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The Effect of Sentence Context on Ongoing Word Recognition: Tests of a Two-Process Theory

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The Posner-Snyder two-process theory of expectancy provides an explanation of the results of some recent studies on the effect of sentence context on ongoing word recognition. The theory also accounts for some recent results on the effect of sentence context on the word recognition times of children differing in reading fluency. Three studies were designed to directly test the applicability of the theory to the performance of fluent adult readers. Experiment 1 tested and falsified an alternative explanation of previous results. Experiments 2 and 3 established and replicated the finding that difficult (but less predictable) words displayed larger context effects than did easy words that were more predictable from the preceding sentence context. This finding cannot be explained by many recent models of contextual effects on ongoing word recognition, but is reasonably well accounted for by the Posner-Snyder theory.

The renewed interest in the psychology of reading displayed by experimental psychologists (see Venezky, 1977, for the history of this problem shift) has led to the development of many new research questions. The attention of researchers has recently been directed toward the important problem of determining how a prior sentence context acts to facilitate ongoing word recognition during reading. Although the amount of empirical and theoretical work on this issue has recently increased (see Spoehr & Schuberth, 1981, for a review), research in this area is still in its infancy. The present paper is a report of some new work on the effect of sentence context on word recognition that we hope will add to the still rather meager literature in this area. The three experiments reported herein were designed to test a well-known model of expectancy and contextual effects that had given a good account of previous results from our laboratory. This particular model has some interesting implications for studies of developmental and individual differences in contextual facilitation, and these will be discussed.

Posner and Snyder (1975a, 1975b) developed a theory of expectancy that provides a framework for studies of contextual effects on word recognition. They proposed that context affects recognition via two processes that act independently and have different properties. The automatic spreading-activation process occurs when stimulus information activates a memory location and automatically spreads some of the activation to nearby semantically related memory locations (see Collins & Loftus, 1975). The automatic spreading-activation process is fast acting, does not use attentional capacity, and does not affect the retrieval of information from memory locations unrelated to those activated by the context. Thus, the automatic-activation process results in a contextual facilitation effect but does not cause an inhibitory effect when a word is incongruous with its preceding context. Contextual facilitation without inhibition is evidence that the automatic-activation process is operative. In addition, the spreading-activation process is extremely rapid, so facilitation due to automatic activation is almost immediately apparent (Fischler & Goodman, 1978). In contrast, the conscious-attention mechanism responds to a preceding

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context by directing the limited-capacity processor to the memory location of the expected stimulus. The conscious-attention mechanism is slow acting, utilizes attentional capacity, and inhibits the retrieval of information from unexpected locations because the limited-capacity processor must move a considerable distance in the memory network to read out the presented information. Thus, when the time between the presentation of the context and the stimulus word is short, facilitation without inhibition results. As this interval increases, it becomes more likely that the conscious-attention mechanism will have time to act and thus add to the facilitation effect. However, as the conscious-attention mechanism becomes more implicated in performance, contextual inhibition will also begin to appear. The two expectancy processes of the Posner-Snyder theory are very similar to the location-shifting and spreading-excitation models originally proposed by Meyer and Schvaneveldt (1971).

The Posner-Snyder two-process theory of expectancy has received support from studies employing single-word priming paradigms (Fischler, 1977a; Neely, 1977; Tweedy, Lapinski, and Schvaneveldt, 1977; Yates, 1978; Hanson, Kamil, & Snyder, Note 1) and from studies employing a full-sentence context (Stanovich & West, 1979; West & Stanovich, 1978). In particular, the idea of contextual facilitation due to an automatic spreading-activation mechanism has received wide support (Davelaar & Coltheart, 1975; Fischler, 1977a; Fischler & Goodman, 1978; Neely, 1977; Stanovich & West, 1979; Swinney, Onifer, Prather, & Hirshkowitz, 1979; Tversky, Havousha, & Poller, 1979; Underwood, 1977).

In previous studies, we (Stanovich & West, 1979; West & Stanovich, 1978) designed several experiments to test the applicability of the Posner-Snyder theory to sentence context effects. In several experimental conditions where a target word appeared shortly after the sentence context, recognition time showed the facilitation without inhibition that is characteristic of the operation of the automatic spreading-activation mechanism. When the time interval between the processing of the context and the onset of the target word was lengthened, inhibition began to appear. These findings suggest that at short intervals a target word is recognized before the conscious-attention mechanism has time to act and that only the spreading-activation mechanism is operative. As the context-target interval is lengthened, the conscious-attention mechanism becomes more implicated in performance. An analogous pattern of results obtains when the target word is degraded via contrast reduction. In short, any variable that delays recognition of the target word appears to cause an increase in the amount of inhibition. The Posner-Snyder theory accounts for this phenomenon because the cause of inhibition in their model (the conscious-attention mechanism) is slow acting and has a greater influence on performance as recognition of the target word is delayed. The results of our experiments are consistent with many other studies that did not employ a neutral control condition (and thus do not separate inhibition from facilitation) but did find an interaction between context and stimulus degradation (Becker & Killion, 1977; Forster, 1976; Massaro, Jones, Lipscomb, & Scholz, 1978; Meyer, Schvaneveldt, & Ruddy, 1975; Sanford, Garrod, & Boyle, 1977; Roth, Perfetti, & Lesgold, Note 2).

