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Word Context During Initial Exposure Influences Degree of Priming in Word Fragment Completion

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Priming in word fragment completion is revealed by the increased probability of correctly completing a fragment like "_ll_p_e" when the word "ellipse" was seen recently. Three experiments investigated the effects on priming of manipulating the context in which the words were seen. Three principal results emerged. Experiments 1 and 2 demonstrated that there was much more priming for words studied in a to-be-learned list than read in meaningful passages. In these same two experiments, low-frequency words were subject to more priming than were higher frequency words, regardless of context. Experiment 3 revealed more priming for words when they did not fit sensibly into connected discourse than when they did. The results suggest that context plays a critical role in priming: As a word moves from being contextually bound in meaningful discourse to being isolated in a list, its probability of priming increases.

The distinction between aware and unaware access to memory has become the subject of increased research attention in the 1980s, fostering interest in a growing set of new memory tests. This article focuses on one of these new tests, the word fragment completion test. Here, a person is given parts of words—for example, _O_O_UT, _A_RI_T, and _LL_P_E—and asked to complete each with the first suitable word that comes to mind. When Warrington and Weiskrantz (1970, 1974) first used a similar test, they found that people were more likely to complete a fragment when they had seen the corresponding word recently than when they had not seen it. This relative advantage for previously experienced words is called *priming*.

What is particularly intriguing from the perspective of understanding memory is that priming can occur apparently without awareness. Even when no mention is made of the recently studied words during the person's instructions for fragment completion, and when there is no reason to expect the subject to try intentionally to retrieve those words, priming is evident. Most striking of all is the finding that amnesic patients show quite normal priming despite great difficulty in recalling or recognizing the same words (e.g., Graf & Schacter, 1985).

Much of the work on fragment completion has centered on the contrast between two classes of memory test, direct and indirect. As Johnson and Hasher (1987, p. 641) present this distinction, "*Direct* memory tasks (free recall, cued recall, recognition) require conscious expressions of remembering; *indirect* memory tasks (e.g., perceptual identification, homophone spelling, word completion, skill learning) do not." Frequently, the indirect test of choice has been fragment completion (e.g., Graf & Schacter, 1985, 1987; MacLeod, 1989; Roediger & Blaxton, 1987b; Schacter & Graf, 1986; Tulving, Schacter, & Stark, 1982). It is now well documented that performance on the two classes of tests can be quite different, sometimes even qualitatively different. Recently, Richardson-Klavehn and Bjork (1988) have provided a comprehensive review of the relevant research.

With the increasing interest in indirect memory tests, one goal should certainly be to understand these tests better. Toward this end, the present study investigates fragment completion only, as Roediger and Blaxton (1987a) have done in their study of modality effects and the role of surface features. However, the present work focuses on a different variable—the impact of context during the initial experience on later priming. A brief overview of four related studies will help to demonstrate why such a study would potentially be worthwhile.

Consider first Jacoby's (1983) work. He used perceptual identification as his indirect memory test, requesting the subject to identify a briefly presented, masked target word on each trial. Jacoby and Dallas (1981) had already demonstrated priming in this task, in that previously seen words typically were identified with higher probability than were new words. Jacoby showed that individual words originally presented without context (e.g., XXX–COLD) produced greater priming in perceptual identification than did words originally presented with context (e.g., hot–COLD). The difference in priming was quite marked.

Blaxton (in press) obtained a result very similar to Jacoby's by using fragment completion as the indirect memory measure. Like Jacoby, she contrasted context during original presentation (hawk–EAGLE) with no context during original presentation (XXX–EAGLE) and found considerably more priming in the no-context condition. Clearly, there is some generality

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to the phenomenon: Context affects the likelihood of recovering an item on a later indirect test.

Graf and Schacter (1985, 1987; Schacter & Graf, 1986) observed a gradient of priming on a word-stem completion task. Their subjects studied unrelated word pairs (e.g., window–REASON) and later were confronted with same-context test items (window–REA———) or different-context test items (officer–REA———). Relative to unprimed items, different-context items showed reliable priming, but same-context items showed even more priming.

Perhaps most relevant to the present study is an experiment reported by Oliphant (1983) investigating repetition priming in the lexical decision task. Scarborough, Gerard, and Cortese (1979) had shown that deciding whether a letter string was or was not a word was speeded for words seen prior to the lexical decision task. In Oliphant's study, the control group was not exposed to any of the target words prior to lexical decision, whereas the repetition group studied all of the target words in a list. Comparison of these two groups was expected to replicate the finding of Scarborough et al. The clever twist was the addition of a third group that saw all of the target words before lexical decision, but the words were inserted into a preexperimental questionnaire and into the instructions.

As expected, the first two groups replicated the results of Scarborough et al.; however, the new third group showed no evidence of priming. Oliphant interpreted these results as indicating that awareness of repetition is necessary for repetition priming to occur, contrary to the claim of Scarborough et al. (1979). One could, however, interpret the results in a way that is more consistent with what Jacoby (1983) and Blaxton (in press) argue. That is, words experienced in context during initial exposure are less likely to produce priming than are words not in context, at least if that context is absent at the time of test. Reading words in connected discourse may provide such a context (cf. Auble & Franks, 1983).

