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Source of Inhibition in Experiments on the Effect of Sentence Context on Word Recognition

Richard F. West
James Madison University

Keith E. Stanovich
Oakland University

Previous research on the effect of a sentence context on word recognition has yielded ambiguous results regarding the relative magnitudes of the facilitation and inhibition effects produced by congruous and incongruous contexts. A review of the literature indicates that the pattern of results was task correlated. Experiments in which a lexical-decision task was employed have tended to produce larger inhibition effects than have experiments in which a naming task was employed. In the present article, two experiments are reported in which the different tasks were directly compared using the same subjects, stimuli, and experimental methodology. The results indicate that the lexical-decision task does tend to produce greater inhibition effects. It is argued that the reason for the larger inhibition effects is that responses in the lexical-decision task are affected by postlexical message-level processes that detect incongruity. Contrary to previous interpretations, the inhibition observed in the task is not due to a mismatch between the stimulus word and lexical-level expectations. If the goal of an investigation is to study sentence context effects on the process of word recognition, then the naming task is probably preferable.

In a 1977 article, Schuberth and Eimas introduced a method of studying sentence context effects on visual word recognition that involved having subjects make a lexical decision about a letter string that had been preceded by an incomplete sentence. Compared to a neutral condition, subjects responded faster to a word preceded by a congruous context (an effect hereafter called *contextual facilitation*) and slower to a word preceded by a context that made the word incongruous (an effect hereafter called *contextual inhibition*). West and Stanovich (1978) employed a similar paradigm, but instead had the subject name the terminal word. Subsequent studies using the latter paradigm (Stanovich & West, 1979, 1981) have yielded a set of results that puts several constraints on possible models of sentence context effects on word recognition. For example, contextual effects were larger for words that were more difficult to recognize in isolation. This effect occurred despite the fact that words that were more difficult to recognize in isolation tended to be *less* predictable from the preceding sentence context than were easier words. Contextual effects were also larger when the target word was degraded by contrast reduction.

A further strong trend running through all of the experiments of Stanovich and West (1979, 1981; West & Stanovich, 1978) was that when adults named words under clear visual conditions, the results displayed a pattern of facilitation dominance. Only when the target word was degraded did the response times of adults begin to display inhibition. Children, who find words more difficult to recognize in isolation than do adults, are more prone to display contextual inhibition (Stanovich, West, & Feeman, 1981; West & Stanovich, 1978), although even the naming times of second-grade children can

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Requests for reprints should be sent to Keith E. Stanovich, Department of Psychology, Oakland University, Rochester, Michigan 48063.

become facilitation dominant if they are naming very easy words (Stanovich et al., 1981). Perfetti and Roth (1981) reported results consistent with these trends. They employed a naming task and used word targets that were preceded by either highly predictable or incongruous two-sentence contexts. Their third context condition was not a neutral context, as in the previous experiments, but was instead a context that was congruous with the target word, although the target word was not predictable from the context. For example, the target "dump" would be preceded by "Albert didn't have the money he needed to buy the part to fix his car. Luckily, he found the part he wanted at the." Although these unpredictable contexts may not be neutral, it can be expected that if they deviate from neutrality, it is probably in terms of producing facilitation. Thus, inhibition effects calculated by subtracting the times in the unpredictable condition from the incongruous condition should be *overestimated*. Indeed, another experiment in the Perfetti and Roth (1981) article indicates that target words in unpredictable contexts are named somewhat faster than target words in isolation. Nevertheless, Perfetti and Roth (1981) found that fourth-grade children who were skilled readers did not display an inhibition effect even when their times were calculated from the unpredictable condition. In contrast, less-skilled fourth-grade children displayed an inhibition effect of 104 msec.

Several studies, however, have reported results inconsistent with the suggested trend that performance is facilitation dominant when adults are responding to words under normal stimulus conditions. Employing a lexical-decision task, Schuberth and Eimas (1977) found that a sentence context produced roughly equal amounts of facilitation and inhibition. In a series of experiments, Fischler and Bloom (1979) found a recurring pattern of inhibition dominance. Lexical decisions for target words preceded by an incongruous sentence context were markedly slower than for target words in a neutral condition. In contrast, the facilitation observed for congruous target words was quite modest. Only the most highly predictable congruous words displayed significant facilitation. This pattern of inhibition dominance was also observed in an experiment where the words of the sentence context were presented one at a time at rates varying from 4 to 28 words per second (Fischler & Bloom, 1980). Mitchell and Green (Note 1, Experiment 1) employed a task in which the subjects advanced themselves through a passage one word at a time by pressing a response button. The task was turned into a continuous lexical-decision task by inserting nonwords into the passage and instructing the subject to stop and count to 10 when a nonword appeared. The lexical-decision times to 20 critical words appearing in a coherent prose passage were no faster than when the words were displayed in a random sequence. In contrast, response times to incongruous words were much slower in the coherent passage than in the random sequence. Thus, the Mitchell and Green (Note 1) data show inhibition dominance. Finally, a sentence context experiment conducted by Schwantes, Boesl, and Ritz (1980) produced data indicating roughly equivalent amounts of facilitation and inhibition in the lexical-decision times of third-grade children, sixth-grade children, and adults.

Although the studies reviewed above appear to have yielded inconsistent results regarding the relative facilitation versus inhibition dominance in the sentence context situation, there is in fact a consistent trend running through the data. Specifically, studies employing naming tasks (e.g., Perfetti & Roth, 1981; Stanovich & West, 1979, 1981; West & Stanovich, 1978) have tended to find a pattern of facilitation dominance, whereas studies employing lexical-decision tasks have yielded either inhibition dominance or roughly equal amounts of facilitation and inhibition (e.g., Fischler & Bloom, 1979, 1980; Schuberth & Eimas, 1977; Schwantes et al., 1980). Investigation of this possible task difference is critical, because differing patterns of facilitation and inhibition have been used as an inferential tool by researchers who have studied context effects on word recognition (e.g., Becker, 1980; Fischler & Bloom, 1979; Neely, 1976, 1977; Stanovich & West, 1979, 1981). The distinction between types of context effects is particularly important for investigators who make use of the two-process theory of expectancy developed by Posner and Snyder (1975a, 1975b).