One additional aspect of the Posner-Snyder theory that makes it particularly useful is that it accounts nicely for the results of recent research on changes in the relative influence of contextual and stimulus factors on word recognition as reading fluency develops. For example, we (West & Stanovich, 1978) found that under stimulus presentation conditions where adults displayed facilitation without inhibition, fourth and sixth graders displayed significant inhibition effects. In addition, the magnitude of the facilitation effect did not differ significantly across the three groups and, in fact, showed a slight tendency to decrease with age. These results are predictable from the Posner-Snyder theory, given the empirical fact that the time required to recognize words in isolation decreases with age. Younger children take longer to encode a target word, and thus it

is more likely that the conscious-attention mechanism, which is the cause of contextual inhibition, will become implicated in their performance. Adult readers recognize a target word before the conscious-attention mechanism has time to act, and only the spreading-activation mechanism influences their performance. Thus, in light of our previously discussed study (Stanovich & West, 1979), where stimulus degradation was manipulated, we can say that the effects of the subject variable *reading fluency* and the independent variable *stimulus degradation* mimic each other. (A particularly striking example of such mimicry is contained in a paper by Roth et al., Note 2.) Although no other developmental studies of context effects have allowed the assessment of facilitation and inhibition, several studies have found that context had a greater influence on the recognition times of the poorer readers in the studies (Biemiller, 1977–1978; Perfetti, Goldman, & Hogaboam, 1979; Schvaneveldt, Ackerman, & Semlear, 1977; Roth, Perfetti, & Lesgold, Note 2). This interaction should occur because poorer readers have slower word recognition times (Perfetti, Finger, & Hogaboam, 1978; Perfetti & Hogaboam, 1975) and, thus, it is more likely that both expectancy mechanisms are influencing the performance of these readers.

The Posner-Snyder theory is an elegant framework for interpreting the results of studies on single-word and sentence context and provides a provocative interpretation of the results of developmental studies. However, the theory still rests on a comparatively thin empirical base. Thus, in the present paper we have attempted to further test the Posner-Snyder theory, to replicate some previous results, and to explore the boundary conditions of the two-process model.

Experiment 1

In previous studies (Stanovich & West, 1979) we adopted a processing-time explanation for the facilitation without inhibition that we observed in experiments. That is, we argued that in conditions approximating actual reading, words are recognized so rapidly that only the spreading-activation mechanism has time to act. The conscious-attention mechanism is, in a sense, short-circuited. There are, however, other possible explanations for the fact that no inhibition was observed in some of the experimental conditions of our previous studies. It is important to realize that the conscious-attention mechanism is just that—a conscious strategy that a subject can choose or not choose to employ. As Posner and Rogers (1978) recently emphasized:

> We believe that subjects can bring even quite automatic activity under attentive control and will generally do so if given the incentive. On the other hand, when an item is of low validity or subjects' attention is elsewhere, these same operations may go on without the cost that accompanies them when attended. Thus, the flexibility of the cost function corresponds to the ability of subjects to control the attentive mechanism by endogenous strategies. (pp. 165–166)

Thus, facilitation without inhibition may be observed not because of processing-time limitations but because the subject simply does not develop conscious expectancies regarding the target stimulus. If this were the case, then only the automatic component of expectancy effects would be observed. It then might be thought relevant that the experimental situation we employed (Stanovich & West, 1979) was not one that would strongly encourage the development of conscious expectancies. Specifically, we required no recall of the sentence contexts of the subjects and only one half of the target words were congruous with the sentence. A priori, it would seem that such an experimental situation would discourage conscious-expectancy formation. Nevertheless, we did observe significant inhibition effects under conditions where target word recognition was delayed. This finding suggests that conscious expectancies were being employed but that their effects were only manifest when given enough time to operate.

It is, however, possible to further test the processing-time explanation and this was attempted in Experiment 1. The hypothesis under investigation is that the facilitation without inhibition that we observed previously was due to the time constraints of the situation and not to the lack of conscious-expectancy formation. Thus, manipulating the subjects' expectation strategies should not alter our basic finding as long as the time

parameters of the situation are the same. Experiment 1 was suggested by an experiment reported by Tweedy et al. (1977), who used a task in which subjects made lexical decisions to pairs of letter strings. They found that the semantic context effect (faster reaction times when the two words were associated) increased as the proportion of related-word pairs in the list increased. A large proportion of related-word trials seems to induce a strategy in subjects whereby they are better able to utilize semantic association when it occurs. Although Tweedy et al. (1977) were unable to separate their context effects into facilitation and inhibition due to the lack of a neutral control condition, the nature of their independent variable (proportion of related items over the entire experiment) strongly suggests that a conscious-expectation strategy was being manipulated. Their experiment thus suggests a way of testing an alternative explanation for the facilitation without inhibition in some of the conditions of our previous experiments (Stanovich & West, 1979; West & Stanovich, 1978). Specifically, increasing the proportion of congruous-context trials in our experimental paradigm leads to differential predictions. According to the processing-time explanation, facilitation without inhibition should still be observed, since inducing the subject more strongly to develop conscious expectancies should have no effect if the conscious-attention mechanism itself is short-circuited because of the time constraints of the experimental situation. In contrast, if the observed facilitation without inhibition was due to a strategic decision not to consciously generate expectancies (because of aspects of the experimental situation previously mentioned), increasing the proportion of congruous trials should induce the subject to develop such expectancies and a significant inhibition effect should be observed. These predictions were tested in Experiment 1, where 80% of the sentence contexts were followed by congruous target words.

