in some way (although that "way" is much more well specified in the case of lexical decision than it is in naming; see Seidenberg et al., 1984).

West and Stanovich (1982; Stanovich & West, 1983) employed a variant of a model proposed by Forster (1979) as a framework for analyzing the processing requirements of the tasks used to assess sentence context effects. The general framework consists of lexical, syntactic, and message-level processors arranged in a serial cascadelike (McClelland, 1979) structure, with each processor simultaneously sending information to a decision-making general problem solver that determines the appropriate response based on task requirements. If the decision maker delays initiating output subsequent to lexical access (due to a variety of possible reasons including conflicting information or a conservative criterion), then more time becomes available for information to accumulate at syntactic and message levels and to seep over from these levels to affect the decision maker in some way. Thus, even a

Table 3
Mean Reaction Times (in Milliseconds) and Mean Percentages of Errors in Experiment 3

Final Word of Context	Target Type			
	Verb		Noun	
	RT	PE	RT	PE
Modal	502	6.3	530	4.7
Preposition	552	7.8	516	3.1

Note—PE = percentage of errors.

naming response, if executed slowly enough, may be influenced by higher processing levels. The attenuated syntactic effects in Experiment 3 are consistent with this idea, because the methodology utilized in that experiment yielded responses that were considerably faster than those in the first two experiments. The faster the response, the less likely it is that a conservative criterion for naming responses was allowing an unusual amount of time for postlexical grammaticality checks that would not normally take place. However, postlexical effects observed with the lexical decision task may be less closely linked to sheer time, but instead result more from the Stroop-like interference on a binary response (see Seidenberg et al., 1984; West & Stanovich, 1982). If these conjectures are accurate, then inducing faster responses may attenuate the context effects in the naming task more than those in the lexical decision task. Thus, when overall response times are faster, it may be possible to detect a three-way interaction among context, target, and task. This is tested in Experiment 4.

Another issue that was addressed in Experiment 4 was the question of whether the syntactic context effects observed in the previous experiments were facilitatory or inhibitory. Wright and Garrett (1984) considered this point, speculating about whether such effects might not reflect postlexical inhibition:

It is, of course, conceivable that the powerful facilitatory effects on performance that are associated with sentence organization in general and syntax in particular do not lie in directing primary contact with the lexical inventory, but rather in filtering the products of basic lexical recognition processes, selecting those to be integrated into the current structural analysis and passed on for interpretive processes and possible retention. This conception of the role of syntactic organization on word recognition suggests that it is an inhibitory effect—that is, that the response times (RTs) for syntactically inappropriate recognition targets are increased. (p. 32)

Of course, the separation of contextual effects into facilitatory and inhibitory components requires that a neutral condition be utilized. The choice of this neutral condition is a vexing decision, as the recent review by Jonides and Mack (1984) illustrated. Perhaps the most important point for researchers to appreciate is that the appropriateness of a neutral condition depends on the specific research question being addressed. There is no such thing as a truly neutral condition, one that is inherently neutral when embedded within any experiment. The neutral condition that isolates the particular effect under investigation will vary from study to study. This is relevant to the issues addressed here. For example, Stanovich and West (1983) used (among others) the neutral context "they said it was the" to isolate the semantic sentence context effects in their experiments because it was not predictive of the target words and was not semantically related to the target words, but—like the congruous and incongruous experimental conditions—it provided an appropriate syntactic context for the nouns that were used as targets.

Clearly, though, this neutral condition would not be appropriate for assessing the nature of the syntactic context effects on the verbs in the present experiments. We decided that a better candidate would be the sentence fragment "the next word will be," originally used by McClelland and O'Regan (1981). One advantage of this neutral condition is that, in one of the few direct empirical comparisons of several different neutral conditions that has been reported in the literature, Stanovich and West (1983) demonstrated that it converged with two other neutral conditions when used to assess the facilitatory and inhibitory effects of semantic context. Nevertheless, the choice of an appropriate neutral condition for assessing the syntactic effects observed by Wright and Garrett (1984) and in Experiments 1–3 reported here is a very difficult one, and any results should be viewed very tentatively. Thus, we do not wish to imply in any way that these results should be viewed as definitive. Instead, our hope was that this particular neutral condition would at least produce some suggestive results.

