How much of sentence priming is word priming?

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Sentence primes were compared with two-word primes in three experiments that employed different conditions of context presentation. The two-word primes were created by deleting from the sentence primes function words assumed not to be semantically associated with the target words. Smaller priming effects were found in the two-word condition in all three experiments, and this trend was significant in two of the three experiments. Although a sizable proportion of the sentence priming effect seems to be due to word priming, factors specific to the sentence condition appear to be additional contributors to the effect.

In previous research reports (Stanovich, 1985; Stanovich, Nathan, West, & Vala-Rossi, 1985; Stanovich & West, 1983), we have argued for a model of lexical access in reading in which word recognition is largely modular. Specifically, in the case of the fluent adult reader, nondegraded materials, we have argued that lexical access is not guided by conscious contextual expectancies, but instead that any observed contextual effects are due to spreading activation within the lexicon. Similar models have been supported by several other investigators (de Groot, 1985; Forster, 1975, 1981; Gough, 1983; Henderson, 1982; Seidenberg, 1985a, 1985b; Seidenberg, Tanenhaus, Leiman, & Bienkowski, 1982). Our modular model of word recognition, augmenting by spreading activation in the lexicon, was derived mainly from experiments on sentence context effects (e.g., Stanovich & West, 1983; West & Stanovich, 1982). In this report we examine how much of the priming that is observed in that paradigm can be accounted for by priming from the context words in the sentence. We describe three experiments in which we compared the priming effects produced by sentence contexts (semantic associates and syntactic information) with those produced by only the main two context words of the sentence contexts (main semantic associate and syntactic information). The three experiments differed primarily in their methods of presenting the stimuli.

EXPERIMENT 1

Method

Subjects. The subjects were 8 undergraduate volunteers recruited from an undergraduate psychology subject pool.

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Stimuli and apparatus. The stimuli used in the sentence prime condition were those listed in Appendix A of Stanovich and West (1981). These stimuli were 192 sentences that had been constructed so that their last two words were "the" and a noun that was predictable from the preceding context. The 192 sentences were composed of 96 pairs. The 2 sentences that made up a pair were identical except for their terminal words (e.g., "the skier is buried in the snow" and "the skier is buried in the avalanche"). One of the target words in each 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 = 2.2). According to Ehrlich and Francis's (1967) data, the mean frequency of the easy words was 124.3, and the mean frequency of the difficult words was 7.3. The easy words were more predictable from the contexts (see Stanovich & West, 1983). The 96 contexts were organized into 48 pairs (e.g., "the skier is buried in the" was paired with "the body is buried in the"). Inseparable sentences were formed by interchanging the target words. The neutral sentence primes were the incomplete sentences "they said it was the.

The stimuli used in the two-word prime condition were identical to those used in the sentence prime condition except that the prime consisted of only the two main context words of the sentence context (e.g., "the skier is buried in the" was referred to as "skier buried"). Most of the words that were deleted from the sentence contexts in forming the two-word primes were function words that expressed primarily grammatical relationships (65% articles, 18% prepositions, 8% copula, 3% pronouns, and 6% other). Thus, the vast majority of cases, the two words retained were the only context words in the sentence. The neutral two-word prime consisted of the words "they said.

In the following 3 experiments, two-word primes were controlled by an Apple II microcomputer. A Mountain Hardware clock and a voice-activated relay were interfaced with the computer to enable the collection of the naming times. Target word-nerf were controlled by a button that the experimenter pressed immediately after the subject read the prime aloud. This button caused the target to be displayed and simultaneously started the milliseconds clock (see Stanovich & West, 1983) for a detailed discussion of procedural variations in sentence context experiments).

Procedure. The subjects were told to look at the CRT and to read aloud the primes that appeared. In addition, they were instructed to read the target word aloud as rapidly as possible when it appeared. Each subject was given 10 practice trials to familiarize him with the task. The experimental trials consisted of 1 trial given under each of the 12 conditions formed by the factorial manipulation of two factors: translucent, incongruous, neutral, and target difficulty (easy, difficult). Following the practice trials, each subject received an average of 72 experimental trials that consisted of 6 trials under each of the above 12 condi-

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The results of an item analysis mirrored those of the subject analysis in all critical aspects. There were significant main effects of difficulty [F(1,190) = 200.9, p < .001] and context [F(2,380) = 35.5, p < .001], but no prime (P < .1). Both the prime × context interaction [F(2,380) = 14.8, p < .001] and the difficulty × context interaction [F(2,380) = 6.2, p < .01] were significant. Neither the prime × difficulty interaction nor the prime × difficulty × context interaction was significant (F < 1). Both the subject and the item analyses indicated that the difficulty × context interaction of Experiment 1 replicated that observed in many previous experiments. More importantly, both the subject and item analyses confirmed the key trend in the data of Experiment 1: Sentences produced more priming than did the two-word contexts.

