Journal of Experimental Psychology:
Learning, Memory, and Cognition
1989, Vol. 15, No. 5, 791-801

0278-7393/89/$00.75

Semantic Facilitation of Lexical Access During Sentence Processing

Susan A. Duffy
Amherst College

John M. Henderson
University of Alberta, Edmonton, Alberta, Canada

Robin K. Morris
University of Massachusetts—Amherst

In three experiments we investigated the effect of a sentence context on naming time for a target word. Contexts were presented by using a rapid serial visual presentation; subjects named the last word of the sentence. In the first two experiments, facilitation was observed for a fully congruent context containing a subject and verb that were weakly related to the target word. No facilitation was observed when either the subject or verb was replaced with a more neutral word. In the third experiment, the fully congruent contexts were modified either to preserve or to disrupt the original relation between the subject and verb. Facilitation was observed in both conditions. The full pattern of results suggests that a combination of lexical items can prime a target word in the absence of priming by any of the lexical items individually. This combination priming is not dependent upon the overall meaning of the sentence.

This article focuses on characterizing the mechanisms by which lexical access for a particular word is affected by the preceding sentence context. Within the literature on lexical access a number of studies suggest that lexical access is speeded when the word is preceded by a congruent context. These studies have used a variety of dependent measures to get at lexical access time, including lexical decision (e.g., Fischler & Bloom, 1979, 1980; Schuberth, Spoehr, & Lane, 1981), phoneme monitoring (Foss, 1982), fixation time (Ehrlich & Rayner, 1981; Balota, Pollatsek, & Rayner, 1985), and naming time (e.g., Stanovich & West, 1981, 1983).

The variety of dependent measures reflects the difficulty in finding a measure of lexical access time that is not contaminated by other processes that could also be affected by context. In fact, much of the controversy in the literature has focused on determining whether the context effects that have been found actually reflect an influence on lexical access or on some process that follows access (e.g., Seidenberg, Waters, Sanders, & Langer, 1984; Stanovich & West, 1983; West & Stanovich, 1982).

Perhaps the most convincing evidence for the influence of a sentential context on lexical access has been provided by Stanovich and West (1981, 1983). In these studies, subjects read a context sentence and then named aloud as quickly as possible a target word. In general, Stanovich and West found that a word was named (and by inference, accessed) faster when it appeared in a congruent sentence context than when it appeared in a neutral sentence context. In addition, they found no difference in naming time for incongruent and neutral sentence contexts (i.e., no inhibition effect). The lack of an inhibition effect in the incongruent condition is critical for interpreting the source of facilitation in the congruent contexts. If the context effects are due to postaccess integration processes, then one would expect to find an inhibition effect, reflecting the difficulty of integrating the target word with an incongruent context. The lack of an inhibition effect allows one to argue that naming is reflecting lexical access processes rather than postaccess integration processes. In general, the naming task seems not to reflect postaccess processes to the extent that other measures do (Lorch, Balota, & Stamm, 1986; Seidenberg et al., 1984).

One explanation for the facilitating effect of a congruent context on naming time for a target word is simple lexical–lexical priming (Meyer & Schvaneveldt, 1971). The context is assumed to contain a single word that is semantically associated with the target word. Activation spreading from this context word serves to activate the target and thus make it easier to name once it is encountered. Although this simple mechanism may account for many context effects, it is not a compelling explanation for Stanovich and West's data, given the stimuli they used. Stanovich and West used both easy and difficult target words. They found facilitation in the congruent condition for both types of targets; in fact, the size of the facilitation effect was larger for the difficult target words. An inspection of their stimuli suggests that, especially for the difficult targets, the context did not contain a single strong priming word.

A modified version of a lexical–lexical priming model, however, can account for the pattern of results that Stanovich and West found for the difficult target words. Although the

This research was supported by Grants MH16745 and MH40029 from the National Institute of Mental Health and by Grants BNS83-17900 and BNS86-09336 from the National Science Foundation.

We wish to thank Dolores Shank for assistance in conducting the experiments, Chuck Clifton, Fernanda Ferreira, Don Fisher, and Jerry Myers for useful discussions of the research, and David Balota, Chuck Clifton, Ken den Heyer, Aydin Durgunoglu, Judy Kroll, Michael Masson, and Henry Roediger for comments on an earlier draft of the manuscript.

Correspondence concerning this article should be addressed to: Susan A. Duffy, Department of Psychology, Amherst College, Amherst, Massachusetts 01002.

sentence contexts contained no words that were highly associated with the target words, many of the content words in their sentences are modestly related to the target words. For example, in the sentence "The barber trimmed the mustache," both *barber* and *trim* seem modestly related to mustache, and activation coming independently from *barber* and *trim* might converge at *mustache*. If each content word contributes a modest amount of activation to the target word, then priming might occur through the summation of several sources of activation at the target words. Such a lexical–lexical model would be consistent with the finding of facilitation for congruent contexts for both easy and difficult target words, and with little inhibition.

An alternative class of mechanisms by which context can facilitate focuses on activation resulting from a combination of words in the sentence context. We will refer to these models as *combination models*. Stanovich and West seem to imply such a mechanism in their claim that "... We do not wish to argue that spreading activation in sentences comes only from individual words considered singly. It is possible that spreading activation also results from semantic states induced by combinations of words" (Stanovich & West, 1983, p. 30). Foss and Ross (1983) have discussed more specifically the predictions made by such a class of models. In particular, they suggest that the set of items that is primed by the combination is not necessarily limited to the items primed by the individual lexical items within the combination.

There are a number of possible mechanisms by which combinations of words could produce a priming pattern that differs from the pattern produced by each word individually. For example, one content word might constrain which sense of a succeeding content word is activated, similar to the effect found for ambiguous words when preceded by a strongly associated priming word (Onifer & Swinney, 1981; Seidenberg, Tanenhaus, Leiman, & Bienkowski, 1982). This constraint might cause a concentration of activation along one path which results in activation of a target word that would not otherwise be activated. Alternatively, a concept derived from the integrated meaning of the sentence as a whole might serve to activate entries in the lexicon that would not be activated by any of the individual content words alone. Although these mechanisms clearly differ in terms of their consistency with a modular view of the language system (Fodor, 1983; Forster, 1979), we will postpone discussion of this issue until Experiment 3.

The lexical–lexical models and the combination models differ in one critical aspect. Under the lexical–lexical model, no target word should be primed that is not individually (albeit modestly) primed by at least one word in the sentence context. Under the combination model, priming can occur for target words that are not individually primed by any word alone in the sentence context. In Experiments 1 and 2 below, we test the contrasting predictions of these two kinds of models.