Method

The subjects were 84 undergraduate volunteers recruited through an undergraduate psychology subject pool. Forty-two of the subjects performed in the lexical decision condition, and the remaining 42 subjects performed in the word naming condition. The stimuli and apparatus were the same as in Experiment 1, except that a neutral context condition was created by utilizing the incomplete sentence "the next word will be." The procedure was the same as that used in Experiment 1: The words of the context were presented simultaneously and read aloud by the subjects and target-word onset was controlled by a button pushed by the experimenter subsequent to the subject's articulation of the last word of the context. The one difference from Experiment 1 was that this experiment utilized the trial-by-trial response time feedback employed in Experiments 2 and 3.

After completing 12 practice trials, each subject performing the lexical decision task received a random ordering of 108 experimental trials, consisting of 4 trials under each of the six experimental conditions (MV, MN, PV, PN, NeutralV, NeutralN), 30 word filler trials, and 54 nonword trials. The assignment of targets from the total nonfiller population was counterbalanced across subjects so that each was presented equally often under each of the context conditions. No subject saw the same target word or sentence context more than once in the course of the experiment. Each subject received the same filler trials. The 42 subjects who participated in the naming task received an identical set of trials, with the exception that all nonword trials were deleted.

Results and Discussion

The mean reaction times and the mean percentage of subject errors for the six experimental conditions are displayed in Table 4. All of the analyses that follow are based on the subject's mean reaction time in each condition. A $2 \times 2 \times 2$ (task $\times$ target $\times$ context) analysis of variance on the reaction times (excluding the neutral condition to ensure comparability with the previous analyses) indicated that the main effect of task (lexical decision vs. naming) was significant [$F(1,82) = 29.7, p < .001$]. Reaction times were slower in the lexical decision task than in the naming task. The main effect of target (verb vs. noun) was significant [$F(1,82) = 16.4, p < .001$], but the main

Table 4
Mean Reaction Times (in Milliseconds) and Mean
Percentages of Errors in Experiment 4

Context Condition	Target Type			
	Verb		Noun	
	RT	PE	RT	PE
Lexical Decision Task				
Modal	594	5.4	700	7.1
Preposition	672	5.4	639	3.0
Neutral	590	1.8	614	6.0
Naming Task				
Modal	490	0.0	557	0.0
Preposition	528	3.0	528	0.0
Neutral	494	0.6	509	0.0

Note—PE = percentage of errors.

effect of context (modal vs. preposition) was not [$F(1,82) < 1$]. The verb targets were responded to faster than the nouns. Replicating the previous experiments, the target $\times$ context interaction was significant [$F(1,82) = 58.3, p < .001$]. The main verb targets were responded to more rapidly when preceded by modal contexts, whereas the plural noun targets were responded to more rapidly when preceded by preposition contexts. The critical three-way interaction was statistically significant [$F(1,82) = 7.14, p < .01$]. The syntactic context effects were larger in the lexical decision task than in the naming task. The mean context effects (PV–MV and MN–PN) were 38 and 29 msec, respectively, in the naming task, and 78 and 61 msec, respectively, in the lexical decision task. Performance in the neutral conditions appears to indicate that the context effects in this paradigm are primarily inhibitory. In the lexical decision task, the mean reaction time to nonwords preceded by M contexts was 671 msec (4.5% error), the mean reaction time to nonwords preceded by P contexts was 686 msec (5.1% error), and the mean reaction time to nonwords preceded by the neutral context was 688 msec (5.4% error).

The results of an item analysis mirrored the subject analysis in all critical aspects. There was a significant main effect of task [$F(1,22) = 124.4$], but not of context or prime ($F < 1$ in both cases). The target $\times$ context interaction [$F(1,22) = 11.01, p < .01$] and the task $\times$ target $\times$ context interaction [$F(1,22) = 4.73, p < .05$] were both significant.

Experiment 4 thus replicated the main finding of Experiments 1, 2, and 3: both main verb and plural noun targets were responded to more rapidly when they were syntactically acceptable continuations of sentence fragments. However, in contrast to Experiments 1 and 2, the size of this effect was smaller in the naming task than in the lexical decision task. In addition, performance in the neutral context, not included in the other experiments, appeared to indicate that the context effects were inhibitory in nature (the PV and MN times were slowed relative to the neutral times).