The present experiments were designed to bring together these ideas. The initial question was whether words read in connected discourse would show any priming in fragment completion. Oliphant's lexical decision finding represent the only report of no priming for recently experienced words: Would fragment completion also display this result? The second question concerned the degree to which there would be differential priming for words studied in lists versus read in text: How influential is the reading context? The third question concerned how individual words are processed in text: If attention is somehow directed to particular words in text, would these words later show increased priming? These questions formed the basis for the present study.

Experiment 1

Experiment 1 borrowed from Oliphant's (1983) idea, which in turn borrowed the logic of an earlier study by Tulving (1966) having to do with contextual effects of repetition on rate of free-recall learning. The basic idea was to have subjects read brief connected texts, expecting a comprehension test and unaware of the critical fragment completion test. Within each text, a phrase would be isolated by not fitting semantically, and subjects were to find and cross out these phrases. The task was made to appear plausible by telling subjects that they were assisting in the development of a reading test.

On the basis of Oliphant's (1983) finding, one might expect no priming for words read in the sensible portions of the passages. However, it was not clear whether this extreme result could be expected to replicate. First, it is the only instance of a complete absence of priming for previously read words. Second, switching the task from lexical decision to fragment completion could produce a different pattern. So the first question was whether there would be any priming for the sensible words. The second question concerned whether calling attention to specific words in text—words that did not fit into the meaning of that text—would lead to (more) priming for those particular words. The latter set of words should be less bound to the passage context and therefore more likely to produce priming.

Method

Materials. The materials were derived from the Minnesota Speed of Reading Test (Eurich, 1964), ordinarily used to provide a quick measure of reading speed. Of the 38 passages that comprise the test, 28 were selected for inclusion in the experiment. These were chosen (a) to be similar in length to each other, (b) to provide unique candidate words to serve as fragments, and (c) to avoid cross-passage repetitions of the words that would later appear as fragments. The 28 passages are shown in Appendix A.

From the sensible part of each passage, two potential target words were selected, and two different fragments were created for each of them. Norms on these fragments were collected in the following way. Two test sheets were created, each with a different fragment of every word. Each sheet was administered to approximately 40 people in a class who were asked to complete as many fragments as they could in roughly 15 min. On the basis of these normative data, one word was selected to be the target for the sensible part of each passage so that the probability of completing its fragment was approximately 20%–30%.

As is evident from Appendix A, each passage also contained a phrase that did not fit with the sense of the passage. As in the original test, readers were to cross out this phrase when they located it. For present purposes, the to-be-crossed-out phrase was modified in every case by substituting one of the words in the Appendix of Tulving et al. (1982) for part of the phrase. Thus, the word *kerosene* replaced *Niagara Falls* in Passage 20, but the passage was otherwise unchanged. Every effort was made to substitute a word that fit as well as the original word(s). The reasons for making this change were (a) to ensure single-word targets and (b) to have a set of targets which were known to have completion rates (when unstudied) in the range of 20%–30%. Thus, the two sets of target words should have had roughly equivalent base rates, facilitating comparisons. All 56 of the words that appeared as fragments on the test are shown in Appendix B.

From the final set of 28 passages, 14 were selected for inclusion on Form 1A; the other 14 appeared on Form 1B. Assignment of passages to form was done largely at random, although conceptually similar passages were put on different forms. Three further pairs of forms were prepared in the same way, resulting in four corresponding pairs of forms in all. A roughly equal number of subjects (approximately 10) read each form.

Every subject saw a fragment test sheet containing 56 word fragments—28 from the form that subject had read (14 from sensible parts and 14 that were crossed out) and 28 from the other form of the pair (14 from sensible parts and 14 that would have been crossed

out). All fragments were in lower case, corresponding to how they appeared in the passages. Two different orderings of the test fragments were used—one the reverse of the other—with roughly half of the subjects who read each form getting each ordering. In this way, both reading forms and fragment sheets were counterbalanced over subgroups of subjects.

Procedure. Subjects were told that they were participating in a study of reading speed. Each subject was given either the A or the B version of one of the four forms and was allowed 7 min to read the 14 passages and to cross out the phrase that did not fit in each. An example was shown before reading started, and subjects were told that a test measuring general comprehension for the passages would follow. Subjects were discouraged from memorizing because, they were told, it was counterproductive and would slow them down. An announcement was made when half their time had passed.

After reading the passages, subjects were asked to provide baseline data for "another experiment." They were given the additional justification that this would provide a period of distraction prior to the comprehension test. The fragment completion instructions (including three examples) took about 2 min to deliver. At this point, the fragment completion task was administered, with subjects given 7 min to complete as many fragments as they could. Again, a half-time warning was given. No mention was made of the relation between the passages and the fragments. The experiment ended after the fragment test, and subjects were debriefed.

Subjects. The participants were 83 people who volunteered to take part during a visit to the Ontario Science Centre. The data of 7 participants were not included because they failed to cross out the inappropriate phrase in at least 7 of the 14 passages. Thus, the reported data are based on a sample of 76 people. Subjects participated in groups of from 4 to 14.

