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PRIMING OF WORD FRAGMENT AND WORD STEM COMPLETION

by

JANET M. GIBSON

A THESIS SUBMITTED
IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE

MASTER OF ARTS

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Priming of Word Fragment and Word Stem Completion

Janet M. Gibson

Abstract

Three experiments explored the extent to which word fragment completion and word stem completion could be "primed," or facilitated, by prior study of the words. In Experiment 1, the manner in which the words were studied beforehand had little effect on priming of either kind of completion, but delaying the test reduced the amount of priming. More importantly, priming of fragment completion decreased over the delay to a greater degree than priming of stem completion. In Experiment 2, this interaction was not replicated when both fragments and stems were constructed without controlling the number of possible completions and were placed in the same test. In a third experiment, the number of response alternatives did not affect priming of stem completion. It was concluded that differences in the amount of priming of fragment completion and stem completion cannot be easily explained by the number of response alternatives or by the task difficulty.

Acknowledgments

I thank Drs. David M. Lane and Randi C. Martin for serving on my committee, and Dr. Michael J. Watkins for directing my research. Also, I extend appreciation to Dr. Olga C. Watkins for making many helpful comments on earlier versions of this thesis.

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The ability to perceive an item is generally facilitated, or primed, by prior exposure to that item. Investigations of this phenomenon typically take the form of a study phase, wherein subjects are exposed to a set of items, and a test phase, wherein subjects perform a task in which they are required to identify both the previously studied items and some items not previously studied. Identification of the studied items is usually superior to that of the nonstudied items. In attempting to understand why this priming occurs, researchers have manipulated study and test variables while using a variety of tests to measure priming. One incidental consequence of this research has been the failure to compare frequently used tests within the same experiment. It is the purpose of this thesis to show that the interpretation of the effect of experimental manipulations on priming should not be generalized beyond the test used to measure it.

Examples of priming tests

Priming has been demonstrated with many kinds of tests. One frequently used test involves the brief presentation of words on a computer screen or tachistoscope; the subjects simply try to name each word as it is presented. This test has been given several names, including tachistoscopic recognition, perceptual recognition, and perceptual identification. The latter term will be used throughout this thesis. Winnick and Daniel (1970) were amongst the first to show priming of perceptual identification. In the study phase of their first experiment, subjects were given 30 seconds either to say or

write as many of the states of the union as they could. The average number of states produced was 23.6. Then, for each subject, the experimenter selected fivestates that were named in the study phase, five states that were not named, and five words that were not states, and presented these 15 words in a perceptual identification test. The exposure duration of the words was initially set at 0.01 seconds but was increased in 0.005 second increments until correct identification was made. The results showed that the subjects identified the states they had named in the study phase at shorter exposure times than states that were not named in the study phase, both of which were identified at shorter exposure times than words that were not states.

Two comments should be made about this study. The first is that no difference in identification performance was found between subjects who spoke the states in the study phase and subjects who wrote them. This suggests that priming of perceptual identification is independent of the sensory form of the initial or study presentation. The second concerns the fact that the subjects performed better on states they had not named than on the words that were not names of states. This facilitation is known as semantic priming; it results from prior exposure to the concept or meaning of the test item. In this case, thinking about the category "states of the union" helped identification of specific states. In this thesis, however, discussion will be limited to the facilitation resulting from the repetition of the item itself, which in the literature has sometimes been called direct priming, perceptual priming, or repetition

priming. It is not to be argued here that semantic priming is a different phenomenon from repetition priming, but that repetition priming is an area that has been studied in its own right, and this thesis maintains a specific focus on repetition priming.

The test item is typically presented in degraded form. For example, it may be presented extremely briefly (perhaps for only, say, 35 milliseconds). Or it may be presented in incomplete form. This may be done by presenting several letters dispersed throughout the word, by presenting the first several letters only, or by presenting pieces of each letter of the word. For example, Tulving, Schacter and Stark (1982) replaced several letters in a word with underscored blanks (e.g., "_ S S _ S S _ N"), and they constructed these word fragments so that only one word could complete each one (e.g., "ASSASSIN"). They found that when subjects were presented with a set of words beforehand, they were more likely to complete the fragments of those words than fragments of words that had not been presented. A different way to present an incomplete form of a word involves always presenting the first several letters of the word (e.g., "DEF____" for "DEFEND") and leaving the end of the word unspecified in terms of number of letters to add to complete it. This type of incomplete presentation has been used in a series of studies by Graf and his associates (e.g., Graf & Mandler, 1984; Graf, Mandler, & Haden, 1982; Graf & Schacter, 1986), who refer to the task as one of "word stem completion." Graf and associates chose word stems with at least 10 completions and found that