Experiment 1

In this experiment, a subset of the Stanovich and West (1981) sentence contexts was used, with the difficult target words as targets for naming. Our strategy was systematically to replace the content words of each sentence with neutral words. This allowed us to investigate the contribution made by each content word to the overall facilitation found for the sentence contexts. Contexts used in this experiment contained two content words, a subject noun and a verb which could account for any facilitation effects found for the target word. Thus, these are the content words that were systematically replaced with more neutral terms. Example stimulus materials in the four experimental conditions are given in Table 1. The congruent condition is Stanovich and West's original congruent condition. Two partial content conditions were created: subject neutral and verb neutral. To create the subject-neutral condition, the sentence's original subject was replaced by a more neutral noun. To create the verb-neutral condition, the sentence's original verb was replaced by a more neutral verb. Finally, the subject-verb neutral condition was created by replacing both the subject and verb of the original sentence with their neutral counterparts. Neutral words were chosen that did not have any special relation to the particular target word for that sentence context. Two additional conditions were included: an incongruent condition in which the target word for one sentence was replaced with one from another sentence and Stanovich and West's neutral context, "They said it was the ... " (the standard neutral condition).

The congruent, incongruent, and standard neutral conditions replicate conditions used by Stanovich and West. Thus, they can be expected to show a pattern of facilitation in processing target words following the congruent contexts and little or no inhibition for targets following the incongruent contexts compared with the standard neutral condition.

The critical effects, however, are the relative amount of facilitation observed for the congruent, subject-neutral, and verb-neutral conditions when the subject–verb neutral is the base neutral condition. We use the subject–verb neutral as the base condition for two reasons. First, it exactly matched the contexts in the other conditions in terms of syntax, number of words, and identity of words (except for the subject and/or verb). Second, because a number of neutral nouns and verbs were used, each full neutral context was slightly different from the others. Both of these traits can be considered valuable because they tended to make this neutral condition similar to the experimental conditions on irrelevant complexity dimensions (Jonides & Mack, 1984).

Given that facilitation is found for the congruent condition, the pattern of facilitation found for the two partial content conditions is critical. Under the lexical–lexical priming model, some evidence of facilitation should be found for either the

Table 1
Example Sentences for each Condition in Experiment 1

Condition	Example sentence
Congruent	The barber trimmed the mustache.
Subject neutral	The woman trimmed the mustache.
Verb neutral	The barber saw the mustache.
Subject–verb neutral	The woman saw the mustache.
Standard neutral	They said it was the mustache.
Incongruent	The barber trimmed the artifacts.

subject-neutral contexts, verb-neutral contexts, or both. The exact relation between the size of the priming effect in the congruent condition and the size of the effect within the two partial content conditions will depend upon the process by which separate sources of activation combine when they arrive at the target word.

The lexical–lexical model, as it stands, would have trouble accounting for a pattern in which the congruent condition produced facilitation, but none was observed for the two partial content conditions. Such a pattern would be consistent with the claims of the combination model, in which the combination itself provides a source of priming that differs from that provided by the individual content words alone.

Method

Subjects. Thirty-six University of Massachusetts undergraduates participated in this experiment for extra course credit.

Materials. A norming study was conducted with 28 University of Massachusetts undergraduates who participated for extra course credit. The norming study consisted of a two-response cloze task. The goal of this norming study was to define a set of sentence contexts from which the target word was very unlikely to be predicted. Seventy of the 96 sentence contexts given in the appendix of Stanovich and West (1981) were normed (26 of the original 96 sentence contexts were excluded because either the subject or the verb of the sentence was already "neutral," i.e., carried little or no semantic content, or because there were more than two main content words in the context). The 70 sentence contexts to be normed were presented in a booklet. After each sentence context, two lines were provided. Subjects, tested either individually or in small groups, were instructed to read each sentence context and to write down the first completion that they thought of on the first line and the second completion that they thought of on the second line for each of the sentence contexts. From these norms, 54 experimental sentence contexts were culled. These sentence contexts had the property that the difficult target word given by Stanovich and West (1981) for the context was never the most frequent response in the norming study, and the overall combined percentage of subjects predicting the difficult target word for a given context on either the primary or secondary response was 12.5%.

The congruent condition in Experiment 1 consisted of 54 difficult target words paired with their congruent sentence contexts. The incongruent condition consisted of a random re-pairing of the same contexts and targets with the constraint that the incongruent target made a nonsensical completion of the context. (Note that because all of the targets were nouns, the completed sentences were always syntactically well formed.) The subject–verb neutral condition for a target was created by replacing the two content words (the subject and verb) in the congruent context for that target with "neutral" words (a neutral noun and verb). A set of neutral nouns and verbs was used so that the neutral contexts differed slightly from each other across targets. The subject neutral condition was created by replacing only the subject noun in the sentence context with the noun used in the neutral condition but leaving the original verb. The verb neutral condition was created by replacing only the verb in the sentence frame with the verb from the neutral condition but leaving the original noun. The standard neutral condition consisted of the sentence context "They said it was the" followed by the target word.

Apparatus. Stimuli were presented on a cathode ray tube (CRT) controlled by a minicomputer. Naming latencies were collected by using a microphone connected to a voice-activated relay and interfaced with a digital I/O port on the computer.

Procedure. Six lists of stimuli were created according to a Latin-square design. Across lists, each target appeared in each condition, while within a list each target appeared only once. In an experimental session, subjects received a random ordering of 54 trials, 9 trials of each of the 6 conditions. Each trail consisted of the following events: First, a fixation cross appeared at the center of the CRT for 1,000 ms. The first word of the sentence context then appeared at the center of the CRT, replacing the fixation cross. This word was subsequently replaced at the center of the screen by the next word of the sentence context, and so on for all of the words included in the context. The presentation rate of the context was 250 ms per word. The last word of each context was the article *the,* which appeared on the CRT with a plus sign above and below it, also displayed for 250 ms. The plus signs served as a signal to the subject to name the next word aloud. The target word then appeared and remained on the screen until the subject responded. Subjects were instructed to read the sentences silently to themselves and to name aloud the word following the signal as quickly and as accurately as possible. After the trial, the question "OK?" appeared on the screen. Subjects were asked to press the "yes" button if they had responded appropriately (i.e., had not stumbled over the word) and the voice key had been activated (the target word left the screen when the voice key was triggered). Otherwise, the "no" button was to be pressed. After the subject responded, the fixation cross for the next trial appeared.

Prior to the experimental trials, each subject received 12 practice trials with sentence contexts and targets not included in the experimental materials. Subjects were tested individually in a session that lasted approximately 30 min.