Stanovich (1981) attempted to test whether the suggested difference between the two tasks was indeed real by having subjects complete a lexical-decision task using the same words and experimental conditions that had led to facilitation dominance in the Stanovich and West (1979) study. Unfortunately, the results were somewhat ambiguous. A 12-msec inhibition effect was not statistically significant, but there was a substantial (4.7%) inhibition effect in the error rates. Thus, the suggestion in the literature that the naming and lexical-decision tasks do not produce converging results in the sentence context situation remains problematic. This lack of convergence, if real, would indeed be interesting, because the two tasks have been found to detect context effects of approximately equal magnitude in several single-word priming experiments (e.g., Becker & Killion, 1977; Massaro, Jones, Lipscomb, & Scholz, 1978, Meyer, Schvaneveldt, & Ruddy, 1975).

The lack of convergence between the naming and lexical-decision tasks in sentence context paradigms raises the difficult question of which task is most appropriate for studying the word recognition process that occurs in reading, an issue that has already received much discussion. For example, it has been argued (Coltheart, Davelaar, Jonasson, & Besner, 1977) that because nonwords can be pronounced, then it is possible to pronounce words without involving the lexicon and, as a result, naming tasks may not involve lexical access. Although this argument is logical, there is no empirical evidence to support the conclusion, and there is a good deal of evidence that contradicts it. Semantic context effects have been observed with naming tasks in both the incomplete sentence and single-word priming situations. Donnenwerth-Nolan, Tanenhaus, and Seidenberg (1981) found semantic context effects in a rhyme-detection task that could be performed with only phonological information. Based on several findings—including the observation that there was a sizable correlation between naming times and lexical-decision times for words but not for nonwords—Forster and Chambers (1973) have strongly argued the position that the naming task does involve lexical access. Finally, Coltheart et al. (1977) themselves point out that the finding of Frederiksen and Kroll (1976)—that the same words are named more rapidly when blocked than when mixed with nonwords—implicates the lexicon in the naming process. Thus, although the naming task *could* be performed without involving the lexicon, all available evidence indicates that semantic information is activated when subjects name words.

The lexical-decision task itself has not escaped criticism. One problem that is relevant to the use of the task in sentence context experiments is that it requires an abrupt attention switch, from reading a series of words to making a binary decision. More importantly, Theios and Muise (1977) have argued that the lexical-decision process takes place after a word has been identified and understood, thus leaving open the possibility that some of the effects detected by the task are occurring postlexically. Compared to the lexical-decision task, the naming task requires less information translation in order to initiate a response after lexical access has occurred. Thus, it is less likely that the naming task is detecting postlexical effects. Finally, interpretation of the magnitude of contextual effects using a lexical-decision task is problematic because the size of such effects in the priming paradigm have been shown to depend on the orthographic structure of the nonwords (Shulman & Davison, 1977). Needless to say, no one knows what structure for the nonwords would induce a processing "set" for word recognition that would approximate that in actual reading. Should the nonwords differ by one letter from an expected word (e.g., Antos, 1979), or would this induce a word processing set that was artifically "deep"?

Given the importance of the suggested lack of task convergence in the literature, a direct empirical test appears to be warranted. This is attempted in Experiment 1, in which subjects performed both a naming task and a lexical-decision task using the same stimuli and under identical experimental conditions.[1]

Experiment 1

Method

Subjects. The subjects were 32 undergraduate students recruited through an introductory psychology subject pool at James Madison University.

Stimuli and apparatus. A total of 192 sentences were constructed so that their last two words were the words "the" and a noun that was predictable from the preceding context (e.g., "The skier was buried in the snow"). The 192 sentences consisted of 96 pairs. The two sentences that made up a pair were identical except for their terminal words (e.g., "The skier was buried in the snow" and "The skier was buried in the avalanche"). There were thus 96 sentence contexts, each one having two target words. One of the target words in a pair was a relatively easy word (e.g., "snow"), and the other was a relatively difficult word (e.g., "avalanche"). The mean number of letters in the easy words was 5.0 ($SD = 1.3$) and the mean number of letters in the difficult words was 7.4 ($SD = 2.1$). According to the Kucera and Francis (1967) count, the mean frequency of the easy words was 124.3 and the mean frequency of the difficult words was 7.1. Eighteen pronounceable nonwords (e.g., blonk, nuster, depper) were employed as foils in the lexical-decision task.

A pilot study in which the sentence contexts were presented to 25 college students as a cloze task produced data indicating that the difficult words were less predictable. Across all contexts the easy target word was predicted 43% of the time on the subject's first guess, whereas the difficult target word was predicted only 11% of the time on the subject's first guess. An effort was made to assess the strength of the relationship between the target words and the critical content words of the context. For each sentence, each target word was paired with the noun that was the subject of the sentence and the main verb of the sentence. The resulting four pairs were randomly assigned to one of four lists. Each list was shown to a separate group of 30 subjects. Thus, no subject saw a target word more than once. Subjects made a judgment as to how related the word pair was on a 1–5 scale, on which 5 indicated a high degree of relationship. Across all contexts the mean relatedness rating when the target was paired with the sentence subject was 3.32 for the easy words and 3.37 for the difficult words, a difference that did not approach statistical significance. When the target was paired with the main verb, the mean relatedness rating was 2.68 for the easy words and 2.79 for the difficult words, a difference that also did not approach significance. Thus, although the easy words were more predictable, the easy and difficult word sets were equally related to words in the context. The 96 contexts were organized into 48 pairs (e.g., "the skier was buried in the" was paired with "the bodyguard drove the"). Incongruous sentences were formed by combining target words from one member of the pair with the context of the other. The neutral context condition was the incomplete sentence "they said it was the." The complete set of stimuli is presented in Appendix A of the Stanovich and West (1981) article.