Results and Discussion

All 76 subjects had sufficient time to read the 14 passages, as evidenced by their attempts to cross out inappropriate phrases even in the last passage. The phrases were scored as correctly crossed out if the line went through the critical word that appeared on the fragment completion test. On average, subjects correctly crossed out 12.51 (89%) of the 14 critical phrases. Fragment completion performance for both sensible and to-be-crossed-out words was examined only for those passages in which the inappropriate phrase was correctly crossed out.

The principal analysis was a 2 × 2 repeated measures analysis of variance, with the factors being (a) whether or not the word had been seen during the reading phrase and (b) whether the word came from the sensible part of the passage or was to be crossed out. This analysis was conducted on individual subject proportions of fragments correctly completed in each of the four conditions. Both of the main effects and the interaction were significant: for seen versus not seen, $F(1, 75) = 23.55$, $MS_e = 0.029$, $p < .001$; for sensible versus crossed out, $F(1, 75) = 37.48$, $MS_e = 0.017$, $p < .001$; and for their interaction, $F(1, 75) = 9.94$, $MS_e = 0.021$, $p < .01$.

The first row of Table 1 presents the mean proportions of fragments correctly completed for each of the four conditions. The two baseline conditions are on the left; the two primed conditions are on the right. Note that two baselines are necessary because the sets of items appearing in the sensible and crossed-out conditions were distinct. The items in the sensible condition benefited very little from actually being presented: The priming of 4% was nonsignificant. However, for the items in the crossed-out condition, occurrence in the passages led to a significant 14% priming.[1]

These results appear to confirm and extend the findings that Oliphant (1983) reported for repetition priming in lexical decision. First, there was no significant advantage in fragment completion for words read in meaningful passages prior to the test. This is consistent with Oliphant's claim. Second, when singled out, a recently read word did evidence priming. This extends Oliphant's findings and suggests a role for attention and context in priming. However, before accepting these conclusions, some additional matters must be considered.

One advantage of the present Experiment 1 is that comparison is between words that appeared in the same passages, which was not the case in Oliphant's study. However, there is also a disadvantage here: The sensible and crossed-out conditions used independent sets of words. Although comparison within sets is appropriate, comparison between sets is more problematic. Perhaps the words of the crossed-out set (from Tulving et al., 1982) are more conducive to being primed than are the words of the sensible set. Experiment 1 cannot address this criticism. For this reason, Experiment 2 sought to explore priming for these two sets of items under more traditional list-learning conditions.

Experiment 2

One obvious difference between the two sets of items in Experiment 1 was that the crossed-out words had considerably lower mean frequency than did the sensible words. To confirm this, an examination of item frequency was conducted by

Table 1
Proportions of Fragments Correctly Completed as a Function of Whether the Relevant Words Were Read in Sensible Text, Crossed Out, or not Read at All

	Words not read		Words read	
Experiment	Sensible	Crossed out	Sensible	Crossed out
Experiment 1	.16	.20	.20	.34
Experiment 2	.14	.18	.40	.53
Experiment 3	.19[a]		.25	.31

[a] There is only one value for words not read in Experiment 3 because only a single set of critical words was used in all three conditions.

[1] As an undergraduate research project, Sandra Britton replicated this experiment. She gave subjects as long as necessary to read the passages, although they were told they were being timed. At test, subjects had 20 min (rather than 7 min) to complete as many fragments as they could. All other procedural details were the same as in Experiment 1. Britton did not separate the two baseline conditions, so there are only three condition means—not read (.26), sensible (.29), and crossed out (.48). A one-way analysis of variance showed a significant effect of condition, $F(2, 54) = 15.55$, $MS_e = 0.024$, $p < .001$. The nonsignificant 3% priming for the sensible condition contrasted with the significant 22% priming for the crossed-out condition, demonstrating the reliability of the results of Experiment 1.

using the Francis and Kučera (1982) corpus of slightly over one million words. The mean frequency of the sensible set was 82.43 occurrences per million, with all 28 words appearing in the norms. On the other hand, only 17 of the 28 words in the crossed-out condition appeared in the norms, and their mean frequency was only 15.18 per million. Clearly, the crossed-out set was made up of lower frequency words than was the sensible set. It is possible, then, that the sensible words did not show priming after being read because of a baseline problem stemming from their much higher frequency. But it is also possible that the sensible words would not cause priming under any condition. Experiment 2 was designed partly to evaluate these possibilities.[2]

The other purpose of Experiment 2 was to obtain further information on the role of context in priming. On the basis of Oliphant's (1983) results and those of Experiment 1, it would seem that presenting words in text limits their likelihood of showing priming on a subsequent indirect memory test. Individually studied words generally seem to have produced larger, more robust priming effects in the literature. Thus, the second goal of Experiment 2 was to contrast priming for the same set of words in a list learning as opposed to a reading situation.

Method

Materials. The 28 passages of Experiment 1 each provided a formerly sensible and a formerly crossed-out target word (see Appendix B). The words were typed in lower case (in the same type font as on the fragment sheet) and mounted as 35-mm slides. Six additional common words—*book, guitar, snake, fork, ladder,* and *envelope*—were selected for use as serial position buffers during study. As in Experiment 1, two orderings of the 56-fragment test sheets were used with half of the subjects tested on each order. The buffer items were not included on the fragment test sheets.