Results and Discussion

Trials on which the subject responded "no" to the "OK?" question were excluded from the data analysis, as were trials on which the naming latency was beyond two standard deviations from the mean naming latency. Both of these types of trials were counted as subject errors. The mean naming latencies and mean subject errors for each condition are shown in Table 2. Separate analyses of variance were conducted on the mean naming latencies, and subjects and items were treated as random effects. Overall, the effect of context was significant, $F(5, 175) = 10.73$, $p < .0001$, by subjects, and $F(5, 265) = 5.024$, $p < .001$, by items. Planned comparisons were conducted in order to specify the relation of each condition to the subject–verb neutral control. Because the patterns of significance in the subjects analyses were generally mirrored in the items analyses, only the subjects analyses will be reported except in those cases where they differed.

As can be seen in Table 2, both facilitation and inhibition effects were present in the data: The congruent condition was 20 ms faster than the subject–verb neutral condition, $F(1, 35) = 6.87$, $p < .01$, and the incongruent condition was 39 ms slower than the subject–verb neutral condition, $F(1, 35) = 12.76$, $p < .001$. On the other hand, neither the subject neutral nor the verb neutral conditions differed from the subject–verb neutral control (Fs < 1). Because neither the subject nor verb alone produced facilitation, it appears that the facilitation effect in the congruent condition was not the result of simple summation of activation from the individual content words in the context sentence.

The difference between the subject–verb neutral control condition and the standard neutral condition was marginally

Table 2
Mean Naming Latencies (in Milliseconds) and Amount of Facilitation by Condition in Experiments 1 and 2

Condition	Experiment 1			Experiment 2		
	RT	% Error	Facil.	*RT*	% Error	Facil.
Congruent	588	5	20	570	6	24
Subject neutral	606	10	2	587	7	7
Verb neutral	606	7	2	596	5	−2
Subject–verb neutral	608	6	—	594	8	—
Standard neutral	624	12	−16	597	11	−3
Incongruent	647	12	−39	600	12	−6

Note. Facilitation (Facil.) is the reaction time (RT) for each condition minus the RT for the subject–verb neutral condition.

significant by subjects, $F(1, 35) = 3.63$, $p = .061$, though it was not significant by items ($F < 1$). Although we have used the subject–verb neutral condition as the control condition, the interpretation of the data concerning the combined effects of the content words in the context sentence clearly rests on the choice of an appropriate neutral condition. Unfortunately, it has recently become apparent that determining the appropriate neutral condition for a particular task is a nontrivial problem (Carr, McCauley, Sperber, & Parmalee, 1982; deGroot, 1983; Henderson, Pollatsek, & Rayner, 1987; Jonides & Mack, 1984; Rayner & Slowiaczek, 1981). The most convincing case is usually made when the interpretation remains the same regardless of the neutral condition chosen. Barring that, the next best situation is one in which a particular neutral condition can be preferred for logical reasons.

We would argue that there are several reasons for preferring the subject–verb neutral condition over the standard neutral condition as the appropriate control in Experiment 1. First, only the manipulated aspects of the sentence contexts in the subject–verb neutral condition changed; other sources of processing difficulty, such as overall structural complexity (due, for example, to the use of passives and prepositional phrases), remained constant. The standard neutral, on the other hand, consisted of only one structure, the simple declarative. Second, each subject–verb neutral context viewed by a subject differed from the others. The standard neutral context, by comparison, was repeated nine times for each subject. As Jonides and Mack (1984) have argued, both simplicity and repetition may lead to a neutral that overestimates facilitation and underestimates inhibition effects. Third, it has been argued that given two neutral controls, the faster should be taken as the more conservative neutral estimate (deGroot, 1983). Again, this implicates the subject–verb neutral condition as the appropriate control, because it resulted in shorter latencies than the standard neutral condition. Finally, the results of Experiment 2 reported below supported the use of the subject–verb neutral as the appropriate control.

The finding of inhibition in the incongruent condition was unexpected. Generally, inhibition has been thought to occur in a priming paradigm when attentional processes, such as those associated with conscious prediction of the target word, are engaged (Neely, 1977; Posner & Snyder, 1975). In the current experiment this explanation seems unlikely because the predictability of the target words was quite low, given the congruent contexts. Furthermore, the amount of time available may have been too short for attentional prediction to occur (Neely, 1977).

What, then, caused the inhibition effect? One possible explanation, suggested by the comments of our subjects, is that the warning signal which occurred prior to the target word was insufficient. At the signal, subjects were supposed to halt further processing on the sentence and turn their attention to the task of naming the next word. Suppose, however, that subjects tended to begin processing the target word itself while they were still trying to interpret the warning signal. If this occurred, then subjects would have accessed and begun to integrate the target word into an ongoing sentence representation before they realized that they were supposed to be naming the word. As a result, the ease or difficulty of the integration process might have influenced naming latency. This could be due either to a direct influence of integration difficulty on naming latency or to an indirect influence of integration difficulty on the latency of registering the warning signal. In either case, naming latency would then be partially reflecting the difficulty of sentence integration, a postaccess process. This possibility will be explored further in Experiment 2.

It should be noted that a similar pattern of facilitation accompanied by a rather large inhibition effect was observed by Masson (1986) in his second experiment and by Simpson, Peterson, Casteel, and Burgess (1989) in their first experiment. Masson also presented the sentence contexts by using a rapid serial visual presentation (RSVP) procedure with each word appearing for 150 ms. The target word to be named was not signaled ahead of time; rather, the signal (a row of asterisks) appeared simultaneously with the target word. Simpson et al. used a cumulative presentation in which the words of the sentence context were displayed across the screen, one every 300 ms. The last word was accompanied by dashes to signal the upcoming target to be named. Both procedures would also seem to lead subjects automatically to initiate the integration process before they completed processing of the warning signal and turned to the naming task.

In summary, in Experiment 1 facilitation was observed for a congruent sentence context but not for partial content contexts in which either the original subject or verb had been replaced by a neutral word. This result suggests that the facilitation observed for the congruent contexts is not due to a simple summation of the activation provided by the content words in that sentence, but rather is due to the priming resulting from the combination of the two content words. This conclusion is qualified, however, by the finding of a significant inhibition effect for the incongruent contexts. If an attention-demanding process (such as sentence integration) is causing the inhibition effect, then it may have been responsible for the facilitation effect as well.

Experiment 2

The results of Experiment 1 suggested that an attention-demanding process may have been responsible for the sentential context effects observed. One potential attention-demand-

ing process is the postaccess integration of the target word into an ongoing sentence representation. We hypothesized that naming latencies may reflect such integration processing if the signal to name the target word does not give the subject sufficient warning to prepare to name the next word rather than to integrate it with the rest of the sentence. A second explanation for the observed pattern of facilitation with inhibition is that an attentional prediction strategy was being employed. We know from the norms collected in Experiment 1 that the target words employed were never the most likely completion for the congruent sentence contexts and were only 12.5% predictable even when subjects were given two chances at completion. Still, it is conceivable that even such a low level of predictability is sufficient to produce a reliable context effect if, for example, subjects are able to prepare multiple candidates.