The stimuli were typed on 10.2- × 12.7-cm cards in lowercase Letter Gothic font with an IBM Selectric II typewriter. One set of cards contained the sentence contexts and another contained the target words. Approximately 70% of the contexts required two lines. In these cases the final letter in the last word of the top line was always two spaces directly above the final letter of the sentence context. The stimuli were presented via a Scientific Prototype tachistoscope at a viewing distance of approximately 76 cm. Five-letter words subtended a horizontal visual angle of approximately .72°. The contexts and the target words were presented in separate fields of the tachistoscope and were aligned so that if both were presented simultaneously the stimuli looked like a complete sentence. Target-word onset was controlled by a button pushed by the experimenter that immediately caused the target to be displayed and simultaneously started a millisecond clock. When the subject responded verbally to the target, a voice-activated relay stopped the clock.

Prior to the collection of the data, the experimenter was given extensive practice in synchronizing the pushing of the control button with the articulation "the" (the context word that always immediately preceded the target word). Of course, some time invariably elapsed between the subject's articulation and the experimenter's button press. However, the experimenter tried to minimize this time by attempting on all trials to synchronize the button press with the articulation of "the" such that the button was activated as soon as possible after the end of the articulation of "the." The experi-

[1] In sentence context experiments of this type it is very difficult to control one particular methodological feature, the amount of time elapsing between the subject's reading of the context and the presentation of the target word. Our procedure differs from that of Schuberth and Eimas (1977) in this respect. They presented the contexts for a fixed interval during which the subject read the sentence silently. In our experiments, subjects read the contexts out loud, and the experimenter presented the target immediately after the subject's articulation of the last context word. It should be clear that both procedures induce variability into the context processing—target processing interval. In our procedure the inherent variability in the experimenter's presentation times is the cause of the variance. It is important to note that the fixed presentation procedure does *not* remove this variability, it merely transfers it from the experimenter to the contexts, which differ in the amount of time they take to be read. We recently (Stanovich & West, Note 2) reported an experiment in which the contexts were presented for a fixed interval (roughly equal to the average amount of time that subjects spent reading the contexts in our previous paradigm) during which the sentence was read silently, followed by the naming of the target word. The results clearly replicated all of the data patterns derived from the experimenter-initiation methodology. Difficult words displayed a larger overall context effect, and the pattern of effects remained facilitation dominant. Thus, the two procedures appear to yield converging results.

menter was instructed to develop a criterion so stringent that occasionally the button was pressed during the articulation of "the," thus aborting the trial. Less than 1% of the trials were aborted in this way, however. The few experimenter-aborted trials that did occur were distributed approximately equally across the three context conditions, indicating that the criterion was consistently applied.

Procedure. Subjects were individually tested in a session that lasted approximately 40 min. They were told to look into the tachistoscope and read aloud the sentence contexts that appeared. In the naming task subjects were instructed to read the target word as rapidly as possible when it appeared. In the lexical-decision task the subjects indicated their 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 response to the target word was timed, so they were free to read the contexts at a comfortable pace.

Each subject completed two blocks of experimental trials that were each preceded by 12 practice trials. One half of the subjects completed the naming block first followed by the lexical-decision block, and one half of the subjects received the reverse ordering. The naming block consisted of a random ordering of 36 trials (12 congruous, 12 incongruous, and 12 neutral) and the lexical-decision block consisted of 54 trials, 36 word target trials, and 18 nonword target trials (12 preceded by nonneutral contexts and 6 preceded by the neutral context). The assignment of words from the total population was counterbalanced across subjects so that each word was presented equally often under each of the three context conditions and in each of the tasks. No subject saw the same target word or sentence context more than once in the course of the experiment, and no subject saw more than one member of an easy–difficult word pair. When sentence contexts were used in incongruous-context trials, the deleted terminal words from the original sentences were never seen by the subject.

Results and Discussion

Trials on which some type of experimental malfunction occurred (e.g., the vocal response was too soft for the relay setting; 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 button, had a response time longer than 2,000 msec or longer than two standard deviations above the mean for that condition were scored as subject errors and also dropped from the analysis. The mean reaction times and the mean percentage of subject errors for all of the experimental conditions are displayed in Table 1. Also con-

Table 1
Mean Reaction Times (in msec) for Experiment 1

	Congruous		Neutral		Incongruous		Facilitation		Inhibition		Overall context effect	
Condition	RT	%E	RT	%E	RT	%E	RT	%E	RT	%E	RT	%E
Block 1												
Naming task												
Easy words	523	0	561	1.0	569	2.1	38	1.0	8	1.1	46	2.1
Lexical-decision task												
Easy words	584	3.1	608	2.1	663	2.1	24	−1.0	55	0	79	−1.0
Naming task												
Difficult words	649	1.0	717	1.0	754	5.2	68	0	37	4.2	105	4.2
Lexical-decision task												
Difficult words	738	7.3	788	11.5	815	17.7	50	4.2	27	6.2	77	10.4
Block 2												
Naming task												
Easy words	509	1.0	539	1.0	531	0	30	0	−8	−1.0	22	−1.0
Lexical-decision task												
Easy words	515	2.1	567	2.1	573	1.0	52	0	6	−1.1	58	−1.1
Naming task												
Difficult words	605	4.2	667	6.3	641	5.2	62	2.1	−26	−1.1	36	1.0
Lexical-decision task												
Difficult words	620	5.2	598	5.2	715	12.5	78	0	17	7.3	95	7.3

Note. RT = reaction time; %E = mean percentage of errors.

tained in Table 1 are the magnitudes of the overall context effect (the difference between the congruous and incongruous conditions), the facilitation effect (the difference between the congruous and neutral-context conditions), and the inhibition effect (the difference between the neutral and incongruous conditions). All of the analyses that follow are based on the subject's mean reaction time in each condition.