Procedure. Subjects were told that they should learn the list of words for a later recall test. Each of the 34 list words was presented for 5 s under control of a Kodak Ektagraphic slide projector with onboard timer. The list was made up of a 3-word primacy buffer, the 28 critical words, and a 3-word recency buffer. The 28 critical words were presented in the same order as they had appeared in the A and B versions of the four forms for the subgroups of subjects in Experiment 1, with a least 7 subjects per order. Thus, the critical words alternated between formerly sensible and formerly crossed-out words. Counterbalancing ensured that every word appeared roughly equally often in both the studied and unstudied conditions. After studying the list, the subjects were given the same justification for the fragment test, and the test was administered under precisely the same conditions as in Experiment 1.

Subjects. The participants were 64 student volunteers from introductory psychology classes at the Scarborough Campus of the University of Toronto. They received a 2-point bonus toward their course grade for participation. Subgroups ranged in size from 6–10 people.

Results and Discussion

As in Experiment 1, the principal analysis was a 2 × 2 repeated measures analysis of variance, with the factors being (a) whether or not the word had appeared during the study phase and (b) whether the word had been in the sensible portion or in the crossed-out portion of the passages in Experiment 1. This analysis was conducted on proportions of fragments correctly completed in each of the four conditions. There was a significant main effect of whether a word had been studied, $F(1, 63) = 149.86$, $MS_e = 0.038$, $p < .001$; a significant main effect of type (frequency) of word, $F(1, 63) = 58.46$, $MS_e = 0.008$, $p < .001$; and a significant interaction, $F(1, 63) = 6.11$, $MS_e = 0.023$, $p < .05$.

The second row of Table 1 displays the mean proportions of fragments completed in each condition. The two main effects confirm a large amount of priming overall and a reliable difference in completion probability for the two sets of items. With respect to overall priming, studied words (.46) were completed about 30% more often than were unstudied words (.16). As for item differences, the completion rate for the lower frequency words that were crossed out in Experiment 1 (.36) was 9% greater than that for the higher frequency words that were sensible in Experiment 1 (.27). Finally, the significant interaction demonstrated that there was 9% more priming for the crossed-out set (difference of .35) than for the sensible set (difference of .26).

Consider first the possibility that the differential priming in Experiment 1 was a consequence of item differences. Experiment 2 demonstrated that the higher frequency words of the sensible condition are indeed capable of displaying priming, which is reassuring. However, the difference in priming for the two item sets in Experiment 2 (9%) was virtually identical to the difference in Experiment 1 (10%). This is consistent with the hypothesis that the Tulving et al. (1982) lower frequency items generally benefit more from prior exposure than do higher frequency words. Analogous results have been reported for recognition tests (Gorman, 1961; Schwartz & Rouse, 1961; Shepard, 1967) and for perceptual identification (Jacoby & Dallas, 1981).

With this in mind, then, it is reasonable to argue that the nonsignificant priming for the sensible condition in Experiment 1 was essentially a baseline problem. The lower overall priming that occurs for words in text as opposed to isolated words was insufficient to influence the sensible words much at all in the previous experiment. This temporarily undermines any conclusion about the impact of reading context

[2] Gordon Hayman and Endel Tulving suggested to me that item difficulty, rather than item frequency, might be the crucial difference between the sets. Item analyses of their data had demonstrated that items which were easier to solve when unprimed also generally showed greater priming than did harder to solve items. If the items of the crossed-out set were easier to solve on average when unprimed, then Hayman and Tulving would expect the greater priming observed for crossed out items.

Item analyses were carried out on all three experiments reported here, but the relevance of this difficulty hypothesis is primarily to Experiments 1 and 2, where the sensible and crossed-out conditions used different items. The key analyses involved median splits within or across item sets, with the splits based on unprimed solution probability. Easier items generally (but not always) showed somewhat greater priming, yet there was no evidence that the crossed-out and sensible sets were made up of differentially difficult items. This is one reason that the frequency account is preferred here.

differences in Experiment 1. Experiment 3 will resolve this problem.

Consider now the effect of context on priming. Only two features differed between Experiments 1 and 2. First, they used different subject samples, but the very similar baselines in Table 1 allay concerns about sampling effects and allow direct comparison. Second, words were either read in text (Experiment 1) or studied in a list (Experiment 2). Comparing the two experiments suggests that this manipulation made a difference. This can be evaluated by treating the two experiments as two levels of a between-subjects variable and then conducting a three-way analysis of variance. Consistent with prior analyses, there were significant main effects for whether or not a word was presented, $F(1, 138) = 162.88$, $MS_e = 0.033$, and for whether the word was from the sensible or the crossed-out condition, $F(1, 138) = 85.43$, $MS_e = 0.013$, and these two variables interacted significantly, $F(1, 138) = 15.62$, $MS_e = 0.022$.

More relevant for present concerns were the remaining two significant effects: the main effect of experiment, $F(1, 138) = 38.05$, $MS_e = 0.030$, and the interaction of experiment with whether or not a word was presented, $F(1, 138) = 44.24$. What these results confirm is that overall performance was better in Experiment 2 (.32) than in Experiment 1 (.22) but that this superiority derived solely from previously presented (primed) items. The unprimed conditions of Experiments 1 and 2 were virtually identical (.18 and .16, respectively), but the primed condition displayed considerably better performance in Experiment 2 (.46) than in Experiment 1 (.27). Thus, words seen in isolation in a list produced more priming than did the same words when read in connected discourse.