In Experiment 2 we attempted to contrast competing predictions made by the integration and prediction hypotheses as explanations for the inhibition effect observed in Experiment 1. This experiment replicated Experiment 1 except for one change: The plus signs which signaled subjects to name the next word remained on the screen for 500 ms rather than for 250 ms. We reasoned that if the inhibition effect observed in Experiment 1 was caused by a prediction strategy on the part of the subjects, then increasing the time between the end of the sentence context and the presentation of the target word should increase the size of the inhibition effect. This prediction derives from the fact that prediction requires time to begin operation (Posner & Snyder, 1975; Neely, 1977). If, on the other hand, the inhibition effect was caused by insufficient warning, leading to a tendency to integrate the target word into the sentence context prior to naming, then increasing the time between the end of the sentence context and the target word should allow the subject to prepare to name the next word, thereby decreasing the inhibition effect.

Method

Subjects. Thirty-six University of Massachusetts undergraduates participated in this experiment for extra course credit. None of the subjects had participated in Experiment 1.

Materials. The materials were the same as those used in Experiment 1.

Apparatus. Stimuli were presented by using the same apparatus as Experiment 1.

Procedure. The procedure was the same as in Experiment 1, with the exception of the duration of the plus sign signal used to warn the subject that the next word should be named. In this experiment, the plus signs which appeared around the word *the* remained on the screen an additional 250 ms after *the* had disappeared. Thus, the warning signal had a duration of 500 ms: 250 ms of the article and plus signs together and 250 ms of just the plus signs. The result of this was to lengthen the duration of the warning signal and to increase the interval between the end of the sentence context and the presentation of the target word from 0 ms in Experiment 1 to 250 ms in Experiment 2.

Results and Discussion

Trials on which the subject responded "no" to the "OK?" question were excluded from the data analysis, as were trials on which the naming latency was beyond two standard deviations from the mean naming latency. Both of these types of trials were counted as subject errors. The mean naming latencies and mean subject errors for each condition are shown in Table 2. Separate analyses of variance were conducted on the mean naming latencies, and subjects and items were treated as random effects. Overall, the effect of context was significant, $F(5, 175) = 3.57$, $p < .005$, by subjects, and $F(5, 265) = 3.04$, $p < .02$, by items. Planned comparisons were conducted in order to specify the relation of each condition to the subject–verb neutral control. Because the patterns of significance in the subjects analyses were generally mirrored in the items analyses, only the subjects analyses will be reported except in those cases where they differed.

As Table 2 shows, there was a 24-ms facilitation effect for the congruent condition compared with the subject–verb neutral condition, $F(1, 35) = 12.1$, $p < .005$. Contrary to Experiment 1, however, there was no inhibition effect for the incongruent compared with the subject–verb neutral condition ($F < 1$). The fact that increasing the delay between the presentation of the last word of the context and the presentation of the target word decreased the amount of inhibition observed from a significant effect of 39 ms in Experiment 1 to a nonsignificant 6 ms in Experiment 2 suggests that the inhibition effect in Experiment 1 was not due to a prediction strategy. If a prediction strategy had been accounting for the inhibition effect, then increasing the interval between warning and target should have increased rather than decreased the inhibition effect from Experiment 1 to Experiment 2 (Neely, 1977). On the other hand, the inverse relation between the warning–target interval and the amount of inhibition observed is consistent with the sentence integration hypothesis, which states that integration processes will automatically be initiated unless sufficient warning and/or time is given to allow the subject to prepare for a naming response. Increasing the warning–target interval in Experiment 2 allowed the subject to do just that. As a result, naming latency more accurately reflected lexical access time for the target word.

As in Experiment 1, facilitation was observed for the congruent sentence context but for neither of the partial content contexts. Neither the subject neutral nor the verb neutral conditions differed significantly from the subject–verb neutral control, $F(1, 35) = 1.87$, $p > .10$, and $F < 1$, respectively. This result did not depend on a choice between the two neutral conditions, because the standard neutral and the subject–verb neutral conditions did not differ from each other ($F < 1$). Because the pattern of results with either of the two neutral conditions in Experiment 2 replicated the pattern with the subject–verb neutral in Experiment 1, our confidence in the interpretation of the Experiment 1 data based upon the subject–verb neutral control is increased.

The fact that the standard neutral condition was slower than the subject–verb neutral condition in Experiment 1 but not in Experiment 2 suggests that the standard neutral condition might be mildly incongruent. As a result, in the first experiment, the integration process was slowed for the target words following the standard neutral condition, as well as for those following the intended incongruent condition. A consideration of the sentences formed when the target words are

preceded by the standard neutral condition suggests why such mild incongruity arises. For example, "They said it was the mustache" seems incongruent simply because it is not immediately obvious in what context one might actually use such a sentence.

In both Experiments 1 and 2, facilitation was found when the sentence context contained both critical content words, but none was found when the context contained only one of the two content words. Therefore, several characterizations of the process accounting for the facilitation effect are ruled out. For example, it is clear that the facilitation effect is not due to priming from any single content word in the sentence context. Nor can it be due to simple linear summing activation from both content words because this type of model predicts some evidence of facilitation from the partial content contexts. Also ruled out are more complex versions of summing activation in which the rate of change of activation at the target word's node, given a constant amount of input activation, slows as the threshold is reached. A model of this type (which is perhaps a more realistic conception of summing activation) would also predict evidence of facilitation from the partial content contexts. It thus appears that the facilitation of lexical access that is produced by a congruent sentence context is an emergent property of the combination of words contained in the sentence context.

Experiment 3

There are a number of ways in which a combination model might be instantiated. These instantiations differ in the specific mechanisms by which access of the target word is primed by the combination of content words contained in the sentence context. These instantiations also differ in terms of whether they fit within the class of language processing models labeled *modular* or *autonomous* (Fodor, 1983; Forster, 1979) or within those labeled *nonmodular* or *interactive* (e.g., Marslen-Wilson & Tyler, 1980; McClelland, 1987).

In an instantiation in which modularity was preserved, one would have to claim that the subject–verb combination facilitated naming of the target word through pathways existing within the lexicon (Forster, 1979). As a result, the facilitation effect should not be sensitive to changes in syntax of the sentence that changed the relation between the critical noun and verb. That is, for example, any sentence containing both *barber* and *trim* should facilitate *mustache*. This is so because within the assumptions of a modular theory of the language system, an integrated sentence-level representation based upon a particular syntactic parse of the sentence is not able to influence lexical access.