An analysis of variance (ANOVA) on the reaction times indicated that the main effects of context condition, $F(2, 60) = 35.0$, $p < .001$, word difficulty, $F(1, 30) = 190.0$, $p < .001$, and task type, $F(1, 30) = 9.17$, $p < .025$, were significant, whereas the main effect of task order was not significant ($F < 1$). The Context Condition × Word Difficulty interaction that had been observed in previous experiments did not quite reach significance in Experiment 1, $F(2, 60) = 2.54$, $.05 < p < .10$, but the times were again in the expected direction (more difficult words tended to display larger context effects). Furthermore, an ANOVA on the error rates did indicate a significant interaction, $F(2, 60) = 4.60$, $p < .025$. The important interaction between task type and context condition did not reach significance in the reaction time analysis, $F(2, 60) = 2.19$, $.10 < p < .15$, or in the error rate analysis, $F(2, 60) = 1.20$. However, the interpretation of this simple interaction effect is modified by a significant three-way interaction between task type, context condition, and task order in the reaction times, $F(2, 60) = 3.44$, $p < .05$. Inspection of Table 1 indicates that the nature of the interaction is quite interesting. Both tasks show facilitation dominance when they are the second block that the subject completes. However, when the tasks appeared as the first block that the subject completed (as they would in experiments employing only one of the methods), the easy words in the lexical-decision task displayed a significant 55-msec inhibition effect ($p < .01$ in a planned comparison), whereas the easy words in the naming task maintained their pattern of facilitation dominance. Across the two tasks, the difficult words presented in the first block displayed similar amounts of interference in the reaction times and error rates. There was, however, some evidence that even when presented as the second block the lexical-decision task displayed some inhibition. For the difficult words there was a 7.3% inhibition effect in the error rates ($p < .01$ in a planned comparison). Collapsed across conditions, the mean nonword lexical-decision time was 760 msec (10.4% error) when preceded by a nonneutral context and 765 msec (6.8%) when preceded by a neutral context.

In summary, there was some indication in the data that the lexical-decision task results in more inhibition than the naming task when the same stimuli are used in both tasks. The data also suggest that the trend is more apparent in the first block of trials. However, since the statistical support for these trends was only moderate to weak, it was thought desirable to attempt a replication study. A second experiment also provided an opportunity to test an alternative explanation for the inhibition displayed by the lexical-decision task.

Experiment 2

In Experiment 2, the naming and lexical-decision tasks were again directly compared by using the same set of stimuli in both tasks. To increase the sensitivity of the experiment, the number of subjects was doubled. A different apparatus was used in Experiment 2, but the general experimental methodology was like that employed in Experiment 1.

Our earlier discussion alluded to the fact that the response requirements of the lexical-decision task may be responsible for any observed differences between it and the naming task. However, in Experiment 1 there was another critical difference in the task comparison, namely, the presence of nonwords in the lexical-decision task. Strictly speaking, the stimulus sets used in the two tasks were *not* identical. It is possible that the different data patterns resulted not from task differences, but instead derived from this stimulus difference. It is possible that the presence of nonwords induced a strategy that resulted in inhibition effects. As previously mentioned, Frederiksen and Kroll (1976) have observed that mixing nonwords with words slows word-naming time. To control for any possible stimulus effect of this type, subjects in Experiment 2 named nonwords as well as words. Thus, the set of stimuli used in the two tasks was *exactly* the same.

Method

The subjects were 64 undergraduate students recruited through an introductory psychology subject pool at Oakland University. The stimuli were presented on a BMC 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 Lafayette Instruments voice key were all 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 64 cm. Five-letter words subtended a horizontal visual angle of approximately 1.88°. All other aspects of the design, including target onset, timing, number of trials, and counterbalancing were as in Experiment 1, with the following exception: Eighteen additional pronounceable nonwords were constructed so that both blocks contained the same number of nonwords. In the naming block, subjects were instructed to pronounce the nonwords as well as the words.

Results and Discussion

Experimenter and subject errors were scored as in Experiment 1. The mean reaction times and mean percentage of subject errors for all of the experimental conditions are displayed in Table 2. The mean nonword naming time was 696 msec (1.6% error) and 765 msec (1.5% error) in the nonneutral and neutral conditions, respectively. The corresponding nonword lexical-decision times were 721 msec (5.8% error) and 765 msec (6.5% error). An ANOVA on the reaction times indicated that the main effects of context condition, $F(2, 124) = 81.3$, word difficulty, $F(1, 62) = 252.9$, and task type, $F(1, 62) = 24.4$, were all significant at the .001 level, whereas the main effect of task order was not significant ($F < 1$). The Context Condition × Word Difficulty interaction was significant, $F(2, 124) = 12.4$, $p < .001$. Replicating previous experiments, context effects were larger for more difficult words. The critical interaction between task type and context condition was significant, $F(2, 124) = 13.1$, $p < .001$).[2] Unlike Experiment 1, the interpretation of the interaction was not complicated by the presence of a three-way interaction with task order, $F(2, 124) = 1.27$, $p > .25$. Furthermore, the conclusion that the effect of context condition depends on task type is solidified by the presence of a significant interaction in an ANOVA on the error rates, $F(2, 124) = 3.47$, $p < .05$.