In summary, then, two conclusions can now be offered. First, lower frequency words of the sort used by Tulving et al. (1982) tend to produce more priming from a prior occurrence than do higher frequency words of the sort introduced in the present experiments. Although not a large effect—about 10%—it was consistent over two experiments. Second, words studied in isolation produce much more priming than do those same words when read in text. This contextual effect is quite large, estimated here as a difference of around 20%. Both of these are interesting findings and will be considered further in the General Discussion. However, they do not speak to the initial concern of the present research—to determine whether the way in which a word is processed in text affects the extent of priming later observed for that word. This is the major purpose of Experiment 3.

Experiment 3

Experiment 3 was designed to permit all comparisons of interest within the same experiment by using the same set of items counterbalanced over subjects. This represents the best possible control for item effects. The formerly crossed-out item set, from Tulving et al. (1982), was not used at all in the critical conditions. Instead, only the formerly sensible words occurred in the passages, sometimes in a position where they made sense and sometimes in a position where they did not make sense. Furthermore, the not-read (unprimed) condition also used the same items, counterbalanced over subjects. Two questions were addressed. First, contrary to the apparent result of Experiment 1, would there be priming for words just read in the meaningful flow of the text? And second, would the crossed-out condition still show more priming than the sensible condition?

Method

Materials. With some minor rewording, the same 28 passages used in Experiment 1 were used here. However, the words from Tulving et al. (1982) that had been crossed out in Experiment 1 were not used at all in Experiment 3. Instead, the sensible, crossed-out, and not-read conditions all used exactly the same set of words counterbalanced over subjects. These were the 28 words that had been in the sensible condition in Experiment 1.

A computer program performed this counterbalancing as follows. A file was created containing all 28 passages in Appendix A. Every passage had one target word in its proper (sensible) place and an asterisk where the crossed out target word had appeared in Experiment 1. A parallel file of the 28 target words was prepared in such a way that it duplicated passage order. The program randomly selected 7 of the 28 passages to be read by each subject. The 7 "sensible" words were already in place in these passages. The program then randomly selected 7 other target words from the 21 passages not already selected. One of these 7 words was then substituted for the asterisk in each of the 7 passages, constituting the 7 "crossed out" words. The subject would not read the remaining 14 target words in the list; thus they constituted the "not read" condition.

For each subject, the computer prepared a unique sheet of 7 passages, as described above. All 7 passages appeared on a single sheet, with each passage single-spaced and a blank line between passages. Nothing visibly separated the target words from the other words in the passages.

The fragment test consisted of 42 word fragments. These were prepared as 35-mm slides, with letters in lower case and dashes to mark the missing letters. The complete fragment set consisted of the 28 critical items plus 14 drawn from the Tulving et al. (1982) set. For any given subject, the critical items fell into three groups: 7 in the sensible condition, 7 in the crossed-out condition, and 14 in the not-read condition. The 14 extra items from Tulving et al. (1982) were the bottom 7 in each of columns 1 and 2 in Appendix B.

Procedure. In the first phase of the experiment, the subjects were given the same reading test scenario and instructions as used in Experiment 1. To increase the credibility of the cover story, they were told that they were being timed and that they would have a maximum of 7 min to complete the reading and crossing out. As each minute passed, the experimenter would update the elapsed time on the blackboard. When finished reading, a subject was to write the elapsed number of minutes on the back of the passage sheet and then to wait quietly while the others finished. To discourage racing, the subjects were told that everyone had different paragraphs which varied in difficulty. They were also informed that because the aim was to study "natural" reading, they should not reread or try to memorize any passages. An example passage was given and any questions were answered; then the reading began.

In the second phase, subjects were given the same two-part cover story for the fragment completion test as used in Experiment 1. The test proceeded as follows. On the screen at the front of the room, a series of 42 word-fragment slides was displayed one at a time for 15 s each. Subjects were to try to generate an English word that had the right number of letters in the right places. Three examples were given. They were told to work only on the current fragment, going on to the next one as soon as the projector advanced. To prevent discouragement, they were told that the task was difficult and that they

should not expect to solve more than a third to a half of the fragments.

Subjects made their responses on lined sheets numbered 1 through 42. During test, the experimenter identified aloud every tenth slide to help subjects stay on track. There were two different random orders of fragment test slides, each used for roughly half of the subjects. After the test, the subjects were debriefed and asked not to discuss the experiment with other students who might also take part later.

Subjects. The subjects were 62 students from the same pool as in Experiment 2. They participated in subgroups ranging from 12 to 18 members. The data from a further 13 participants who did not cross out at least 4 of the 7 irrelevant words were discarded. Most of these were not native English speakers.

Results and Discussion

The average number of correctly crossed out target words was 5.73 (or 82%). For each subject, the two targets from any passage were included in scoring only if the word intended to be crossed out was in fact crossed out. This ensured that the target words had been processed as requested. Note that no subject every crossed out a word that was actually in the sensible condition. Each subject contributed a score out of 7 (or less) for the sensible condition and for the crossed-out condition. For the not-read condition, every subject contributed a score out of 14. The data for the 14 filler words from Tulving et al. (1982) were not analyzed.