A nonmodular account of the facilitation effect, on the other hand, would suggest that processes beyond the lexical access level help guide the lexical access process. Therefore, an account of the facilitation effect based upon the use of an integrated sentence-level representation (in which the arguments of the verb are assigned to their various roles, for example) would be consistent with the nonmodular hypothesis. Under such a nonmodular model, the facilitation effect should be sensitive to manipulations in the syntax of the sentence that result in a change in the relation between the critical noun and verb. Thus, for example, all sentences containing *barber* and *trim* should not equally prime *mustache*.

To assess the predictions of these alternative instantiations of the combination model, we manipulated the relation between the critical noun and verb in the context sentences by altering the syntax of the sentence. For example, the sentence context "The barber trimmed the" was changed to the following two new sentence contexts:

1. While she talked to him the barber trimmed the . . . .
2. While talking to the barber she trimmed the . . . .

The congruent target word for both of these contexts was the word *mustache*. In Sentence Context 1, representing the subject–verb preserved condition, the main content words (*barber* and *trimmed*) were the subject and verb in the original congruent condition. Thus the subject–verb relation from the congruent condition of the first two experiments was preserved. In Sentence Context 2, representing the subject–verb disrupted condition, the content noun (*barber*) was demoted to a subordinate clause within the sentence, and a neutral pronoun (*she*) became the subject of the original verb.

If the facilitation effect observed in Experiments 1 and 2 was due to a process operating at a purely lexical level, then changing the meaning of the sentence via the syntax would not be expected to reduce the magnitude of the facilitation effect in Experiment 3. This is so because both critical content words are still present in the disrupted condition. If, on the other hand, the facilitation effect was due to priming generated by an integrated representation of the sentence, then changing the meaning of the sentence by changing the relation between the critical noun and verb should reduce or eliminate the effect. For comparison, we also included the congruent, subject–verb neutral, and incongruent conditions employed in Experiments 1 and 2.

Method

Subjects. Sixty-five University of Massachusetts undergraduates participated in this experiment for extra course credit. None of the subjects had participated in either Experiment 1 or Experiment 2.

Materials. The materials were based upon 45 of the sentence contexts used in Experiments 1 and 2. In the congruent, subject–verb neutral, and incongruent conditions, the sentences were identical to those used in the first two experiments. In the subject–verb disrupted condition, the relation between the original subject noun and verb was changed so that the noun was no longer the subject of the verb (although it was still present in the sentence). In most cases, an additional noun or pronoun was added to the original sentence to serve as the new subject of the verb. In the subject–verb preserved condition, the original relation between the critical noun and verb was preserved, although the sentence also contained any additional content words introduced in the subject–verb disrupted condition. The complete set of stimuli used in this experiment is listed in the Appendix.

Apparatus and procedure. Sentences were displayed on a CRT controlled by a microcomputer interfaced with a voice key. Each word was displayed for 200 ms. Asterisks flanked the last *the* of the sentence (** the **) and were displayed for an additional 200 ms after the *the* disappeared.

Results and Discussion

Errors and outliers were treated as in the first two experiments. The mean naming latencies and percent errors are given in Table 3. Overall, the effect of context was significant, $F(4, 256) = 13.65$, $p < .001$, by subjects; $F(4, 176) = 13.78$, $p < .001$, by items.

As Table 3 shows, there was a 31-ms facilitation effect for the congruent context, $F(1, 64) = 13.36$, $p < .001$. There was no significant inhibition for the incongruent context, $F(1, 64) = 1.52$, $p > .22$. Thus, the basic pattern from Experiment 2 was replicated.

More important, both of the new conditions—the preserved and disrupted condition—displayed facilitation effects: 40 ms for the preserved condition, $F(1, 64) = 15.73$, $p < .001$, and 34 ms for the disrupted condition, $F(1, 64) = 17.27$, $p < .001$. There was no difference in latency for the disrupted versus preserved condition ($F < 1$). These findings suggest that the disrupted context facilitated access of the target word to the same degree as did the preserved context and the original congruent context. Because the disrupted context shares the same content words as the preserved but differs at the level of integrated sentence representation, this finding is consistent with the modular versions of the combination model in which the integrated representation is not the source of the facilitation effect.

One might raise the objection that subjects were not comprehending the disrupted sentences correctly. Is it possible that subjects created the same integrated meaning representation for both the preserved and disrupted sentences? This claim seems unlikely, given other results in the literature in which subjects have read words in sentences presented at rates equal to or faster than those used here while maintaining a reasonable level of comprehension. For example, Potter, Kroll, Yachzel, Carpenter, and Sherman (1986) used an RSVP technique to present sentences up to 14 words long at times of 83 and 100 ms per word; subsequent plausibility judgments and recall provided evidence of comprehension. Kintsch and Mross (1985, Exp. 2) used an RSVP technique to present paragraphs (70 to 100 words long); individual words were displayed for 150 ms, with about 40 ms between words. Subjects had no trouble answering subsequent comprehension questions.

The results in Experiment 3 contrast with results reported by Masson (1986) and Simpson et al. (1989) involving the use of scrambled or anomalous sentence contexts. Given a congruent context that primes a target word, Masson (1986) found that scrambling the words in the context eliminates the priming effect. Similarly, Simpson et al. (1989) found no effect of a single priming word on target word naming time when the prime was presented in a scrambled context or in an anomalous context. On the surface, these results seem to provide evidence against a modular version of the combination model because they suggest that priming occurs only when an integrated sentence-level representation can be created. In the current experiment, we find that modifying the relations among the words in the context while maintaining grammaticality does not influence the priming effect. We argue that this result is consistent with the modular view.

These contrasting results can be reconciled by the claim that subjects process normal sentences differently than they do scrambled or anomalous sentences. The content words in normal sentence contexts are maintained in some form of active memory as a byproduct of the higher level syntactic and integrative processes that are required for sentence comprehension. As a result, the lexical items involved remain active and continue to prime the target word. Notice, this explanation preserves modularity because the integrated representation is not creating new sources of priming and because the particular syntactic relations among the words that remain active are not relevant. Rather it is the original lexical items and their combinations within the lexicon that are the source of priming.

In contrast to the processing typical of normal sentences, the complete set of higher level integrative processes cannot be carried out on scrambled and anomalous sentences. That is, the set of processing mechanisms that normally maintain the lexical items of the sentence in an active memory form are useless. As a result, the individual lexical items are unlikely to be available as primes by the time the target word is reached. Under such circumstances, activation from any given context word would be very shortlived, and priming would not be expected to occur unless the priming word was adjacent to the target (Gough, Alford, & Holley-Wilcox, 1981). Indeed, Simpson et al. (1989) did find evidence of priming by their scrambled contexts in just those cases where the priming word was adjacent to the target word.