The nature of the interaction between context condition and task type is quite clear in Experiment 2. The overall context effect is uniformily larger in the lexical-decision task. A consideration of the results in terms of facilitation and inhibition is even more illuminating. The magnitude of the facilitation effects across the two tasks was very similar in each of the four possible comparisons (formed by the 2 × 2 factorial of word difficulty and block). In contrast, in each of the four comparisons, the lexical-decision task displayed more inhibition. These conclusions were reinforced by planned comparisons on the contrasts that defined facilitation and inhibition. All eight conditions displayed facilitation effects that were significant at the .01 level or below. In Block 1 the lexical-decision task showed significant inhibition effects ($p < .05$ and $p < .025$ for the easy and difficult words, respectively). Neither word set displayed inhibition in the naming task. In fact the times were in the opposite direction. In Block 2 the lexical-decision task again displayed significant inhibition ($p < .001$ and $p < .01$ for the easy and difficulty words, respectively; note also the presence of a 5.2% inhibition effect in the error rates for the difficult words). The naming task showed no such inhibition. In fact, the 29-msec effect in the opposite direction in the difficult condition was significant ($p < .05$). This effect can either be viewed as an anomaly due to chance (i.e., a Type I error) or a real effect that is due to the presence of the nonwords in the naming task. We prefer the former explanation for the following reasons. Much previous work with this paradigm (e.g., Stanovich,

[2] This critical interaction was also significant in an item analysis, $F(2, 380) = 17.2$, $p < .001$, as was the Context Condition × Word Difficulty interaction, $F(2, 380) = 8.89$, $p < .001$. The item analysis also revealed significant main effects of context condition, $F(2, 380) = 75.2$, $p < .001$, word difficulty, $F(1, 190) = 306.7$, $p <$ 001, and task type, $F(1, 190) = 87.6$, $p < .001$, as well as a significant Word Difficulty × Task Type interaction, $F(1, 190) = 8.19$, $p < .005$. No other effects were significant.

Table 2
Mean Rection Times (in msec) for Experiment 2

Condition	Congruous RT	Congruous %E	Neutral RT	Neutral %E	Incongruous RT	Incongruous %E	Facilitation RT	Facilitation %E	Inhibition RT	Inhibition %E	Overall context effect RT	Overall context effect %E
Block 1												
Naming task												
Easy words	478	.5	530	.5	505	.5	52	0	−25	0	27	0
Lexical-decision task												
Easy words	519	1.0	561	2.1	589	3.1	42	1.1	28	1.0	70	2.1
Naming task												
Difficult words	589	.5	696	3.7	676	2.1	107	3.2	−20	−1.6	87	1.6
Lexical-decision task												
Difficult words	649	7.8	766	7.8	797	7.8	118	0	31	0	149	0
Block 2												
Naming task												
Easy words	487	1.0	523	1.6	523	0	36	.6	0	−1.6	36	−1.0
Lexical-decision task												
Easy words	502	1.6	540	0	585	2.6	38	−1.6	45	2.6	83	1.0
Naming task												
Difficult words	610	3.1	695	3.7	666	3.1	85	.6	−29	−.6	56	0
Lexical-decision task												
Difficult words	653	4.2	737	7.8	773	13.0	84	3.6	36	5.2	120	8.8

Note. RT = reaction time; %E = mean percentage of errors.

1981; Stanovich & West, 1979, 1981; West & Stanovich, 1978) has indicated that when adults name words that are not degraded in any way, their naming times show no inhibition. Of course, if the inhibition effect is really zero, sample values will vary around this point, and sometimes negative inhibition values will be obtained. If enough experiments are carried out, and within each experiment several inhibition effects are assessed via our standard statistical hypothesis testing procedures, then it is inevitable that a statistically significant negative inhibition effect will eventually be obtained.[3]

More important than the argument over whether the negative–inhibition effect is real, is the point that even if the neutral condition in the naming task is elevated by the presence of the nonwords, such an effect would in no way obscure the basic finding of an interaction between context and task. This is because the overall context effect displayed by the two tasks is markedly different. The decrease in inhibition in the naming task is not accompanied by an increase in the facilitation effect for that task, as would be expected if the entire pattern was merely due to an elevated neutral condition. Even if one's theoretical preference is not to interpret facilitation and inhibition effects constructed by comparison with a neutral condition, the results still indicate that incongruity differentially affected the lexical-decision task. This is illustrated in Table 3, in which the response time difference between the two tasks is displayed as a function of context condition, word difficulty, and block. It is clear that the difference between the two tasks in the incongruous condition is greater than the difference shown in both the neutral and the congruous conditions. (Planned comparisons indicated that the differences in the incongruous conditions were significantly greater than those in the congruous conditions in all cases.) Similar trends were apparent in the error rates.

[3] It is acknowledged that the two nonsignificant negative inhibition effects in Block 1 could be viewed as bolstering the argument that the effect is real.

Table 3
Reaction Time Difference Between the Lexical-Decision Task and Naming Task in Experiment 2 as a Function of Context Condition and Word Difficulty

	Context condition					
	Congruous		Neutral		Incongruous	
Condition	RT	%D	RT	%D	RT	%D
Block 1						
Easy words	41	.5	31	1.6	84	2.6
Difficult words	60	7.3	70	4.1	121	5.7
Block 2						
Easy words	15	.6	17	−1.6	62	2.6
Difficult words	43	1.1	42	4.1	107	9.9

Note. RT = reaction time. %D = mean error percentage difference.