Method

Subjects. Subjects were 18 undergraduate psychology students recruited through a subject pool at Oakland University.

Stimuli and apparatus. The sentences used in the experiment were a subset of those we employed in a previous study (West & Stanovich, 1978). These sentences were constructed so that their last two words were the word "the" and a noun that was highly predictable from the preceding context (e.g., "The car rolled down the hill"). The sentences were organized into pairs (e.g., "The boy swam underneath the bridge" was paired with "The clothes hung inside the closet"), and the terminal word of each sentence was then deleted. The resulting incomplete sentences were used as contexts, and the deleted nouns were used as word targets. A sentence context and a target word were considered congruous when they were derived from the same original sentence (e.g., "The boy swam underneath the" was congruous with the target "bridge"). A sentence context and a target word were considered incongruous when they had been derived from opposite members of the original sentence pairs (e.g., "The clothes hung inside the" was incongruous with the target "bridge"). A neutral-context condition was created by presenting three "the's" before the target. As a whole, the sentences were of a low level of reading difficulty. They were composed of simple, high-frequency words and could all be read by the fourth graders in our previous study (West & Stanovich, 1978).

The stimuli were typed on 6 × 9 inch (15.2 × 22.9 cm) cards in lowercase Prestige Elite font with an IBM Selectric II typewriter. One set of cards contained the sentence contexts and another contained the target words. The stimuli were presented via an Iconix tachistoscope at a viewing distance of 88.9 cm. Five-letter words subtended a horizontal visual angle of approximately .62°. The contexts and the targets were presented in separate fields of the tachistoscope and were aligned so that when both were presented the subject saw what looked like a complete sentence. Target word onset was controlled by a button pushed by the experimenter, which 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 of "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 initiate 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 experimenter was instructed to develop a criterion so stringent that it occasionally resulted in the experimenter's pressing the button during the articulation of "the," thus aborting the trial. Three "the's" were employed as the neutral control condition so that the difficulty of synchronization would be the same across conditions. The number of experimenter-aborted trials was approximately equal across the three conditions.

Procedure. Subjects were individually tested in a session that lasted approximately 30 min. They were instructed to look into the tachistoscope and read aloud

the sentence contexts that appeared. The subjects were told that as soon as they had read the context a word would appear and that they were to pronounce the target word as rapidly as possible. Subjects were told that only the reading of the target word was timed, so they were free to read the contexts at a comfortable pace.

Subsequent to six practice trials, each subject completed 60 randomly ordered experimental trials. Each subject saw the same set of 60 target words. On 40 trials the target word was preceded by a congruous context, on 10 trials by an incongruous context, and on 10 trials by the neutral context (three "the's"). The assignment of context conditions was counterbalanced across subjects so that each word appeared 12 times in a congruous context, 3 times with an incongruous context, and 3 times with the neutral context. No subject saw the same target word or sentence context more than once in the course of the experiment.

Results and Discussion

Trials on which an 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 or had a response time longer than 2.5 *SD* above the mean for that condition were scored as subject errors and were also dropped from the analysis. The mean reaction times and the mean percentage of subject errors across the three context conditions are displayed in Table 1. All of the analyses that follow are based on the mean reaction times in each condition. An analysis of variance on the reaction times indicated that the effect of context condition was significant, $F(2, 34) = 9.46$, $p < .001$. Planned comparisons indicated that the 65-msec facilitation effect was significant ($p < .01$) but the 17-msec inhibition effect was not ($F < 1$). Sixteen of the 18 subjects displayed a facilitation effect, and 13 of the 18 subjects displayed an inhibition effect.

Table 1
Mean Reaction Times and Mean Percentages of Errors for the Three Context Conditions

Context condition	Mean reaction time (msec)	Percentage mean error
Congruous	608	2.1
Neutral	673	.6
Incongruous	690	1.7

The results of Experiment 1 appear to be more supportive of the processing-time explanation than of the conscious-strategy explanation. Although a 17-msec inhibition effect was observed, it did not approach statistical significance and was considerably smaller than the 65-msec facilitation effect. Thus, despite the change in the proportion of congruous trials, the pattern of benefit dominance was still apparent in this experimental situation. The most parsimonious explanation appears to be that the strategy manipulation was ineffective because the target word was recognized before the conscious generation of an expectancy. Thus, only the spreading-activation component of expectancy effects was operative.