The data of primary interest are those from the sensible, crossed-out, and not-read conditions. Note that because of the complete counterbalancing, there is only one not-read condition in this experiment. Mean proportions of correctly completed fragments in each condition are displayed in the bottom row of Table 1. Analysis of variance confirmed a significant overall difference among these conditions, $F(2, 122) = 10.33$, $MS_e = 0.020$, $p < .001$. Planned comparisons demonstrated that there was priming for both the sensible and crossed-out conditions. Taken together, these two conditions differed significantly from the not-read condition, $F(1, 122) = 16.74$, $p < .001$. Furthermore, there was differential priming, with the crossed-out condition showing reliably more priming than the sensible condition, $F(1, 122) = 5.58$, $p < .025$.

Because the observations in all conditions were based on the same set of counterbalanced items, direct comparison of the means is possible. The results clearly showed differential priming. A word that fit sensibly into the flow of meaning was primed by its occurrence in text. A word that occurred in text but did not fit with the sense of the text showed even more priming. Thus, the answer to both of the questions asked at the outset of this experiment was yes.

General Discussion

The three experiments reported in this article provide three new findings relevant to priming in word fragment completion. First, Experiments 1 and 2 showed that for items with apparently equivalent unprimed completion probabilities, lower frequency words benefited more from prior presentation than did higher frequency words. This greater priming was observed whether the words were studied in isolation or read in connected discourse. Second, priming was considerably greater for words studied as part of a to-be-learned list than for words encountered while reading text. Interestingly, there was no evidence that context of prior presentation (list vs. passage) interacted with frequency of the to-be-completed word target. Finally, Experiment 3 demonstrated that the way in which a word is encountered in text influences priming. Words read in meaningful text did produce priming, but words singled out in text by virtue of not fitting in meaningfully produced additional priming.

The frequency effect was, admittedly, a serendipitous finding and ought to be replicated. In so doing, a more systematic manipulation of frequency should be undertaken, and other possibly confounding dimensions of the sets of words should be held constant (e.g., part of speech and word length). Nevertheless, the indications from Experiments 1 and 2 point to word frequency as a potent variable in priming: Lower frequency words benefited more from priming.

This finding generalizes the pattern in recognition (e.g., Gorman, 1961; Gregg, 1976; Schwartz & Rouse, 1961; Shepard, 1967) to parts of words in addition to entire words. Furthermore, this frequency effect in fragment completion is consistent with the priming pattern observed in perceptual identification by Jacoby and Dallas (1981; Experiments 3, 5, and 6) and in repetition priming in lexical decision by Scarborough et al. (1979). Because both of these measures, like fragment completion, are considered to be indirect measures of memory (e.g., Richardson-Klavehn & Bjork, 1988), there is evidence of a common pattern. Frequency appears to be another variable, along with directed forgetting (MacLeod, 1989) and others discussed by Richardson-Klavehn and Bjork (1988), that affect certain direct and indirect tests in the same qualitative fashion.

The other two major results grew directly from the initial question motivating this research. Does the context in which a word was recently encountered influence the extent of priming accruing to that word? Both results provide affirmative answers. It is tempting to suggest that there is a gradient of priming as a function of prior context: Priming for the same word fragment decreases as the word moves from an isolated item in a list to a word singled out of text to a word forming a meaningful part of text. Of course, this may be an overinterpretation of the data, but it is at least a useful summary statement of the results.

To my knowledge, there are only two discordant results in the literature. The first is that of Oliphant (1983), who found no priming for words that appeared in the instructions prior to the lexical decision test. Probably, Oliphant's use of high-frequency words worked against priming, as in the present Experiment 1. However, it may also be that the choice of lexical decision as the indirect test was at least partly the source of the different pattern. In two experiments following Oliphant's logic, Terry Sills (1986) at the University of Toronto attempted a conceptual replication of Oliphant's finding. It is worthwhile to examine the Sills study briefly at this point.

As a subsidiary manipulation in both experiments in his senior honors thesis, Sills included on the test a few words that subjects had read in the instructions. Following Oliphant's procedure subjects were not told of this manipulation.

Sills used word fragment completion, rather than lexical decision, as his indirect test. The results of the two experiments were quite consistent: Words embedded in the instructions produced significant priming relative to the same words when they had not been seen at all. In Experiment 1, the proportions of correctly completed words were .38 in the primed condition and .24 in the unprimed condition; in Experiment 2, the values were .35 and .25, respectively. Thus, the Oliphant result is not general over all types of indirect tests. Certainly fragment completion can demonstrate priming for words recently encountered in continuous text, consistent with the three experiments presented here.

The second result that appears to conflict with mine is reported by Levy and Kirsner (1989) in the immediately following article in this issue. In their first experiment, they found no priming on a perceptual identification test when words had appeared in meaningful text, but they found significant priming when these same words were part of a word list, a result analogous to Oliphant's finding in the lexical decision task. As with Oliphant, their use of relatively high-frequency target words may have minimized priming. Also, both Oliphant and Levy and Kirsner manipulated context between subjects, whereas context was a within-subjects variable in my studies. However, the most likely account of this discrepancy seems to be test differences. Perhaps fragment completion is a more sensitive index of priming in text than are lexical decision and perceptual identification. It would be interesting to exchange tests between the Levy and Kirsner study and mine to examine this possibility.