General Discussion

The results of Experiments 1 and 2 provide direct empirical support for the hypothesis that previous research on sentence context effects had suggested: Inhibition is greater in the lexical-decision task than in the naming task. There appears to be a genuine lack of convergence between the two tasks in the sentence context situation, in contrast to the single-word priming paradigm, in which they have produced reasonably similar results. We conjecture that the inhibition found in lexical-decision tasks arises because the task heavily implicates processes that take place subsequent to word recognition. Postlexical processes that are related to the presence of a sentence context are affecting the response time. If this conjecture has any validity, it has an important implication—that although the lexical-decision task may be appropriate for studying word recognition in the isolated word or single-word priming situations, the use of the task to study the process of word recognition in sentence context situations is problematic.

Basically, our argument builds on the suggestion of Theios and Muise (1977) that the lexical-decision task requires more information translation subsequent to lexical access in order to arrive at a response than does the naming task (see also Forster, 1979). Indeed, this hypothesis accounts for the fact that lexical-decision times are always slower than naming times. This difference in response decision times should not be a problem in single-word recognition experiments in which there is little else going on in the processing system during the response decision stage. However, in sentence context experiments, there exists the possibility that processes at the sentential level may interact with the target word once it has been recognized and that this may take place during the response decision stage. The relatively long response-decision stage in the lexical-decision task would thus make it more likely that this task is picking up—in addition to sentence context effects on word recognition—postlexical sentential processes that attempt to integrate the meanings of the words in a sentence once the meanings have been accessed.

This conjecture is similar to, and receives support from, an analysis of language processing by Forster (1979). He hypothesizes that the language processor is composed of three separate subsystems: a lexical processor, which attempts to access entries in the lexicon based on elements in the input string; a syntactic processor, which extracts from the lexical entries the information required to assign a syntactic structure to a sentence; and a message processor, which converts a linguistic representation into a conceptual structure of the intended message. The three processors are arranged in a serial, bottom-up fashion, such that each stage receives input from only the immediately preceding stage. However, each level can pass on intermediate results to the next level. Thus, each stage may begin processing before the operations of the previous stage have been completed and as such, the processors are arranged in a "cascade" structure similar to that discussed by McClelland (1979). A decision-making general problem solver has access to the outputs of each of the stages of the language processor. It is this feature that makes it difficult to determine if lexical-decision responses in sentence context experiments are solely the result of operations at the lexical level, because all levels are simultaneously feeding output to the decision maker. For example, Forster (1979) discusses the seemingly paradoxical finding that occurs in many lexical-decision experiments (e.g., Neely, 1976, 1977; Schuberth & Eimas, 1977)—that the responses to the nonwords are *also* facilitated by a context. In the sentence context case, Forster argues that the syntactic processor will begin to mark the entire string as ungrammatical when it begins to receive the information that the lexical level is classifying the string as a nonword. This information from the syntactic level is available to the decision maker and may serve to bias the decision toward a "no" response.[4] Such a bias would not be present for nonwords out of context. (Neely, 1977, pp. 250–251, and Schvaneveldt & McDonald, 1981, pp. 680–681, have made similar arguments for the nonword facilitation found in single-word context paradigms.) Forster (1979) argued that similar postlexical effects may have accounted for the facilitation of word processing due to congruity that Schuberth and Eimas (1977) observed in a lexical-decision task. When a congruent word appears, the decision maker receives input from the syntactic and message processors indicating congruency, thus biasing the decision maker toward a "yes" response.

Similar arguments can explain why lexical-decision tasks show more of an inhibition dominant pattern than do naming tasks. The slow response-decision process in lexical-decision tasks allows time for information from the syntactic and message processors to reach the decision maker. The message processor, having detected an incongruity, will send information that may bias the decision maker toward a "no" response. Overcoming this bias may take time, thus resulting in "yes" responses to incongruous words being slower than responses to words in a neutral context. In fact, if Forster (1979) is correct in arguing that the output of the message processor is more accessible to the decision maker than any lower level[5] (because the purpose of sentence processing is to bring a sentence interpretation to conscious awareness as soon as possible), then we might expect that on occasion the decision maker may be dominated by the output of the message center to such an extent that incorrect "no" responses to incongruous words will result. The error data from Experiments 1 and 2 are consistent with this agrument. The difficult words in the lexical-decision task displayed average error rates of 15.1% in the incongruous conditions of Experiment 1 and 10.4% in the incongruous conditions of Experiment 2, an error percentage that is a good deal larger than that obtained in single-word priming experiments.

In short, the argument is that the complex decision process involved in the lexical-decision task leaves ample time for postlexical processes at the sentential level to become implicated in the response time. Use of the lexical-decision task in sentence context situations results in a type of "Stroop" effect where incongruous words require a "yes" response from the lexical level, but sentential levels signaling incongruity may prime the "no" response.[6] Overcoming the latter bias lengthens response time, thus causing an inhibition effect that is not due to sentence context affecting word recognition, but to postlexical message-level processes. This problem of the differential priming of a binary choice that is determined by a complex interaction of levels is not a factor in the naming task. The naming task, with its relatively fast and automatic connection between lexicon and response, leaves much less time for postlexical processes, unless the words are degraded or difficult to recognize. If the goal of an investigation is to study the speed of word recognition, then as Forster (1979) argued,

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[4] Actually, Forster argues for a "race" model, in which the first information processed by the decision maker determines the response. However, rather than assume that the race is totally "won" or "lost" by a particular stage, one may relax the assumption and hypothesize that the decision maker integrates information from all levels.

[5] A study by Fischler and Bloom (1979, Experiment 5) supports this assumption. They found that subjects showed the same pattern of contextual effects even when told to avoid generating expectancies and to treat the reading of the context and the lexical decision as separate tasks.