Experiment 2

As previously mentioned, we originally employed the Posner-Snyder theory as an explanation for the results of a developmental study (West & Stanovich, 1978) in which we found that fourth and sixth graders showed contextual facilitation and inhibition while adults displayed facilitation without inhibition. It was hypothesized that the rapid word recognition of the adult subjects short-circuited the conscious-attention mechanism (thus eliminating the source of inhibition) but that the word recognition of children was slow enough for that mechanism to be implicated in their performance. In subsequent experiments (Stanovich & West, 1979) we found that the performance of adults mimicked that of children (i.e., showed inhibition) when the adult word recognition times were slowed by contrast reduction (see Roth et al., Note 2). There are, however, several other ways to increase word recognition time that are more ecologically valid than the rather artificial manipulations of visual quality that have been employed. Natural language variables such as word frequency and word length also serve to make words more or less difficult to recognize. Thus, in Experiment 2 we employed two sets of words, easy and difficult. According to the Posner-Snyder theory, expectancy mechanisms require more time to operate when the target word is difficult because difficult words take

longer to recognize. Thus, larger contextual effects (especially inhibition effects) should be evident in the difficult-word condition.

For Experiment 2 we constructed a new set of sentence contexts and two target words that were congruent with each context. These sentences were, as a whole, at a higher level of difficulty than those employed in Experiment 1, since the latter sentences were constructed to be read by fourth graders. In addition, for each sentence one of the targets was an easy word and one of the targets was a difficult word. Difficult words were less frequent and contained more letters than did easy words. It was thought desirable to let both of these variables (word frequency and word length), which naturally covary, define our manipulation of word difficulty, since on the basis of previous work (e.g., Perfetti et al., 1979; Stanovich & West, 1979) we knew that differences in word recognition time of at least 100 msec are required for different patterns of facilitation and inhibition to be observed. Manipulating word frequency alone would not be adequate, since word frequency effects in naming tasks are often considerably less than 100 msec (cf. Theios & Muise, 1977). This fact may account for the lack of a sentence context by word frequency interaction in the data of Schuberth and Eimas (1977), although Becker (1979), using a single-word priming task, did find such an interaction in the presence of a relatively small frequency effect.

As regards the final word of a sentence, there is of course, a tendency for easy words to be more predictable than difficult words. We decided not to try to eliminate this natural language correlation in the materials, for reasons of ecological validity (see Petrinovich, 1979) and because it serves to work against the predictions of the Posner-Snyder theory. This is especially true when we contrast the Posner-Snyder theory with other recent theoretical statements. Fischler and Bloom (1979) conducted a series of experiments on sentence context effects and argued that facilitation will only be found for highly predictable words. The arguments in their paper would lead one to predict that in our Experiment 2 facilitation would be found only for the easy words and performance on the difficult words would be interference dominant (i.e., a large inhibition and minimal facilitation would be observed).

The verification model (Becker, 1979, 1980; Becker & Killion, 1977) was developed and tested in the context of single-word priming studies; however, it does appear that predictions about the pattern of sentence context effects that should appear in Experiment 2 can be generated from the theory. According to the most recent version of the model (Becker, 1980) context effects result from either of two mutually exclusive strategies that the subject may adopt. The pattern of facilitation and inhibition that is observed differs markedly depending on which strategy is chosen. Performance is characterized by benefit dominance (considerable facilitation and minimal inhibition) when the prediction strategy is chosen. This strategy also results in predictability effects (more predictable stimuli showing greater facilitation) becoming apparent in the data. In contrast, the expectancy strategy results in interference dominance and no predictability effects. (See Becker, 1980, for a fuller discussion of these two strategies and the conditions under which they are presumed to occur.)

Thus, in Experiment 2, where easy- and difficult-word trials were mixed and the easy words were more predictable than the difficult words, the verification model made the following predictions. If the prediction strategy is adopted, the easy words should show more facilitation than the difficult words and neither set should display much inhibition. If the expectancy strategy is adopted, both word sets should display large and nearly equivalent inhibition effects and neither should show much facilitation. Of course, a given subject might change strategies from trial to trial. However, the most important point relevant to Experiment 2 is that according to the verification model, no possible mixture of strategies can result in the difficult words showing more inhibition or facilitation than the easy words (because the subject cannot anticipate whether an easy or a difficult word will occur and thus change strategy accordingly). However, these are precisely the predictions made by the Pos-

ner-Snyder theory. That is, in contrast to the predictions derived from the Fischler and Bloom (1979) paper and from the verification model, the Posner-Snyder theory predicts greater inhibition and facilitation effects for the difficult words.

Finally, in order to push the Posner-Snyder theory to its predictive limits, we included one more variable in Experiment 2. Subjects were given practice in the rapid naming of one half of the target words (equal numbers of easy and difficult words) before participating in the experiment. Practiced words should be recognized faster and context effects should be attenuated with such words. However, we anticipated that it might be difficult to induce in a single session a practice effect large enough to result in differential contextual effects.

Method

Subjects. Subjects were 48 undergraduate psychology students recruited through a subject pool at James Madison University.