Returning to the present contextual pattern, there are at least two ways in which it can be explained. The first account is that of Jacoby (1983) and Roediger and associates (Roediger & Blaxton, 1987b; Roediger, Weldon, & Challis, in press), in terms of data-driven versus conceptually driven processing. Basically, as words move from no context (list) to a nonmeaningful context (crossed out) to a meaningful context (sensible), the degree of conceptual processing increases, and the degree of data-driven processing decreases. This processing view correctly predicts that priming on an indirect test will decrease as the meaningfulness of the context increases. This account has the advantage of having been successfully employed elsewhere already (cf. Richardson-Klavehn & Bjork, 1988; and Roediger et al., in press, for reviews).

An alternative account would emphasize not the type of processing but the type of representational information used. Specifically, the distinction between item-specific and relational information in memory (e.g., Humphreys, 1978; Hunt & Einstein, 1981) seems relevant. It may be that indirect tests are especially affected by changes in item-specific information, and direct tests by changes in relational information, as argued by MacLeod and Bassili (in press). Under this account, then, as the meaningfulness of the context increases, so do the connections (or relations) among words. Simultaneously, item-specific information is given less weight. Consequently, this view also predicts the observed pattern and is in keeping with other ideas about text versus word processing (e.g., Auble & Franks, 1983). For the present, it is not clear which is the better position. Both explanations are consistent with the present data and others already in the literature.

The main conclusion to be drawn from these experiments is that how a word is processed—in terms of the context in which it appeared—can have a significant impact upon how much priming that word will later display. This may occur because of different processes, different representations, or both. The present experiments implicate context as playing a role in priming, in concert with other findings in the literature (e.g., Blaxton, in press; Jacoby, 1983; Oliphant, 1983; Schacter & Graf, 1986). They also suggest further lines of research. For example, would the centrality of a word to a passage influence priming, as predicted by theories of text processing (cf. Kintsch, Kozminsky, Streby, McKoon, & Keenan, 1975)? Counterintuitively, a more central word might be expected to show less priming because it is more bound in a meaningful way to the context in which it occurs. Such possibilities point to the fact that we are just beginning to understand what affects the extent of priming on indirect tests of memory. Context seems to be one such factor.

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Appendix A

The 28 Passages From Experiments 1 and 3

The phrases to be crossed out are in italics; the two critical words in each passage are capitalized. The italicized critical words appeared as shown in Experiment 1 but were replaced with nonitalicized critical words from different passages in Experiment 3.

1. Jefferson was the most finished scholar of Revolutionary times, and he was always interested in education. He spent the later years of his life trying to improve the schools of Virginia *which occurred during an* ELLIPSE, and helping to establish the UNIVERSITY of Virginia.

2. During the past two decases the methods of teaching in our schools have changed rapidly and profoundly. The critics of our schools think that our newer methods give children too much FREEDOM, and especially that they substitute the use of the hand *which should be sprinkled with* CINAMMON for the exercise of the brain.

3. In ANCIENT Greece the first lessons taught were the use of the instrument and the simple chants of the religious service. As soon as the pupil knew how to play, the master taught him to render the works of the great lyric writers of Greece *who were reared in the* TWILIGHT ZONE.

4. Much of the Old Testament written in a Semitic dialect is POETRY to compare with the Homeric words, which are in the Indo-European dialects. It further contains an account of the Hebrews and their relations with other states, *an exact duplicate of a* PIMENTO, and a system of ritual.

5. The key to any analysis of aims in education is to be found in an analysis of the activities of life in which people should or do engage. The aim of secondary education, therefore, must be interpreted in terms of the activities in which individuals *with* INSOMNIA PARTICIPATE.

6. Switzerland with ten million acres of mountains has cultivated rather efficiently the three and five-tenths percent that seemed worth cultivating. She has been importing some food, but having little to EXCHANGE for food, excessive population increase *among insects and* DINOSAURS on the products of other soils was denied her.

7. It happened in the eighteenth century that there were several remarkably intelligent MONARCHS—Frederick II of Prussia, Catherine the Great of Russia, Charles III of Spain, Emperor Joseph II and his brother Leopold, *Grand Duke of the* UNIVERSE. These rulers read the works of reformers and planned many reforms for bettering existing conditions.

8. When commerce advanced, industry did not stand still. To satisfy the demands of a growing number of customers all over the world, production must be increased. But that could not be done without changes both in the method of MANUFACTURE *which depended on the* COCONUT *crop* and its organization.

9. Notwithstanding Spanish indifference and monastic opposition, the Filipinos have opened elementary schools in almost every village. They have also founded high schools and COLLEGES throughout the archipelago, and two large normal schools *for janitors and* POLLIWOGS, and five large schools for women in Manila.

10. It is generally held among HISTORIANS that the first appearance of our cultural ancestors upon the soil of Western Europe occurred about 2000 B.C. At that time a group of tribes, admitting kinship to common origin, came down out of the grassland of central Asia *by* TRICYCLE and overran the peninsula.