[6] This situation may be logically similar to a much-discussed problem (see Posner, 1978, p. 110) with using the matching task in a priming paradigm, that subjects tend to include the prime in the match (see also Neely, 1977).

the most pressing problem . . . is to design a task in which the decision process is clearly controlled by the lexical level of processing. . . . The naming task has one advantage over lexical decision: There is no way the subject can infer the correct response from sentential properties of the input (as is possible in the lexical decision task). Hence naming times are more likley to reflect speed of lexical processing. (p. 64)

Mitchell and Green (Note 1) employed an analysis like that above in order to explain the results from their continuous lexical-decision task, in which the subjects advanced themselves through a passage one word at a time, stopping to count to 10 when a nonword appeared (see also Mitchell & Green, 1978). These results are unlike any of the lexical-decision or naming experiments described above in that they did not find facilitation for words in a coherent passage, when compared to the lexical-decision times for the same words presented in a random sequence. However, they did find a large inhibition effect when syntactically and semantically anomalous words appeared in the coherent passage. Their results thus represent an extreme form of inhibition dominance. They speculated, consistent with the argument presented above, that

if context doesn't affect *word recognition* it is reasonable to ask what process *is* affected by context when anomalous materials are used as in the two examples discussed above. One possibility is that recently recognized material might be submitted to additional analysis designed to check whether it is compatible with prior text. On this hypothesis, material in the anomalous condition would fail the test and this might lead to further analysis (e.g., reprocessing the words, attempts to reinterpret the context so that is becomes compatible with the new word, etc.). Thus, while the constraining effect of context may not become available early enough to influence lexical access the analysis of prior material might be completed early enough to be used in a post-access checking procedure. (p. 10)

This argument only differs from that of the present authors in that we emphasize that it is the relative response incompatibility of the lexical decision task that serves to magnify, if not create, this effect.

Fischler and Bloom (1979, Table 4) presented evidence indicating that the inhibition for incongruous words in their experiments was not due to a lexical-level mismatch of the target word with a conscious prediction generated from the sentence context. They compared performance on sentences with a high degree of predictability (mean cloze probability of .92) to that on sentences with much lower degrees of predictability. If a mismatch with conscious expectancies is the cause of the inhibition in their paradigm, then congruous words that are not the primary cloze response should show more of a tendency toward inhibition, or at least yield slower lexical-decision times, in the highly predictable sentences. This prediction was clearly falsified. We would argue that unexpected congruous words did not display inhibition because there was no incongruity to prime the "no" response. It is incongruity at the message level, not expectancies that interfere with lexical access, that is the cause of the inhibition in the lexical-decision paradigm. This conclusion is supported by the results of Experiment 5 of the Fischler and Bloom (1979) article, in which instructions that discouraged conscious expectancy formation did not eliminate inhibition. Additional support comes from the fact that manipulations of the probabilities of predictable and incongruous target words does not eliminate the inhibition found in the lexical-decision task (Fischler, Note 3), nor create inhibition in the naming task (Stanovich & West, 1981, Experiment 1). Finally, Wright (Note 4) has observed syntactic effects on the lexical-decision times of target words that were neither predictable from the sentence context nor related to words in the context. Here again, the task appears to be sensitive to processes occurring *after* lexical access.

Our explanation for the inhibition observed in lexical-decision experiments is in terms of task characteristics and does not necessitate any drastic changes in current thinking about information processing, such as the comment of Fischler and Bloom (1979) that "the inability of subjects, given the suppression instructions, to eliminate the inhibition suggests that the concept of attentional mechanisms as being under a subjects' active control needs to be revised" (p. 16). In fact, Fischler and Bloom (1980, p. 223) consider an explanation in terms of task characteristics that may be Stroop-like. However, they develop it along lines different than those argued above, and prematurely reject it because Stroop interference arises when the required and interfering responses are incompatible and, "in contrast, the correct overt response is the same for semantically anomalous and acceptable words" (p. 223). However, if we consider that all three components of the language processor may be contributing information to a decision maker that is faced with the ecologically unprecedented situation of making a yes/no response to linguistic materials, it is not inconceivable that anomalous words are priming an incompatible "no" response through their effect on the message-level processor.

Whether the operation of the message-level processor is automatic or attentional is problematic given the current data base, and leads us to reiterate the suggestion of Fischler and Bloom (1980) that the strict dichotomy between automatic and attentional processes may not hold up when applied to complex tasks like reading and that a more continuous conception is needed. Instructions to treat the context reading and lexical decision as separate tasks (Fischler & Bloom, 1979, Experiment 5) did not eliminate the inhibition, indicating that the transmission of information from the lexical and syntactic levels to the message level and from the message level to the decision maker is not under subject control. However, changes in strategic set via strong manipulations to materials have reduced inhibition. Fischler and Bloom (1979, Experiment 2) did succeed in eliminating inhibition when every sentence the subject saw was incongruous. In short, it appears to be very diffficult, but possible, to "turn off" the message-level processor.

Finally, it should be noted that although they consider a number of possible explanations for the inhibition dominance in their experiments, Fischler and Bloom (1980) at one point come close to the argument presented here when they state that

> the effects of semantic anomaly are therefore likely to be produced at levels "deeper" than that needed for individual word processing. . . . Meaning plays a more concurrent role in sentence role in sentence perception, . . . and that [contextual inhibition] would be of value to the reader as a signal that perception or comprehension has failed, and that some reanalysis is called for. (p. 224)

In short, under normal stimulus conditions, the increase in lexical-decison time that occurs when an incongruous word appears is due to the disruption of comprehension processes rather than word-recognition processes (see also, Mitchell & Green, 1978). Fischler (Note 3) has recently elaborated this point in a manner related to the arguments outlined above. He argues that the violation of the general linguistic expectation that a string of words will be meaningful may disrupt the meaningfulness judgment at the lexical level that is called for by the lexical-decision task.