a stem is more likely to be completed with a previously studied word than with one of the other words. A similar finding of priming of word stem completion has been reported by Warrington and Weiskrantz (1974, 1978). A third way to present an incomplete form of a word might best be described as presenting a picture of a word that is missing parts of each letter. For example, Warrington and Weiskrantz (1968, 1970) constructed versions of the fragmented word, ranging from all of each letter visible (easiest to name) to most of each letter missing (hardest to name), and starting with the most difficult version, presented the versions in succession until the subjects could name the word. Warrington and Weiskrantz found that subjects could identify the word sooner if they had just previously been presented with the word. Thus the previous presentation primed word completion.

It should be noted that the word fragments used by Tulving et al. and the incomplete words used by Warrington and Weiskrantz (1968, 1970) had only one completion and that the word stems used by Warrrington and Weiskrantz (1974, 1978) and Graf and associates (e.g., Graf & Mandler, 1984; Graf, Mandler, & Haden, 1982; Graf & Schacter, 1985) had at least 10 completions. In all cases, prior study primed word completion. The difference in the number of completions available to a cue may, however, be relevant to the degree of priming of word fragment and word stem completions (cf. Graf & Mandler, 1984). A second point, which leads to a broader issue, is that Warrington and Weiskrantz (1968, 1970, 1974, 1978), and Graf and associates (Graf &

Schacter, 1985; Graf et al., 1982; Graf, Squire, & Mandler, 1984; Graf, Shimamura, & Squire, 1985) used subjects with severe memory impairments (amnesics). These subjects suffered from impaired memory for recent events, so that their recognition or recall of the words they had studied earlier was poor, and yet the prior exposure to those words still primed their performance on the word completion test.

The distinction between memory and priming

The studies by Warrington and Weiskrantz and others (e.g., Graf et al., 1982; Graf, Squire, & Mandler, 1984; Jacoby & Witherspoon, 1982; Schacter, 1985a; Woods & Piercy, 1974) demonstrate that priming occurs for words whose first presentations are not even remembered. In fact, tests that are used for measuring priming are distinguished from memory tests on this very point. Tests that measure priming do not ask subjects to think about whether items on the test have been encountered before. For instance, in the perceptual identification test subjects are instructed to name the briefly presented word, and in a word fragment test subjects are instructed to complete the fragment to make a meaningful word. No suggestion is made in the instructions that subjects should think back to a specific occasion in order to produce the words on the current test. These tests may be completed without remembering prior study lists. This, of course, is not what memory tests require; they explicitly ask subjects to remember a specific context or episode.

The distinction between memory tests and priming tests has led to a

certain confusion in terminology. Jacoby and Witherspoon (1982) referred to priming as "memory without awareness." In one experiment in their paper, they showed that amnesic subjects were influenced by the context in which homophones were presented at study even though they were not aware (i.e., did not remember) that the homophones had been presented earlier. In the study phase, the subjects were asked questions containing a homophone, such as "name a musical instrument that employs a *reed* " (p. 304). The priming test was a spelling test in which the subjects were asked to spell, in addition to other words, the homophones that were presented earlier. They found that subjects were more likely to spell each homophone as it should be spelled in the context of its prior presentation (e.g., "reed" rather than "read"). In a recognition test following the spelling test, the amnesic subjects failed to recognize that the homophones had been presented earlier even though their spelling of the homophones indicated an effect of the prior presentations. Since the amnesics' spelling was influenced by the words' earlier presentations and yet the subjects were unaware that these words had occurred earlier, Jacoby and Witherspoon called this behavior memory without awareness. Making a similar distinction, Graf and Mandler (1984) introduced the term "implicit memory" to refer to priming and "explicit memory" to refer to memory. These terms seem to be popular among contemporary researchers, and tests which measure priming are often called tests of implicit memory.