**EXPERIMENT 2**

In previous studies of sentence context effects (e.g., Stanovich & West, 1983), we compared alternative ways of presenting the stimuli. For example, the experimenter initiation procedure employed in Experiment 1 was compared with a fixed interval procedure in which the subject reads the contexts silently (see Fischer & Bloom, 1979). Experiment 2 was a fixed interval study that is directly comparable with Experiment 1.

**Method**

The subjects were 32 undergraduate volunteers recruited through an undergraduate psychology subject pool. The stimuli, apparatus, and procedures were the same as in Experiment 1, except that target-word onset was under the control of the computer rather than the experimenter. The target word appeared 2,400 msec (an estimate of the approximate time needed to read the sentence primes out loud) after the onset of the primes. The subjects were instructed to read the primes silently and then read the target words aloud when they appeared.

**Results**

The main reaction times and the mean percentages of subject errors for all experimental conditions are displayed in Table 2.

A 2 × 2 × 3 (prime × difficulty × context) analysis of variance conducted on the reaction times indicated that the main effects of difficulty [F(1,31) = 166.2, p < .001] and context [F(2,62) = 11.0, p < .001] were significant.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Mean Reaction Times (in msec) and Mean Percentages of Errors (%) for Experiment 1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Context</strong></td>
<td><strong>Mean</strong></td>
</tr>
<tr>
<td><strong>Congruent</strong></td>
<td><strong>Neutral</strong></td>
</tr>
<tr>
<td>Easy</td>
<td>462</td>
</tr>
<tr>
<td>Difficult</td>
<td>581</td>
</tr>
<tr>
<td><strong>Difficult</strong></td>
<td><strong>Easy</strong></td>
</tr>
<tr>
<td>449</td>
<td>0.8</td>
</tr>
<tr>
<td>Difficulty</td>
<td>604</td>
</tr>
</tbody>
</table>
The main effect of prime type was not significant [F(1,31) = 1.3]. The prime × context interaction [F(2,62) = 1.1], the difficulty × context interaction [F(2,62) = 1.6], the prime × difficulty interaction [F(1,31) < 1], and the prime × difficulty context interaction [F(2,62) < 1] all failed to reach significance. Although not significant, the directions of the effects in Experiment 2 were the same as in Experiment 1. The mean overall context effects for the easy and difficult arguables in the sentence prime condition (29 and 55 msec, respectively) tended to be larger than those in the two-word prime condition (10 and 43 msec, respectively). Planned comparisons indicated that three of the four facilitation effects were significant but that none of the inhibition effects reached significance.

The results of an item analysis mirrored those of the subject analysis in all critical aspects. There were significant main effects of difficulty [F(1,190) = 128.6, p < .001] and context [F(2,380) = 13.6, p < .001]. The results of Experiment 2 were thus equivocal. All of the relevant trends were in the same direction as those in Experiment 1, but neither the context × prime nor the context × difficulty interaction reached significance. Experiment 2 employed a smaller N than that of Experiment 1, and perhaps this reduction in power resulted in a failure to detect effects that were roughly the same size as those in Experiment 1.

**EXPERIMENT 3**

In Experiment 3 an attempt was made to replicate the results of Experiment 1 using another stimulus presentation procedure. This was a procedure in which the context words were displayed sequentially to allow more precise control over when each context word was being processed. Such procedures have been used by other investigators (e.g., Forster, 1981; Wright & Garrett, 1984), and we previously examined a variant of this method (West & Stanovich, 1986).