The above arguments would seem to indicate that the naming task rather than the lexical-decision task appears to be preferable when the experimental hypotheses concern sentence context effects on word recognition. Given that the naming task readily detects facilitation effects in sentence context experiments, and that it reveals overall context effects in single-word priming experiments similar to those shown by the lexical-decision task, there is no reason to believe that the task would not detect the inhibition effects revealed by the lexical-decision task if the effects were indeed on lexical access. The most parsimonious explanation of the differences between the two tasks in the sentence context situation appears to be that the naming task does not show extensive inhibition because the inhibition in the lexical-decision task is due to postlexical processes that are not as heavily implicated in the naming task.

Based on the arguments above, the general view of word processing during reading that we appear to be arriving at bears similarities to an explanation of the processing of lexical ambiguities put forth by Onifer and Swinney (1981; see also Cairns, Cowart, & Jablon, 1981; Tanenhaus, Leiman, & Seidenberg, 1979; and the important recent discussion of these issues by Seidenberg, Tanenhaus, Leiman, & Bienkowski, in press). They argue that lexical access is an automatic autonomous subroutine that is not driven or guided by previously occurring semantic information. Followng lexical access, postaccess processes evaluate accessed entries in terms of contextual information. We would make only a few addenda to this general outline. First, although we would agree that lexical access is not guided by expectations based on the previous context, we would add that automatic spreading activation from semantically associated words in the previous context may act to speed word recognition. This is the mechanism that we believe is responsible for the facilitation effects observed by Stanovich and West (1979, 1981), and in Experiments 1 and 2 of the present article. The facilitation dominance of the results from the naming task are suggestive of this mechanism, as is the fact that the facilitation effects displayed by the two tasks in Experiments 1 and 2 were of a similar magnitude.

The operation of a spreading activation mechanism can also probably explain why various lexical-decision experiments have differed in the amounts of facilitation observed. Fischler and Bloom (1979, 1980) have observed that the lexical-decision time for an incongruous word was much slower than that for a word that was congruous but reasonably unpredictable from the preceding context (e.g., "He mailed the letter without a *check*"). This inhibition of incongruous words relative to unpredictable words is similar to the inhibition displayed relative to a neutral context (i.e., a string of Xs) and supports the explanation of the causes of inhibition in the lexical-decision task discussed earlier. If the inhibition was caused by a mismatch between a prediction and the target word, then unpredictable words should also show inhibition. In the data of Fischler and Bloom (1979, 1980) the inhibition effect was much larger than the facilitation displayed by predictable congruous words when compared to unpredictable congruous words. Kleiman (1980) reported a lexical-decision experiment in which the facilitation was much larger than that observed by Fischler and Bloom (1979, 1980). The difference between the results is probably due to the fact that Fischler and Bloom (1979, 1980) avoided relationships between context words and target words when constructing their materials, whereas in Kleiman's (1980) materials, as in those used in the experiments reported above, many of the predictable target words were associated with or related to context words (e.g., bacon–eggs, log–cabin, month–year, rains–flood, cup–coffee, toothache–dentist).

The basic finding that difficult words show larger facilitation effects than easy words is also indirect evidence for the operation of an automatic spreading activation process. Since the easy words are more predictable from the contexts, one would expect that if a conscious prediction process were the cause of the contextual effects, easy words should show greater facilitation, because the conscious prediction will more often match the target word on easy word trials. However, the actual outcome, replicated in the experiments reported above, is just the opposite. Difficult words displayed more facilitation. It is probably relevant that although the difficult words were less predictable, they were *not* less strongly related to the content words in the sentence contexts (see the Method section of Experiment 1). This means that, when in a congruous context, difficult words are less likely to benefit from conscious predictions but are just as likely to benefit from activation that spreads from associated or semantically related words in the context. If the process responsible for the contextual effects was one of automatic spreading activation in a semantic network rather than conscious prediction, then difficult words should stand to benefit from congruity just as much as easy words. In fact, if certain properties of difficult words serve to slow feature extraction and encoding (for example, a larger number of letters are subject to lateral masking), then a larger facilitation effect for these words might be expected. Seymour (1976) and Sanford, Garrod, and Boyle (1977) have shown that Morton's (1969) logogen model would make this prediction. When the rate of feature extraction is slowed, factors that affect the evidence requirements of logogens (e.g., contextual information) will have a greater effect on performance (see Figure 5 of Sanford et al., 1977).

Finally, previous work does suggest that spreading activation is a viable mechanism for facilitation in situations approximating the parameters of the sentence context paradigm. In single-word priming experiments, spreading activation effects have been shown to persist despite intervening words between the prime and target (Brown & Block, 1980; Davelaar & Coltheart, 1975; Loftus, 1973; Loftus & Loftus, 1974; Schvaneveldt & Meyer, 1973), and purely in terms of time, the effects seem to persist long enough to be operative in the sentence context situation (Blank & Foss, 1978; Warren, 1972). Although it is true that sentences rarely contain words that are highly associated, facilitation due to spreading activation seems to be very pervasive (Collins & Loftus, 1975); it occurs even for nonassociated words as long as they are semantically related (Fischler, 1977).

Conscious processes that select word meanings and integrate access entries do not *guide* lexical access, but instead operate *after* lexical access. However, lexical access occurs so rapidly that there is clearly time for integrative message-level processes to become implicated in the performance of tasks with complex response requirements. Several different experiments have yielded estimates of lexical access time in the range of 150–250 msec (Gough & Cosky, 1977; Loftus & Loftus, 1974; Rohrman & Gough, 1967; Sabol & DeRosa, 1976). Consistent with these estimates, Kutas and Hillyard (1980) found that cortical potentials indicating semantic anomaly begin as early as 250 msec after target-word onset. Thus, even if conscious expectancies do not facilitate lexical access, such processes can have early-occurring and potent effects on word processing.

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