Graf and Mandler (1984) have provided empirical support for the

functional distinction between memory and priming. In one of their experiments, subjects studied a set of words in either a semantic processing condition (while making liking judgments) or a nonsemantic processing condition (while counting T-junctions in the words). This manipulation of the manner in which words are studied results in superior memory performance for words studied in the "deeper" or semantic processing condition (e.g., Craik & Tulving, 1975). Subjects were then given a stem completion test under two conditions. In the "memory" instruction group, they were asked to complete the stems with words from the study list (i.e., cued recall instructions). In the "priming" instruction group, they were asked to complete the stems with any words that came to mind that began with the stems. The results showed that processing condition had a large effect on stem completion when memory instructions were given (words in the semantic condition doing better than those in the nonsemantic condition) but not when priming instructions were given. Graf, Squire, and Mandler (1984) also included a group of amnesics using the same instructions manipulation. The amnesics given memory instructions performed poorly on the word stem test--that is, they did not write the word from the study list as a completion to the stem--but the amnesics given the priming instructions completed stems with studied words as often as normal memory subjects given the same priming instructions. Since performance on otherwise identical stem completion tests can be influenced by the instructions, the authors argued for a functional distinction between

memory and priming.

A problem with research on priming

Graf and his colleagues have gone beyond terminology and have developed a theory of priming and why it occurs. Their theory is basically an activation theory, where the representation of the word in semantic memory is activated when it is first encountered, and this activation helps bring the word to mind when part of it is represented on the subsequent test. To develop their theory, Graf and his colleagues have manipulated a variety of experimental variables (e.g., modality of study and test presentations, delay, and amount of elaborative processing at study). They have, however, consistently used word stem completion as the test for measuring priming, and therein lies a problem. What are the consequences of using only one type of test when there are several that can be used? Are these consequences similar to those that would arise if a researcher formed a memory theory using data from only a free recall test?

Other researchers have also relied on only one test to formulate theories of priming. Jacoby (1983a, 1983b, 1984; Jacoby & Dallas, 1981; Johnston, Dark, & Jacoby, 1985) has relied heavily on a perceptual identification test to develop his theory of priming as a perceptual enhancement. According to Jacoby, the perception of a word is enhanced by the initial presentation; thus briefly presented words are perceived more completely if they were previously studied. Similarly, Tulving, Schacter, and

Stark (1982) have raised theoretical issues based on a single test--that of word fragment completion. They studied the effect of delay on priming and on recognition memory and found that while recognition performance dropped over seven days, the facilitation in completing fragments of studied words was as great seven days after study as it was one hour after study. Tulving et al. posited that Tulving's conceptions of an episodic memory system and a semantic memory system could not accommodate this result, and they suggested that a third memory system is indicated, a suggestion Tulving (1983, 1984, 1985) has continued to make.

The point being made is not about the particulars of the theory each group of researchers is developing, but that the theories are based on studies that used only one particular test. The authors may acknowledge other work using a different test, by citing it in the Introduction or Discussion sections of their papers, and try to accommodate those findings with their own, but they develop their own questions by testing hypotheses with one and the same test.

It is reasonable to question whether the different tests of priming are equally sensitive to experimental manipulations. If it were not the case that these tests are equal in their ability to measure priming, then developing theories of priming based on one test, or citing support from research that also used that test invites a danger of generalizing beyond the experimental conditions. The consequences of the practice of dissociating the priming effect from the particular test used are not clear because little attention has been

paid to the role of the test in the interpretation of the results. In fact, it often appears that the choice of the particular priming test used in a study was arbitrary, which again suggests that the authors are assuming that priming tests do not differ importantly in their susceptibility to experimental manipulations. This assumption should not be taken for granted but should be investigated experimentally by having more than one priming test in a single experiment. An examination of most of the research on priming effects reported in the literature reveals that it is rare to find an experiment in which more than one test was used to measure priming, but three such studies were found, and these will be looked at in detail.

Review of studies that have used two priming tests

Warrington and Weiskrantz (1970) gave amnesic and control subjects both a word stem completion test and a word fragment completion test, along with recall and recognition tests, one minute after they had studied a list of words three times. Unfortunately, the two priming tests were collectively treated as the "method of partial information," and their results were not compared. In addition, Warrington and Weiskrantz used a procedure that clouds interpretation of the results. Namely, they presented a set of word fragments and word stems to their subjects at the beginning of the experiment, asking them to complete the fragments and stems with words. Fragments and stems that were completed with target words were not used in the experiment proper. The fragments and stems that were used in the test phase of the

experiment, therefore, had been seen before (but had not been completed), and, additionally, following their initial exposure the words that completed them were presented in the study phase. Completion of these fragments and stems in the test phase, then, is probably a function of both their prior presentation and the prior presentation of the words that completed them. Such a function may not be the same for both fragment and stem completion, making it difficult to compare the effect of prior presentation of the word on word completion.