GENERAL DISCUSSION

The results of these four experiments demonstrate that the effects of syntactic structure on word processing observed by Wright and Garrett (1984) are very robust. In the lexical decision task the critical context condition $\times$ target word interaction was replicated with two methodological variations different from the word-by-word presentation procedure used by Wright and Garrett (1984): having the subject read the contexts out loud and presenting the contexts for a fixed interval for silent reading. More importantly, the syntactic context effect was replicated using a naming task. Unlike the single-word syntactic priming effect studied by Goodman et al. (1981), the syntactic effect obtained with the Wright and Garrett (1984) stimuli did not disappear when a naming task was employed. The critical context $\times$ target interaction was also observed under several different methodological variations using the naming task. Thus, this particular effect is both larger and more robust than the one studied by Goodman et al. (1981).

The experiments reported here do not provide definitive evidence regarding the locus of the syntactic context effect, but they are suggestive. The three-way interaction in Experiments 1 and 2 was not significant, indicating that the syntactic context effects were as large in the naming task as in the lexical decision task. This was at first surprising, because it was conjectured (extrapolating from the results of Seidenberg et al., 1984) that the effect observed by Wright and Garrett (1984) was a postlexical effect. Since, based on previous research, it was thought that the naming task would be less sensitive to postlexical effects, a three-way interaction was expected.

Although Experiments 1 and 2 indicated that the naming task was just as susceptible to the effects of syntactic structure as was the lexical decision task, Experiments 3 and 4 were more consistent with previous research in indicating that the former task was not as sensitive under all conditions. Experiment 3, using the word-by-word presentation procedure and response-time feedback, resulted in naming times some 70–100 msec faster than those in Experiments 1 and 2, and yielded somewhat smaller context effects. Experiment 4, with similar fast times revealed an interaction between task type and the magnitude of the context effect. A partial explanation of the different outcomes in the four experiments is possible if it is assumed that faster times allow less of an opportunity for postlexical effects to become implicated in performance, and that postlexical effects in the naming task are more directly related to the time available for integrative processing than in the lexical decision task, due perhaps to the different logic of responding in the two tasks (Balota & Chumbley, 1984; Seidenberg et al., 1984; West & Stanovich, 1982). These assumptions suggested that a naming task performed under conditions that minimized the opportunity for postlexical processing

would, when compared with a lexical decision task, yield the expected three-way interaction. This is what occurred in Experiment 4, where faster overall times were obtained. The three-way interaction was significant in this experiment, and it occurred because the context effects in the naming task were smaller than those in Experiments 1 and 2, whereas those observed with the lexical decision task were of the same size. Thus, the results of Experiment 4 were consistent with previous research in indicating that the naming task is less susceptible to postlexical effects.

However, even if such an interpretation of Experiment 4 is accepted, the fact remains that robust syntactic effects were observed in the naming task, even under relatively speeded conditions (Experiments 3 and 4). Thus, it appears that we must accept one of two possibilities: either the naming task taps only lexical access and the syntactic effect is localized at this stage, or the naming task is sensitive to postlexical effects. (Of course, a combination of these possibilities could also account for the results.) Although the issue is far from closed, the second explanation appears to be preferable. First, Seidenberg et al. (1984) demonstrated that at least one syntactic effect—the single-word priming effect of Goodman et al. (1981)—appears to be postlexical. Second, the constraints provided by syntax appear to be too weak to cause facilitatory effects as large as those observed in these experiments (see Tanenhaus & Lucas, in press; Tyler & Wessels, 1983).