Stimuli and apparatus. A total of 192 sentences were constructed so that their last two words were the word "the" and a noun that was predictable from the preceding context (e.g., "The skier was buried in the snow"). The 192 sentences were organized into 96 pairs. The two sentences that constituted 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. 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. 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 same as that in Experiment 1. The complete set of stimuli is presented in the Appendix.

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. However, for all experimental trials, sentence context offset was simultaneous with target word onset. Target word onset and timing were controlled as in Experiment 1. The onset of the target word was simultaneous with the experimenter's button press.

Procedure. Subjects were individually tested in a session that lasted approximately 50 min. First, they were asked to practice reading two different 18-word lists of target words. One half of the words on each list were easy target words, and the other half were difficult target words. Practice consisted of the subjects reading both lists five times as rapidly as possible. After the practice in rapid word naming, the subjects completed the main part of the experiment. Subjects were told to look into the tachistoscope and read aloud the sentence contexts that appeared. They were instructed to read the target word as rapidly as possible when it appeared. In addition, the subjects were told that only the reading of the target word was timed, so they were free to read the contexts at a comfortable pace. Target words were read under congruous-, incongruous-, and neutral-context conditions. One half of the targets were easy words, and the other half were difficult words. In addition, one half of each type of target word had been practiced.

Each subject received a random ordering of 12 practice trials consisting of 1 trial given under each of the 12 conditions formed by the factorial combination of the context (congruous, incongruous, neutral context), word difficulty (easy, difficult), and practice (practice, no practice) variables. Following the practice trials, each subject received a random ordering of 72 experimental trials consisting of 6 trials given under each of the above 12 conditions. In the experimental trials, each subject saw a subset of 72 out of the total population of 192 possible target words. The assignment of words from the total population was counterbalanced across subjects so that each word was read equally often under each of the 6 conditions formed by the factorial combination of context condition and practice. 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 terminal words deleted from the original sentences were never seen by the subject.

Results and Discussion

Trials on which some type of experimental malfunction occurred were dropped from the

data analysis. Trials on which the subject articulated the wrong word or had a response time longer than 2 *SD* above the mean for that condition were scored as subject errors and were also dropped from the analysis.

The mean reaction times and mean percentages of subject errors are displayed in Table 2. All of the analyses that follow are based on the mean reaction times in each condition. An analysis of variance on the reaction times indicated that the effects of practice, $F(1, 47) = 49.0$, word difficulty $F(1, 47) = 230.5$, and context condition, $F(2, 94) = 45.1$, were all significant at the .001 level. Our doubts about our ability to induce a large enough practice effect in a single session were unfortunately confirmed. Although it was statistically significant, the main effect of the practice variable was only 30 msec, not nearly enough of a time difference to lead to differential context effects. Thus, the practice variable did not interact with context condition, $F(2, 94) = .93$, but did interact with word difficulty, $F(1, 47) = 12.37$, $ps < .005$. The difficult words displayed a larger practice effect. The interaction between word difficulty and context condition was statistically significant, $F(2, 94) = 5.63$, $p < .01$. The more difficult words displayed larger context effects despite the fact that they were less predictable.

As is clear from Table 2, all four experimental conditions displayed facilitation and failed to display inhibition effects. Planned comparisons indicated that the facilitation effect was statistically significant in all four conditions: $p < .01$ for the unpracticed–easy condition, $p < .025$ for the practiced–easy condition, $p < .001$ for the unpracticed–difficult condition, and $p < .001$ for the practiced–difficult condition. None of the inhibition effects approached statistical significance. The number of subjects showing a facilitation effect was 44 for the unpracticed–easy condition, 41 for the practiced–easy condition, 36 for the unpracticed–difficult condition, and 38 for the practiced–difficult condition. The number of subjects showing an inhibition effect was 19, 26, 20, and 19 across the four conditions.

Experiment 2 confirmed an important prediction made by the Posner-Snyder theory: Word difficulty interacted with context condition, and the direction of the interaction was such that larger context effects were observed in difficult word conditions. The confirmation of this prediction is particularly impressive given that the experimental design was biased against the Posner-Snyder theory because the difficult words were less predictable from the context. However, a glance at Table 2 will reveal that the greater contextual effects for the difficult words did not become apparent in precisely the manner predicted by the Posner-Snyder theory. Specifically, difficult words displayed larger facilitation effects than did easy words, but there was no difference between the two in the magnitude of the inhibition effect, since neither word condition displayed any inhibition. It was expected that the increase in the contextual effect for the difficult words would be particularly apparent when inhibition effects were considered. However, it

Table 2
Mean Reaction Times and Mean Percentages of Errors for the Context and Target Word Conditions

Practice conditon and word type	Context condition						Difference	
	Congruous		Neutral		Incongruous			
	RT	ME	RT	ME	RT	ME	Facilitation	Inhibition
Unpracticed–easy	507	.4	548	2.1	534	1.4	41	−14
Practiced–easy	494	.7	526	1.7	532	1.0	32	6
Unpracticed–difficult	610	4.9	687	6.6	671	3.1	77	−16
Practiced–difficult	566	1.7	635	3.1	623	1.7	69	−12

Note. RT = mean reaction time (in msec), ME = mean error (%).

will be argued below that the account of these results given by the Posner-Snyder theory, while not perfect, appears to be clearly superior to that of other recent theoretical statements.