Woods and Piercy (1974) also used two priming tests within an experiment. They attempted to replicate Warrington and Weiskrantz's (1970) finding that even when memory performance is impaired, priming of word stem completion and word fragment completion is not. Normal memory subjects were tested immediately and also one week later, when it was hoped that their memory for the studied words would mirror the memory performance of Warrington and Weiskrantz's amnesics. In addition to the two completion tests, Woods and Piercy gave a yes/no recognition memory test. The subjects studied 100 words and then received one of the three tests for half of the words immediately afterwards and received a test of the same type but with the remaining words one week later. The word stem test involved presenting subjects with the first two letters of a word and asking them to think of a five letter word beginning with those letters within 10 seconds. The word fragment test was composed of words degraded so that only parts of each letter were

visible, and the subjects were given 5 seconds to name each one. As did Warrington and Weiskrantz (1970), Woods and Piercy gave the subjects the stems and fragments of all words before the study phase of the experiment, but they noted that words from the study list that were given as answers on this initial test provided a baseline performance, that is, the number of times that the studied words were given by chance. Unlike Warrington and Weiskrantz, however, they did not discard the fragments and stems that were completed in this initial test but rather used them in the experiment proper. The results indicated that recognition declined over the one week interval (83.0% to 63.7%) as did completion of stems with studied words (43.0% to 28.4%). However, fragment completion did not decline over time (62.4% to 66.4%). Woods and Piercy reported a one-way analysis of variance on arcsine transformations of differences between scores for the immediate and one week tests that yielded a reliable difference for the two types of priming tests, $F(1,15) = 6.8$, $p < .05$. Thus, it would appear that delay had differential effects on the measurement of priming on the two tests.

Unfortunately there are several problems with this study. First, Woods and Piercy used cued recall instructions for the stem and fragment tasks. Second, the baselines on the completion tests differed: In the initial test, subjects completed 14.0% of the stems and 39.5% of the fragments with the target words. This means, in terms of being completed with the target word, that fragment completion was less difficult than stem completion. Lastly, the

effects of twice presenting the stem or fragment, and of possibly remembering the answers given on the first presentation, are confounded with test performance. Hence, the results are difficult to interpret.

The third study that used two tests to measure priming in the same experiment was conducted by Kirsner, Milech, and Standen (1983). They used a perceptual identification test and a lexical decision test. A lexical decision test involves the presentation of letter strings to which subjects decide as quickly as possible whether or not the strings are meaningful words. Accuracy on such a lexical decision test is usually high, so the dependent variable is the time taken to respond (latency). Words that have been studied before the test are responded to in less time than nonstudied words (the priming effect). Kirsner et al. were interested in modality effects. They reasoned that words would show facilitated lexical decisions regardless of whether the word had been heard or seen at study, because, in their view, this test relies on a semantic memory that is independent of modality. On the other hand, they also reasoned that facilitation in perceptual identification relies on the repetition of the visual features of the word, so they predicted that priming would occur with this test only when the words were studied visually. This latter prediction was supported by Jacoby and Dallas (1981, Exp. 6), who found that auditorily presented words did not prime perceptual identification but, as noted earlier, Winnick and Daniel (1970) found priming of perceptual identification to be independent of the modality of the study words. Kirsner et

al. also varied depth of processing of the words in the study phase. Subjects were asked to decide if the auditorily or visually presented word contained labial consonants (i.e., p, b, m), considered to be a "shallow" task, or if the word "involved an 'animate' or 'inanimate' concept" (Kirsner et al., 1983, p. 622), considered to be a "deep" task.

The results showed that priming occurred for both visually and auditorily presented words on both perceptual identification and lexical decision tests, and that for both tests, prior study of visually presented words facilitated performance more than did prior study of auditorily presented words. Depth of processing did not seem to have an effect on lexical decision, and its effect on the perceptual identification test was unclear because of an apparent word confound that showed up in a reliable difference for nonstudied words in the two depth of processing word groups, a difference that should not have been there. Also, Kirsner et al. did not compare the magnitude of priming on the two tests.

To summarize this section, three sets of researchers have used two priming tests within an experiment for the purpose of seeing whether a variable--prior study in the Warrington and Weiskrantz case, delay (or weakness of the memory trace) in the Woods and Piercy study, and depth of processing and modality in the Kirsner et al. study--would effect different measures of priming in the same way. The researchers did not seem interested in making comparisons of the magnitude of priming between tests,

although Woods and Piercy did at least report a t-test for the interaction of the two tests with delay. So we are left with only between-studies comparisons of the sensitivity of different priming tests to experimental manipulations.