Table 3
Mean Naming Latencies (in Milliseconds) and Amount of Facilitation by Condition in Experiment 3

Condition	*RT*	% Error	Facil.
Congruent	575	7	31
Subject–verb preserved	566	7	40
Subject–verb disrupted	572	6	34
Subject–verb neutral	606	11	—
Incongruent	618	11	−12

Note. Facilitation (Facil.) is the reaction time (RT) for each condition minus the RT for the subject–verb neutral condition.

General Discussion

The present study focused on characterizing the mechanisms by which sentence context influences the process of lexical access. In Experiments 1 and 2, we found that the combination of the subject and verb of the sentence context served to facilitate naming time for a target word when neither the subject nor verb alone provided any facilitation. Furthermore, in Experiment 2, we provided evidence that this facilitation effect occurs in the absence of postaccess processes such as integration or other attentional processes such as prediction. The results of the first two experiments were inconsistent with a model in which facilitation results from the simple summation of activation from the individual content words in a sentence. Rather, they were consistent with a model in which the content words *in combination* activate target words that would not otherwise be activated (Foss & Ross, 1983).

In Experiment 3, the combination of the content noun and verb facilitated naming for the target word regardless of the particular syntactic relation specified between the critical noun and verb within the sentence context. This suggested that the facilitation occurred as a result of an automatic combination of content words within the lexicon rather than the integration of sentence meaning at the message level. Thus, the results provide evidence for a modular interpretation of the priming effects observed.

There are a number of ways of conceptualizing the mechanisms by which a combination of items within the lexicon could activate a related item. We will discuss two specific models below. One model is a threshold model in which no priming is observed unless a baseline threshold of activation for a word is reached. Although the critical noun or verb alone might not be sufficient to push the target word activation over this threshold level, activation from both the subject and verb might be sufficient. Such a model was proposed by McClelland and O'Regan (1981) to account for a pattern similar to ours in which a weak context and a parafoveal preview combined to facilitate recognition of a target word when no facilitation was observed for either alone. In their model, one weak source alone resulted in no priming because the many words activated by the weak source mutually inhibited each other. It was not until activation from two weak sources converged on one common target word that facilitation could be observed.

A second model within the modular framework might be one in which the noun placed constraints on the senses of the verb that were activated once the verb was encountered, and vice versa. For example, consider the target sentence "The barber trimmed the mustache." The verb *trim* has many senses: trim hair, trim fingernails, trim a hedge, trim the grass, trim the sails, trim a Christmas tree, trim paper, and so forth. In the presence of the word *barber*, however, most of these senses seem much less likely than the barbershop sense. As a result, activation may be focused on just those words related to the barbershop sense of trim as opposed to being spread thinly among all of the senses of the verb. Such a priming of senses of words has been suggested by experiments of Whitney, McKay, Kellas, and Emerson (1985) and of Tabossi (1988).

The current experiments provide no evidence that an integrated *semantic* representation of the sentence context influences lexical access for the target word. In contrast, however, two recent studies have found an effect of the higher level *syntactic* representation on lexical decision (Wright & Garrett, 1984) and on naming (West & Stanovich, 1986). Specifically, inhibition effects were found: Response times for target words were long when the target word did not fit syntactically into the sentence context (e.g., "The man spoke but could not *entries*"). As West and Stanovich indicate, this inhibition effect may arise because syntactic analyses do affect lexical access or because the naming task itself reflects some postaccess processes like the integration of the target word into the syntactic structure of the whole sentence.

Although these inhibition effects may reflect postaccess processes, the current studies provide no evidence that the facilitating effects of congruent sentence contexts on naming times come from higher level semantic processes influencing either lexical access or postlexical access processes. The fact that the same facilitation effect is found regardless of the particular syntactic relation among the priming words provides evidence that the naming task is not reflecting an influence of a higher level integrated semantic representation on lexical access. The lack of an inhibition effect for incongruent contexts in Experiments 2 and 3 provides evidence that the naming task is not reflecting the postaccess process of integrating the target word into the sentence meaning.

In summary, the experiments reported here provide evidence that congruent sentence contexts facilitate lexical access because combinations of the content words prime the target word. This priming occurs when the content words individually show no evidence of priming, and it occurs regardless of the syntactic relation among the content words. The mechanisms by which combinations of lexical items prime are as yet unclear and are currently under investigation.

References

Balota, D. A., Pollatsek, A., & Rayner, K. (1985). The interaction of contextual constraints and parafoveal visual information in reading. *Cognitive Psychology, 17*, 364–390.

Carr, T. H., McCauley, C., Sperber, R. D., & Parmalee, C. M. (1982). Words, pictures and priming: On semantic activation, conscious identification, and the automaticity of information processing. *Journal of Experimental Psychology: Human Perception and Performance, 8*, 757–777.

deGroot, A. M. B. (1983). The range of automatic spreading activation in word priming. *Journal of Verbal Learning and Verbal Behavior, 22*, 417–436.

Ehrlich, S. F., & Rayner, K. (1981). Contextual effects on word perception and eye movements during reading. *Journal of Verbal Learning and Verbal Behavior, 20*, 641–655.

Fischler, I., & Bloom, P. A. (1979). Automatic and attentional processes in the effects of sentence contexts on word recognition. *Journal of Verbal Learning and Verbal Behavior, 18*, 1–20.

Fischler, I., & Bloom, P. A. (1980). Rapid processing of the meaning of sentences. *Memory & Cognition, 8*, 216–225.

Fodor, J. A. (1983). *The modularity of mind.* Cambridge, MA: MIT Press.

Forster, K. I. (1979). Levels of processing and the structure of the language processor. In W. E. Cooper & E. Walker (Eds.), *Sentence processing: Psycholinguistic studies presented to Merrill Garrett* (pp. 27–85). Hillsdale, NJ: Erlbaum.

Foss, D. J. (1982). A discourse on semantic priming. *Cognitive Psychology, 14*, 590–607.

Foss, D. J., & Ross, J. R. (1983). Great expectations: Context effects during sentence processing. In G. B. Flores d'Arcais & R. J. Jarvella (Eds.), *The process of language understanding* (pp. 169–191). Chichester: Wiley.

Gough, P. B., Alford, J. A., Jr., & Holley-Wilcox, P. (1981). Words and contexts. In O. J. L. Tzeng & H. Singer (Eds.), *Perception of print: Reading research in experimental psychology* (pp. 85–102). Hillsdale, NJ: Erlbaum.

Henderson, J. M., Pollatsek, A., & Rayner, K. (1987). Effects of foveal priming and extrafoveal preview on object identification. *Journal of Experimental Psychology: Human Perception and Performance, 13*, 449–463.