The results of Fischler and Bloom's (1979) work would lead us to predict that little facilitation would be observed with the difficult words because of their low predictability. This prediction was not confirmed in Experiment 2. Before deriving predictions from the verification model, we first had to infer from the entire pattern of results which expectation strategy was predominant in the experiment. Fortunately, the predominant strategy was clear-cut. All four conditions displayed benefit dominance, indicating that the prediction strategy was being employed. Thus, the verification model predicts that the easy words should display a larger facilitation effect. This prediction was clearly disconfirmed. Given the failure of alternative conceptualizations, it would appear to be worthwhile to pursue further the question of whether the results of Experiment 2 are really incompatible with the Posner-Snyder theory.

The larger facilitation effects in the difficult-word conditions are clearly predicted by the Posner-Snyder theory. Since, as previously mentioned, the differential predictability of the two-word sets works against this prediction, its confirmation is even more impressive. The large facilitation effects occur because it takes longer to recognize the difficult words, leaving more time for the spreading-activation and conscious-attention mechanisms to operate. However, since no inhibition was observed in the difficult-word conditions, we are forced to assume that the larger facilitation effect was entirely due to the automatic-activation component. This is not a completely unfounded conclusion, because Fischler and Goodman (1978), using a single-word priming paradigm, demonstrated that relatively small differences in effective contextual interval were associated with significant changes in contextual effects that were entirely due to automatic spreading activation.

The other major result of Experiment 2 that must be explained is the lack of inhibition in the difficult-word conditions. This finding suggests that even though the difficult-word conditions were some 108 msec slower than the easy-word conditions, the former still did not allow enough time for the conscious-attention mechanism to become implicated in performance. Thus, the results could be summarized as indicating that manipulating the effective contextual interval by 108 msec in the range under consideration had a sizable effect on the automatic-activation expectancy mechanism but little effect on the conscious-attention mechanism. First of all, it should be emphasized that this conclusion is entirely consistent with Fischler and Goodman's (1978) work on the time course of spreading activation and our work (Stanovich & West, 1979) on the time course of inhibition caused by conscious attention (see Stanovich & West, 1979, Figure 1). Second, it should be noted that the effective contextual interval in even the unpracticed–difficult condition of Experiment 2 was in a range where, based on previous research, inhibition would not be expected. This was because Experiment 2 was conducted with a different apparatus with visual conditions that led to faster overall reaction times than those found in previous experiments. The slowest condition in Experiment 2 (the unpracticed–difficult-word condition) had reaction times approximately 100 msec faster than the RSI-150 normal condition of an earlier experiment (Stanovich & West, 1979, Experiment 2, where no inhibition was observed) and reaction times equal to those in Experiment 1 of the present paper (where no inhibition was also observed). Thus, the speed of recognition of even the unpracticed difficult words was in a range where inhibition would not be expected. Of course, this explanation can be tested by simultaneously manipulating word difficulty and the response–stimulus interval (RSI) between the reading of the last context word and the presentation of the target word. These two variables were orthogonally manipulated in Experiment 3.

Experiment 3

Method

Subjects. The subjects were 32 undergraduate psychology students recruited through a subject pool at Oakland University.

Stimuli and apparatus. The sentences employed in Experiment 2 were used as stimuli. The apparatus employed in Experiment 3 was the same as that used in Experiment 1.

Procedure. The procedure and design of the study were the same as in Experiment 2, except that the response–stimulus interval (RSI) was manipulated rather than practice. Thus, RSI was inserted into the design in place of the practice variable. The RSI variable (the time between the experimenter's button press and the onset of the target word) took on two values, 0 (as in Experiment 2) and 800. The number of experimental and practice trials was the same as in Experiment 2, as was all counterbalancing. It should be emphasized that 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 terminal words deleted from the original sentences were never seen by the subject.

Results and Discussion

Trials on which some type of experimental malfunction occurred were dropped from the data analysis. Trials on which the subject articulated the wrong word or had a response time longer than 2 *SD* above the mean for that condition were scored as subject errors and were also dropped from the analysis.

The mean reaction times and mean percentage of subject errors are displayed in Table 3. All of the analyses that follow are based on the mean reaction times in each condition. An analysis of variance on the reaction times indicated that the effects of word difficulty, $F(1, 31) = 118.9$, and context condition, $F(2, 62) = 25.6$, were both significant at the .001 level. The effect of RSI was not significant, $F(1, 31) = 2.50$. The crucial interactions between word difficulty and context condition, $F(2, 62) = 7.19$, $p < .005$, and between RSI and context condition, $F(2, 62) = 3.73$, $p < .05$, were both significant, as predicted. Context effects were larger in the difficult word conditions and in the long-RSI conditions. Neither the Word Difficulty × RSI interaction nor the triple interaction was significant.