11. A simple and convenient starting point may be found in the STATEMENT that political science deals with government. The word

"government," used in its widest sense, rests on the fundamental idea of control and obedience; it implies authority *of the National YOGHURT Company*, and a submission to that authority.

12. The American democracy depends for its EXISTENCE and success on the social consciousness and social cooperation of its citizens. Unless the school can make a significant contribution to the development of social consciousness and social cooperation *among plants and PLANKTON*, it must fail in one of its most important purposes.

13. Until the world learns what it means to pull together with other people, we shall never have the realization of the real PATRIOT. And we will never learn to pull together as long as we are taught that one of us *who eats a CUPCAKE* is worth half a dozen others.

14. It is the specific purpose of this ARTICLE to attempt to estimate what America's fundamental ideas about international cooperation are likely to be, and to consider how far *under the direct IDEOLOGY of the woman's clubs* they are likely to be compatible with the views and necessities of Europe.

15. One of the most natural ways of thinking is that in which, as soon as one makes an ASSERTION, he recalls individual instances in which it has proved true; in other words, examples of the fact asserted. Therefore, this method of building up thought *by using BEESWAX* is common.

16. Prolonged studies of the origin of very gifted children in this country have been confined largely to cities. They have shown repeatedly that the great MAJORITY of these children originate in families where the father is a professional man, *a CHIMNEY sweep*, or an owner or executive in business.

17. Constant pressure is being put upon pupils to continue in school for full time after completing the elementary school curriculum. With a view to facilitating the TRANSITION from the elementary to the high school, the junior high school *which is adapted to the LADYBUG* is being widely established.

18. Rome's institutions as she developed them remained those of a city. It was difficult to apply them to the vast TERRITORY she attempted to govern with their aid. They were clumsy institutions which functioned irregularly and proved a system *for the construction of TOBOGGANS* that could not and did not last.

19. With the WIDESPREAD extension of good roads has come a very rapid growth of transportation by motor trucks and motor buses which usually pay only a small license fee *for the right to wear FLANNEL pajamas*, and which derive profit from the carrying of freight and passengers.

20. The English colonies of the Atlantic SEABOARD, occupied with their own problems of developing their agricultural resources, building up their commerce, defending their precious rights of self-government against king and proprietor, were slow to realize the serious meaning of the French power *generated by KEROSENE* which was gradually surrounding them.

21. Early types of vocational education were especially strong in the practical aspects of the subject and weak in the more ABSTRACT phases. The home, farm, and shop have always provided an abundance of practical tasks and examples whereby to teach boys and girls *who were fond of BROCCOLI* the simple vocational arts.

22. The older the school pupil becomes, the stronger is the force of those ECONOMIC and social influences which ultimately will remove him from the school. Up to the age of fourteen the public schools hold the pupils well aided by the compulsory attendance laws *under the guidance of the AARDVARK*.

23. The term "EXECUTIVE" is used to designate those officers of the government whose business it is to carry out the law of the land. In the narrower sense it often signifies merely the supreme head of the administration *who always serves as a SURGEON*, or the same person together with his chief subordinates.

24. The man who succeeds must think, and the man who thinks must get his thought clear in his own mind. To define his thought clearly to himself, he must put it accurately into words—LANGUAGE. To communicate accurately, he must learn what words, *which are found at the end of the RAINBOW*, mean.

25. Recent studies have shown that feeble-mindedness is one of the important causes of permanent delinquency. Goddard has shown that mental defect is hereditary in perhaps sixty-five to seventy-five percent of the cases. If his estimate is correct, feeble-mindedness *which results from GANGRENE* is largely an HEREDITARY factor.

26. The life of a dry cell BATTERY is not fixed but depends on the circuit in which it is used. Oftentimes dry cells which are merely standing on the shelf for a year without being used at all will dry up *because the RUTABAGA has not been watered* and become practically useless.

27. The life AMBITION of Emma Hart Willard was to organize a system of education for women which should possess the same permanency, uniformity and respectability as educational institutions for men, and yet should so differ as to be adapted *under the BEHAVIOR of Julius Caesar* to the needs of women.

28. During the unprecedented SCIENTIFIC development of the past half century, there have frequently arisen certain technical tendencies on the part of researchers which have caused many other persons to misunderstand the real nature of truth *which is found in BACHELORS and old maids*.

Appendix B

Critical Words for All Experiments

Crossed out in Experiment 1		Sensible in Experiment 1	
ellipse	cinnamon	university	freedom
twilight	pimento	ancient	poetry
insomnia	dinosaur	participate	exchange
universe	coconut	monarch	manufacture
polliwog	tricycle	college	historian
yoghurt	plankton	statement	existence
cupcake	ideology	patriot	article
beeswax	chimney	assertion	majority
ladybug	toboggan	transition	territory
flannel	kerosene	widespread	seaboard
broccoli	aardvark	abstract	economic
surgeon	rainbow	executive	language
gangrene	rutabaga	hereditary	battery
behavior	bachelor	ambition	scientific

Note. The two critical words from the same passage (in Experiment 1) appear in corresponding positions in columns 1 and 3 and 2 and 4. The underlined letters were the ones omitted in the fragments. The top 7 words in columns 1 and 2 were not used in Experiment 3.

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