**Method**

The subjects were 80 undergraduate volunteers recruited through an undergraduate psychology subject pool. The stimuli, apparatus, and procedure were the same as in Experiment 1, except that the primes were presented sequentially from left to right across the CRT. A new prime word appeared every 400 msec, and each word stayed on the screen as others were added. A plus sign appeared on the screen before the onset of the first context word. The plus sign indicated the position on the screen where the first letter of the target would appear. When all the words of the context and the target were displayed, the target onset was 400 msec after the onset of the last word of the primes, the location that had been occupied by the plus sign was occupied by the first letter of the target. The subjects were instructed to read silently each word of the prime as it appeared and then read the target word aloud when it appeared. In Experiment 3, the subject's reaction time in milliseconds was displayed in the upper right corner of the display after each trial.

**Results**

The mean reaction times and the mean percentages of subject errors for all experimental conditions are displayed in Table 3. A 2 × 2 × 3 (prime × difficulty × context) analysis of variance on the reaction times indicated that the main effects of difficulty [F(1,79) = 289.8, p < .001], context [F(2,158) = 30.2, p < .001], and prime [F(3,75) =

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**Table 2**

<table>
<thead>
<tr>
<th>Word Type</th>
<th>Congruous Mean %E</th>
<th>Neutral Mean %E</th>
<th>Incongruous Mean %E</th>
<th>Facilitation</th>
<th>Inhibition</th>
<th>Overall Context Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easy</td>
<td>553 0.5</td>
<td>556 1.0</td>
<td>552 0.0</td>
<td>33 -4</td>
<td>29</td>
<td></td>
</tr>
<tr>
<td>Difficult</td>
<td>658 1.6</td>
<td>711 3.6</td>
<td>713 4.2</td>
<td>53 -5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 3**

<table>
<thead>
<tr>
<th>Word Type</th>
<th>Congruous Mean %E</th>
<th>Neutral Mean %E</th>
<th>Incongruous Mean %E</th>
<th>Facilitation</th>
<th>Inhibition</th>
<th>Overall Context Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easy</td>
<td>459 0.6</td>
<td>469 0.4</td>
<td>480 0.2</td>
<td>9 12 -21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difficult</td>
<td>541 0.8</td>
<td>591 2.9</td>
<td>597 1.7</td>
<td>50 6 -56</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Two-Word Condition**

| Easy      | 487 0.6           | 497 0.6         | 491 0.2            | 10 -6 4      |
| Difficult | 574 2.5           | 585 3.1         | 616 1.5            | 11 7 -42     |
32.2, p < .001) were significant. Reaction times were faster for the easy targets, for the congruent conditions, and for the sentence primes. The prime × context interaction [F(2, 158) = 10.6, p < .001], the prime × difficulty × context interaction [F(2, 158) = 5.2, p < .01] were the only significant. Only the inhibition effect for the difficult targets in the two-word prime condition reached significance (p < .001).

The results of an arcsin analysis mirrored those of the subject analysis in all critical aspects. There were significant main effects of difficulty [F(1, 79) = 147.6, p < .001], context [F(2, 380) = 27.7, p < .001], and prime [F(1,190) = 17.3, p < .001]. Both the difficulty × context interaction [F(2, 380) = 9.5, p < .001] and the prime × difficulty × context interaction [F(2, 380) = 5.7, p < .01] were significant. The prime × context interaction approached significance [F(2, 380) = 2.7, p = .07], and the prime × difficulty interaction was not significant.

GENERAL DISCUSSION

The results of the three experiments indicate that a large proportion of the context effect observed from sentence primes can be attributed to priming arising from the subject context words of the sentence. Nevertheless, there was a consistent tendency for priming to be larger in the sentence condition than in the two-word condition. The effect is not large, and it was not significant in Experiment 2, but it is probably real. The trend was consistent among the three very different methods of auditory presentation methods that also consistently contained the prime (of large context effects for more difficult target words). Note that the design of the experiments was based in the direction of finding equal effects for the two context conditions. This was because the ordering of the words in the two-word condition was maintained from the sentence condition, allowing the possibility that subjects covertly "filled in" the missing function words.

In short, not all of sentence priming tones to be due to word priming. Further investigations need to explore the mechanisms responsible for the differential context effects observed in these experiments. Certainly many such potential mechanisms have been identified in previous studies of configural effects (Atchley & Franks, 1985; Efan & Harwood, 1973) and potential effects in continuity used priming tasks, including naming (Banks & Chumbley, 1984, 1990; de Groot, 1985; Selbinger, Waters, Sanders, & Lauter, 1984; West & Stanovich, 1982).

REFERENCES


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