Planned comparisons indicated that the facilitation effects in the difficult-0 condition and difficult-800 condition were statistically significant (ps $< .001$ and .005, respectively), while the 39-msec facilitation effect in the easy-0 condition approached significance ($p < .10$). The only inhibition effect to reach statistical significance was the 79-msec effect in the difficult-800 condition ($p < .001$). The number of subjects showing a facilitation effect was 22, 19, 24, and 20 for the easy-0, easy-800, difficult-0, and difficult-800 conditions, respectively. The number of subjects showing an inhibition effect was 16, 22, 17, and 21 across the four conditions.

Experiment 3 replicated the important finding of Experiment 2: Word difficulty interacted with context condition. Larger contextual effects were observed in difficult-word conditions even though the difficult words were less predictable. In addition, the RSI × Context Condition interaction replicated the data pattern observed in an earlier experiment (Stanovich & West, 1979, Experiment 2). More importantly, our explanation for the lack of inhibition in the difficult-word conditions of Experiment 2 of the present paper received support. There was no inhibition in the difficult-0 condition of Experiment 3, replicating the lack of inhibition in the comparable condition of Ex-

Table 3
Mean Reaction Times and Mean Percentages of Errors for the Context and Target Word Conditions

Word type and RSI	Context condition: Congruous RT	Congruous ME	Neutral RT	Neutral ME	Incongruous RT	Incongruous ME	Difference: Facilitation	Difference: Inhibition
Easy-0	746	.0	785	2.6	774	2.6	39	−11
Easy-800	731	.0	754	3.1	784	.5	23	30
Difficult-0	891	2.6	986	4.7	997	6.3	95	11
Difficult-800	864	2.1	930	4.7	1009	6.3	66	79

Note. RSI = response–stimulus interval, RT = mean reaction time (in msec), ME = mean error (%).

periment 2. However, when the RSI was lengthened, the difficult words displayed a highly significant inhibition effect. These results are all consistent with an explanation of context effects in terms of the Posner-Snyder theory. The only outcome of Experiment 3 that was not quite consistent with the theory was the lack of inhibition in the easy-800 condition. The 30-msec inhibition effect in that condition did not reach accepted levels of statistical significance ($p < .15$). It should also be noted that the decrease in facilitation in the two 800 RSI conditions was not entirely unexpected. Both Neely (1977), using a single-word priming paradigm, and Stanovich and West (1979), in a sentence context experiment, previously observed such a decrease. They also speculated that the decrease was due to the fact that the time course of context effects was such that facilitation caused by attentional control did not reach its maximum until after substantial decay of the automatic spreading activation.

General Discussion

The initial results of our developmental study of sentence effects (West & Stanovich, 1978) appeared to be parsimoniously explained by Posner and Snyder's (1975a, 1975b) two-process theory of expectancy. Further experiments that were designed to directly test the theory were supportive of its predictions (Stanovich & West, 1979). Experiments 1, 2, and 3 reported above were also designed to test the Posner-Snyder theory and to assess its boundary conditions. The results of these experiments were also largely supportive of the theory. While there were some discrepancies, the very least that can be said is that the Posner-Snyder theory provides a better account of the body of data than do other models. In particular, the pattern of results of Experiments 2 and 3 cannot be accounted for by any other current theory of contextual effects.

One other advantage of the Posner-Snyder theory is that it can account for the growing empirical evidence that less skilled readers display larger contextual effects than do more skilled readers (Biemiller, 1977–1978; Perfetti et al., 1979; Samuels, Begy, & Chen, 1975–1976; Schvaneveldt et al., 1977; West & Stanovich, 1978; Roth et al., Note 2), a finding that contradicts a prediction made by some popular global theories of the reading process (e.g., Goodman, 1970; Smith, 1971). The Posner-Snyder theory provides a specification of how compensatory processing (see Stanovich, 1980) guarantees this finding. When word recognition is slow, another, higher-level expectancy process (the conscious-attention mechanism) has time to operate and thus provides additional facilitation as a result of contextual information. Since poorer readers have slower word recognition times, it is likely that this additional source of facilitation is implicated in their performance. Also consistent with this account is the fact that semantic context has a greater effect on the recognition times of fluent readers when the target word is degraded (Becker & Killion, 1977; Forster, 1976; Massaro et al., 1978; Meyer et al., 1975; Sanford et al., 1977; Sperber, McCauley, Ragain, & Weil, 1979). Thus, it appears that as reading fluency develops, the facilitation of ongoing word recognition resulting from preceding sentence context decreases, and that at high levels of fluency the residual facilitation effect is almost entirely due to automatic spreading activation.