Jonides, J., & Mack, R. (1984). On the cost and benefit of cost and benefit. *Psychological Bulletin, 96*, 29–44.

Kintsch, W., & Mross, E. F. (1985). Context effects in word identification. *Journal of Memory and Language, 24,* 336–349.

Lorch, R. F., Jr., Balota, D. A., & Stamm, E. G. (1986). Locus of inhibition effects in the priming of lexical decisions: Pre- or post-lexical access? *Memory & Cognition, 14,* 95–103.

Marslen-Wilson, W. D., & Tyler, L. K. (1980). The temporal structure of spoken language understanding. *Cognition, 8,* 1–71.

Masson, M. E. J. (1986). Comprehension of rapidly presented sentences: The mind is quicker than the eye. *Journal of Memory and Language, 25,* 588–604.

McClelland, J. L. (1987). The case for interactionism in language processing. In M. Coltheart (Ed.), *Attention and performance XII: The psychology of reading* (pp. 3–36). London: Erlbaum.

McClelland, J. L., & O'Regan, J. K. (1981). Expectations increase the benefit derived from parafoveal visual information in reading words aloud. *Journal of Experimental Psychology: Human Perception and Performance, 7,* 634–644.

Meyer, D. E., & Schvaneveldt, R. W. (1971). Facilitation in recognizing pairs of words: Evidence of a dependence between retrieval operations. *Journal of Experimental Psychology, 90,* 227–234.

Neely, J. H. (1977). Semantic priming and retrieval from lexical memory: Roles of spreading activation and limited-capacity attention. *Journal of Experimental Psychology: General, 106,* 226–254.

Onifer, W., & Swinney, D. A. (1981). Accessing lexical ambiguities during sentence comprehension: Effects of frequency of meaning and contextual bias. *Memory & Cognition, 9,* 225–236.

Posner, M. I., & Snyder, C. R. R. (1975). Facilitation and inhibition in the processing of signals. In P. M. A. Rabbitt & S. Dornic (Eds.), *Attention and performance V* (pp. 669–682). New York: Academic Press.

Potter, M. C., Kroll, J. F., Yachzel, B., Carpenter, E., & Sherman, J. (1986). Pictures in sentences: Understanding without words. *Journal of Experimental Psychology: General, 115,* 281–294.

Rayner, K., & Slowiaczek, M. L. (1981). Expectations and parafoveal information in reading: Comments on McClelland and O'Regan. *Journal of Experimental Psychology: Human Perception and Performance, 7,* 645–651.

Schuberth, R. E., Spoehr, K. T., & Lane, D. M. (1981). Effects of stimulus and contextual information on the lexical decision process. *Memory & Cognition, 9,* 68–77.

Seidenberg, M. S., Tanenhaus, M. K., Leiman, J. L., & Bienkowski, M. (1982). Automatic access of the meanings of ambiguous words in context: Some limitations of knowledge-based processing. *Cognitive Psychology, 14,* 489–537.

Seidenberg, M. S., Waters, G. S., Sanders, M., & Langer, P. (1984). Pre- and postlexical loci of contextual effects on word recognition. *Memory & Cognition, 12,* 315–328.

Simpson, G. B., Peterson, R. R., Casteel, M. A., & Burgess, C. (1989). Lexical and sentence context effects in word recognition. *Journal of Experimental Psychology: Learning, Memory and Cognition, 15,* 88–97.

Stanovich, K. E., & West, R. F. (1981). The effect of sentence context on ongoing word recognition: Tests of a two-process theory. *Journal of Experimental Psychology: Human Perception and Performance, 7,* 658–672.

Stanovich, K. E., & West, R. F. (1983). On priming by a sentence context. *Journal of Experimental Psychology: General, 112,* 1–36.

Tabossi, P. (1988). Effects of context on the immediate interpretation of unambiguous nouns. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 14,* 153–162.

West, R. F., & Stanovich, K. E. (1982). Source of inhibition in experiments on the effect of sentence context on word recognition. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 8,* 385–399.

West, R. F., & Stanovich, K. E. (1986). Robust effects of syntactic structure on visual word processing. *Memory & Cognition, 14,* 104–112.

Whitney, P., McKay, T., Kellas, G., & Emerson, W. A., Jr. (1985). Semantic activation of noun concepts in context. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 11,* 126–135.

Wright, B., & Garrett, M. (1984). Lexical decision in sentences: Effects of syntactic structure. *Memory & Cognition, 8,* 385–399.

(Appendix follows on next page)

Appendix

Context sentences and target words used in Experiment 3 are given below in the following order: congruent, subject–verb neutral, incongruent, subject–verb preserved, subject–verb disrupted.