Although the assumption that the naming task reflects some postlexical processing is perhaps most consistent with the present results, the assumption does leave some unresolved problems. Most important is the fact that although there exist some specific conceptualizations about how syntactic and semantic incongruity might disrupt lexical decisions (Seidenberg et al., 1984; West & Stanovich, 1982), it is less clear exactly how naming is inhibited, and thus the nature of the postlexical effect remains unspecified. Perhaps sentence integration processes sensitive to syntactic anomaly can disrupt naming responses in some way. A more promising candidate hypothesis, however, would appear to be some type of prearticulatory output editing operating in the naming task (Garnsey & Dell, 1984; Motley, Baars, & Camden, 1981; Motley, Camden, & Baars, 1982; M. K. Tanenhaus, personal communication, June 23, 1985). For example, Motley et al. (1981) had subjects articulate nonword pairs in which initial consonant exchanges would result in real words (for example, responding *nine cups* to the stimulus *kine nups*). They found that consonant exchanges were more likely when the resulting word pair was syntactically appropriate. That is, nonword pairs like *drot hink* (where an exchange resulted in *hot drink*) yielded more exchanges than did pairs like *drot hank* (where an exchange resulted in *hot drank*). It is thus possible that the syntactic context effects observed in the naming task are due to a prearticulatory editing process that serves to inhibit responses in the inappropriate conditions. This con-

jecture is supported by the results of Experiment 4, which indicated that the context effects in the naming task were exclusively inhibitory in nature (as were the context effects in the lexical decision task, although presumably for different reasons).

The present results contrast somewhat with the findings of experiments on task differences in the effect of semantic congruity. It seems much easier to demonstrate that the naming and lexical decision tasks are differentially sensitive to postlexical semantic congruity effects (see de Groot, 1985; Forster, 1981; Seidenberg et al., 1984; Stanovich & West, 1983; West & Stanovich, 1982). It is possible that Forster's model (1979; see West & Stanovich, 1982) can aid in understanding this difference. Due to the serial arrangement of the language processing stages, output from the syntactic processor reaches the general problem solver (which computes the response) before output from the message level. Naming may be a task that can escape message-level incongruity but not syntactic inappropriateness. This may be because message-level information reaches the general problem solver too late to affect the response, but information from the syntactic process does not (but see Tyler & Marslen-Wilson, 1977). Alternatively, incongruity signaled by the message level may not disrupt lexically driven naming responses when the latter are reinforced by a syntactic level signaling that the target is appropriate (which would happen in the West & Stanovich, 1982, experiments where the semantically incongruous targets were syntactically appropriate). However, a syntactic analysis signaling an inappropriate input may be able to disrupt lexically driven naming when no reinforcing message-level information is present (as is the case with the Wright & Garrett, 1984, stimuli). Regardless of the eventual resolution of these issues, the implications of the results of the naming conditions are important, because the interpretations of various tasks in the word processing literature are currently in flux (Balota & Chumbley, 1984, 1985; Chumbley & Balota, 1984; de Groot, 1984, 1985; Forster, 1979, 1981; Jakimik, Cole, & Rudnicky, 1985; Seidenberg et al., 1984; Stanovich & West, 1983; West & Stanovich, 1982).

Although these and other important issues remain to be decided, the present experiments have consolidated an empirical phenomenon of some importance. The syntactic manipulation employed by Wright and Garrett (1984) is very robust. It obtains under several different methodological variations and is observed in a task that has been relatively insensitive to other contextual effects. For example, the naming of incongruous words is disrupted only slightly as long as the word is as syntactically appropriate in the incongruous condition as in the neutral condition (Stanovich & West, 1983). Syntactically appropriate incongruous words experience inhibition only when in lexical decision tasks or in naming tasks where they are visually degraded or very difficult to recognize.

Although the event-related potential data of Kutas and Hillyard (1983) suggested different and separable sources of semantic and syntactic effects in sentence processing,

several investigators (e.g., Cowart, 1982; Goodman et al., 1981) have pointed out that syntactic manipulations like those investigated here are subtly intertwined with semantics and are difficult to separate absolutely. However, this point only serves to emphasize the interest of the present results. This is because it should be easier to demonstrate differential task sensitivity to the phenomenon, the more that the syntactic manipulation is confounded with semantic congruity, since it is relatively easy to demonstrate task differences with the latter. Instead, in the experiments reported here, the expected differential task sensitivity was relatively difficult to demonstrate, perhaps indicating some type of convergence with the results of Kutas and Hillyard (1983).

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(Manuscript received June 13, 1985;
revision accepted for publication October 7, 1985.)