A few restrictions on the conclusions of the previous paragraphs should, however, be mentioned. The possibility and/or importance of facilitation resulting from spreading activation has been questioned on the ground that sentences rarely contain words that are directly associated (Forster, 1976; Mitchell, Note 3). Such criticisms seem to assume that spreading activation occurs within a highly simplified semantic memory network, such as the simple hierarchial structure described by Collins and Quillian (1969) for purposes of illustration. However, spreading activation resulting from the moderate and sometimes tangential relationships between the words in typical sentences would be much more likely if the structure of semantic memory were somewhat more complex. The extended Quillian model discussed by Collins and Loftus (1975) and the active structural networks described by Norman and Rumelhart (1975) are models of semantic memory where facilitation resulting from spreading

activation from the words within sentences would be likely to occur. Results from a study by Fischler (1977b) are consistent with this argument. He found that priming can occur for pairs of words that are not highly associated, as long as the words are semantically related. Thus, spreading activation appears to be extremely pervasive and is not simply limited to strongly associated words. Nevertheless, the point is well taken that it would be desirable to have a more precise specification of exactly how spreading activation operates to facilitate words within the same sentence. Finally, it should be noted that neither the experiments reported above nor most of the studies cited herein have investigated the effects of contextual material preceding the sentence containing the critical word. The theorizing in this paper should be restricted accordingly. It is possible that contextual information that precedes the sentence containing the critical word acts to facilitate recognition and that the effect may be attentional. Several studies that address this possibility are currently in progress.

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(*Appendix follows*)

Appendix

Table A1
Sentence Contexts and Target Words

Sentence context	Easy target	Difficult target
1. The accountant balanced the The politician appealed to the	1. books people	ledger constituency
2. The preacher spread the The cat drank from the	2. word bowl	gospel saucer
3. The movie was at the The meal was prepared by the	3. theater cook	cinema chef
4. The painter fell off the The election was won by the	4. ladder candidate	scaffold incumbent
5. The pianist played at the The man was convicted of the	5. concert crime	recital felony
6. The man put his leg in the We stayed until the	6. pants end	trousers finale
7. The coed belonged to the She walked down the	7. group street	sorority aisle
8. The insane patient lived in the The waiter handed them the	8. hospital check	asylum menu
9. The banker locked the The tennis player found the	9. safe ball	vault racquet
10. The boy was bitten by the The awards were presented after the	10. dog dinner	mosquito banquet
11. The prospector found the The couple made up after the	11. gold fight	uranium quarrel
12. The jewel thieves planned the They worshipped in the	12. robbery church	heist synagogue
13. The man paid the The bomb destroyed everything in the	13. bill area	cashier vicinity
14. The house was destroyed by the The team won the	14. fire game	tornado tournament
15. The train pulled into the The couple adopted the	15. station child	depot orphan
16. The hotel's guests liked the The city stored water in the	16. rooms tank	accommodations reservoir
17. The climber reached the The whale was injured by the	17. top ship	summit harpoon
18. The body was stolen from the The comb was on the	18. grave table	morgue bureau
19. The car came down the The homecoming was attended by the	19. road students	boulevard alumni
20. The game warden fined the The man made coffee in the	20. hunter pot	poacher percolator
21. The general revised the The skier lived in the	21. plans house	strategy chalet
22. The doctor gave the The artist painted the	22. shot picture	prescription mural
23. The fisherman exceeded the The politician attended the	23. limit meeting	quota convention

(*table continued*)

Table A1 (*continued*)

Sentence context	Easy target	Difficult target
24. The cold girl turned up the The anthropologist found the	24. heat bone	thermostat artifacts
25. The bodyguard drove the The skier was buried in the	25. car snow	limousine avalanche
26. The woman dialed the The bridge crossed the	26. number river	operator ravine
27. The interpreter knew the The baker smelled the	27. language bread	dialect aroma
28. The train went over the The sun was totally hidden by the	28. bridge clouds	trestle eclipse
29. She ordered the dress from the It is the brightest star in the	29. store sky	catalogue constellations
30. The cowboy fired the The soldiers flew in the	30. gun plane	pistol helicopter
31. The tree was uprooted in the The mortician examined the	31. flood body	hurricane cadaver
32. Water dripped from the The sick child saw the	32. tap doctor	faucet pediatrician
33. The cowboy roped the The farmer picked an apple from the	33. horse tree	mustang orchard
34. The man poured beer into the The crook was sent to the	34. glass jail	pitcher penitentiary
35. The patient swallowed the The carpenter drove in the	35. pill nail	medicine spike
36. The flood waters broke over the The plane was buffeted by the	36. dam wind	dike turbulence
37. Behind the wheel was the The hay was in the	37. driver barn	chauffeur loft
38. The housewife waxed the The ship was in the	38. floor water	linoleum harbor
39. The dentist filled the The girl skated across the	39. tooth ice	cavity rink
40. The lamp provided the The gardener dug with the	40. light shovel	illumination trowel
41. The wine was served from the Music blared from the	41. bottle speaker	decanter jukebox
42. The bartender served the The boy handed his date the	41. drinks flowers	cocktails corsage
43. The biologist examined The school allows no running in the	43. slide hall	specimen corridor
44. The country was ruled by the The radiation caused the	44. king illness	dictator mutation
45. The driver stepped on the The barber trimmed the	45. gas hair	accelerator mustache
46. The bride drank the The singers clapped their hands to the	46. punch beat	champagne rhythm
47. The speaker stood at the The witness confirmed the	47. front story	podium alibi
48. The antiseptic killed the The stars of the circus were the	48. germs clowns	bacteria acrobats

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