1. The wine was served from the decanter.
   The stuff was placed near the decanter.
   The politician appealed to the decanter.
   Juice replaced the wine which was served from the decanter.
   Juice replaced the wine and was served from the decanter.
2. The housewife waxed the linoleum.
   The person liked the linoleum.
   The wine was served from the linoleum.
   The boy watched the housewife wax the linoleum.
   The boy who watched the housewife waxed the linoleum.
3. The mortician examined the cadaver.
   The people noticed the cadaver.
   The fisherman exceeded the cadaver.
   The man knew the mortician who examined the cadaver.
   The man who knew the mortician well examined the cadaver.
4. The baker smelled the aroma.
   The women knew the aroma.
   The accountant balanced the aroma.
   The child smiled as the baker smelled the aroma.
   The child smiled at the baker and smelled the aroma.
5. The politician appealed to the constituency.
   The woman thought about the constituency.
   The general revised the constituency.
   The man ignored the politician who appealed to the constituency.
   The man ignored the politician and appealed to the constituency.
6. The fisherman exceeded the quota.
   The person forgot the quota.
   The baker smelled the quota.
   The man stopped the fisherman who exceeded the quota.
   The man who stopped the fisherman exceeded the quota.
7. The accountant balanced the ledger.
   The woman wanted the ledger.
   The housewife waxed the ledger.
   The daughter saw the accountant balance the ledger.
   The daughter of the accountant balanced the ledger.
8. The team won the tournament.
   The boys saw the tournament.
   The mortician examined the tournament.
   The reporter took pictures as the team won the tournament.
   The reporter who took pictures of the team won the tournament.
9. The general revised the strategy.
   The person ignored the strategy.
   The team won the strategy.
   The reporter interviewed the general who revised the strategy.
   The reporter who interviewed the general revised the strategy.
10. The biologist examined the specimen.
    The person noticed the specimen.
    The artist painted the specimen.
    The woman left after the biologist examined the specimen.
    The woman left the biologist and examined the specimen.
11. The preacher spread the gospel.
    The people liked the gospel.
    The biologist examined the gospel.
    The tailor outfitted the preacher who spread the gospel.
    The tailor outfitted the preacher and spread the gospel.
12. The tree was uprooted in the hurricane.
    The thing was affected by the hurricane.
    The preacher spread the hurricane.
    The flower was beside the tree that was uprooted in the hurricane.
    The flower beside the tree was uprooted in the hurricane.
13. The painter fell off the scaffold.
    The person looked at the scaffold.
    The tree was uprooted in the scaffold.
    While she watched him the painter fell off the scaffold.
    While watching the painter she fell off the scaffold.
14. The country was ruled by the dictator.
    The place was seen by the dictator.
    The painter fell off the dictator.
    The tourists were in the country ruled by the dictator.
    The tourists in the country were ruled by the dictator.
15. The train went over the trestle.
    The thing was near the trestle.
    The country was ruled by the trestle.
    The boy waved as the train went over the trestle.
    The boy waved to the train and went over the trestle.
16. The soldiers flew in the helicopter.
    The people were near the helicopter.
    The skier lived in the helicopter.
    The woman watched as the soldiers flew in the helicopter.
    The woman watched the soldiers and flew in the helicopter.
17. The artist painted the mural.
    The person wanted the mural.
    The train went over the mural.
    The person argued with the artist who painted the mural.
    The person who argued with the artist painted the mural.
18. The skier lived in the chalet.
    The person looked at the chalet.
    The soldiers flew in the chalet.
    The woman murdered the skier who lived in the chalet.
    The woman murdered the skier and lived in the chalet.
19. The cowboy fired the pistol.
    The person liked the pistol.
    The interpreter knew the pistol.
    The woman watched as the cowboy fired the pistol.
    The woman watched the cowboy and fired the pistol.
20. The crook was sent to the penitentiary.
    The man was seen near the penitentiary.
    The cowboy fired the penitentiary.
    The crook was sent to the penitentiary.
    The crook sent it to the penitentiary.
21. The couple adopted the orphan.
    The people ignored the orphan.
    The crook was sent to the orphan.
    The man lied about the couple who adopted the orphan.
    The man lied about the couple and adopted the orphan.
22. The house was destroyed by the tornado.
    The place was affected by the tornado.
    The couple adopted the tornado.
    The china was inside the house that was destroyed by the tornado.
    The china inside the house was destroyed by the tornado.
23. The barber trimmed the mustache.
    The woman saw the mustache.
    The house was destroyed by the mustache.
    While she talked to him the barber trimmed the mustache.
    While talking to the barber she trimmed the mustache.
24. The hotel's guests liked the accommodations.
    The new people wanted the accommodations.
    The barber trimmed the accommodations.
    The man knew that the hotel's guests would like the accommodations.
    The man who knew the hotel's guests well liked the accommodations.
25. The carpenter drove in the spike.

The people looked at the spike.
The hotel's guests liked the spike.
The man left as the carpenter drove in the spike.
The man left the carpenter and drove in the spike.

26. The waiter handed them the menu.
The man looked at the menu.
The carpenter drove in the menu.
The waiter handed them the menu.
The waiter was handed the menu.

27. The interpreter knew the dialect.
The people liked the dialect.
The waiter handed them the dialect.
The man painted the interpreter who knew the dialect.
The man who painted the interpreter knew the dialect.

28. The bartender served the cocktails.
The woman wanted the cocktails.
The bomb destroyed everything in the cocktails.
The woman knew that the bartender served the cocktails.
The woman who knew the bartender well served the cocktails.

29. The train pulled into the depot.
The vehicle arrived at the depot.
The election was won by the depot.
The car passed by as the train pulled into the depot.
The car passed the train and pulled into the depot.

30. The pianist played at the recital.
The woman was at the recital.
The skier was buried in the recital.
The girl ignored the pianist who played at the recital.
The girl ignored the pianist and played at the recital.

31. The bomb destroyed everything in the vicinity.
The object affected everything in the vicinity.
The sun was totally hidden by the vicinity.
The cat heard the bomb that destroyed everything in the vicinity.
The cat heard the bomb and destroyed everything in the vicinity.

32. The election was won by the incumbent.
The event was ignored by the incumbent.
The cat drank from the incumbent.
The games were played after the election was won by the incumbent.
The games played after the election were won by the incumbent.

33. The sun was totally hidden by the eclipse.
The thing was not affected by the eclipse.
The game warden fined the eclipse.
The clouds neared the sun which was totally hidden by the eclipse.
The cloud near the sun was totally hidden by the eclipse.

34. The cat drank from the saucer.
The man looked at the saucer.
The train pulled into the saucer.
The squirrel chattered while the cat drank from the saucer.
The squirrel chattered at the cat and drank from the saucer.

35. The skier was buried in the avalanche.
The man was looking at the avalanche.
The bartender served the avalanche.
The woman knew the skier who was buried in the avalanche.
The woman who knew the skier well was buried in the avalanche.

36. The game warden fined the poacher.
The nice person liked the poacher.
The pianist played at the poacher.
The game warden fined the poacher.
The game warden was fined by the poacher.

37. The politician attended the convention.
The person watched the convention.
The driver stepped on the convention.
The man photographed the politician who attended the convention.
The man who photographed the politician attended the convention.

38. The climber reached the summit.
The people watched the summit.
The cowboy roped the summit.
The woman married the climber who reached the summit.
The woman who married the climber reached the summit.

39. The witness confirmed the alibi.
The person disliked the alibi.
The anthropologist found the alibi.
The boy hated the witness who confirmed the alibi.
The boy who hated the witness confirmed the alibi.

40. The prospector found the uranium.
The woman noticed the uranium.
The gardener dug with the uranium.
The waiter served the prospector who found the uranium.
The waiter served the prospector and found the uranium.

41. The driver stepped on the accelerator.
The person looked at the accelerator.
The climber reached the accelerator.
The woman saw that the driver stepped on the accelerator.
The woman saw the driver and stepped on the accelerator.

42. The cowboy roped the mustang.
The person saw the mustang.
The witness confirmed the mustang.
The man asked the cowboy to rope the mustang.
The man promised the cowboy to rope the mustang.

43. The anthropologist found the artifacts.
The person wanted the artifacts.
The coed belonged to the artifacts.
Before she phoned him the anthropologist had found the artifacts.
Before she phoned the anthropologist she found the artifacts.

44. The coed belonged to the sorority.
The man thought of the sorority.
The prospector found the sorority.
The mother knew the coed belonged to the sorority.
The mother of the coed belonged to the sorority.

45. The gardener dug with the trowel.
The woman looked at the trowel.
The politician attended the trowel.
The child disliked the gardener who dug with the trowel.
The child who disliked the gardener dug with the trowel.

Received July 29, 1988
Revision received December 15, 1988
Accepted December 22, 1988 ■