Between studies comparisons of results obtained from different priming tests

A consistent finding in the literature is that priming is not greatly affected by elaborative or depth of processing manipulations--that is, it does not seem to matter whether in the study phase the word is simply read, its physical characteristics are emphasized, or its meaning is emphasized; priming occurs in each case with equal magnitude. Such findings have been reported in studies using a perceptual identification task (Clarke & Morton, 1983, Exp. 2; Jacoby & Dallas, 1981, Exp. 2), a word stem completion task (Graf & Mandler, 1984; Graf et al., 1982; Schacter, 1985b; Schacter & Graf, 1986), and a lexical decision task (Carroll & Kirsner, 1982; Kirsner et al., 1983).

Finding such a consistency across studies where different priming tests were used suggests that there may be no need for concern about the tests' sensitivities and could be used as a defense for arbitrarily choosing a test to research the phenomenon of priming. However, finding some inconsistency in results across studies, where a variable does not have the same effect on the measure of priming when different tests are used, would support the need for interpreting results specifically with respect to the test that was used.

One inconsistency reported in the priming literature concerns the effect of delay on priming. Jacoby (1983b; Jacoby & Dallas, 1981, Exp. 5) found

priming of perceptual identification to be just as great 24 hours after study as it was immediately after study. Similarly, Tulving et al. (1982) found a priming effect with a word fragment completion test to be just as great one week after study as it was one hour afterwards. Yet, other studies have reported a decline in priming over time. Jacoby (1983b, Exp. 4) found that priming declined on the perceptual identification test over a five day period. Light, Singh, and Capps (1986) found that there was a significant decrease in priming of fragment completion between immediate testing and testing one week later. Graf and Mandler (1984, Exp. 2) and Schacter and Graf (1986, Exp. 2 & 3) found a reliable decrease in priming of word stem completion over a 90 minute delay interval and a 24 hour delay, respectively. Graf, Squire, and Mandler (1984) found that, for both amnesic subjects and their controls, priming disappeared in 2 hours on the word stem completion task; that is, two hours after study, subjects completed a stem with the study word only as often as chance would predict.

What is the effect of delay on priming? It might indeed depend upon the type of test used. Graf and his colleagues speculated on why priming of word stem completion appears to decline rapidly over time while priming of word fragment completion shows a less steep decline. They wrote:

> "However, some examples of priming and perceptual recognition last a day or more, whereas the effects of word presentation on completion in the present study persisted for about 2 hours. Thus the time course of activation remains a puzzle: it may be determined by several factors such as word frequency, number of response alternatives, list

length, and number of repetitions." (Graf et al., 1984, p. 175).

> "The different life spans of the phenomena revealed by our results and by those of Tulving et al. seem to stem from a difference in the cues provided on the completion test. Tulving's *word fragment completion test* provides unique cues for assessing each studied word whereas the cues provided by the *word stem completion test* can be completed to form a number of different words, only one of which was presented to each subject. The availability of alternative completions for each of the cues on the completion test transforms it into a test of competition--the recently presented words will be given on the word stem completion test as long as they provide the most accessible responses to the cues....Finally, the word fragment completion test may also involve deliberate retrieval whereas the stem completion test reflects automatic accessibility (see Experiment 3). For example, on the stem completion test subjects give a response within a few seconds, while the word fragment test is demanding of time and effort. When no completion immediately comes to mind, subjects may attempt to retrieve words they have recently seen." (Graf & Mandler, 1984, p. 562).

These hypotheses for why the discrepancy exists between the effect of delay on priming of word stem completion and word fragment completion can be empirically tested, and the experiments to be reported here were attempts to do just that. The first experiment looked to see if we would find a difference between priming of word fragment completion and word stem completion. We gave the same subjects both types of completion tests immediately after study and after a delay interval. We also looked at the effect on priming of depth of processing at study: The words were rated for either the subjects' liking of their meaning or sound. Following the rating task, subjects completed one of two tests. They completed word stems (the initial 3 letters of words) or they completed word fragments (blanks replaced some of the letters in the word). These tests were taken immediately after the study task and approximately 20

minutes later.

To anticipate, priming of both types of completion was unaffected by the depth of processing manipulation. The amount of priming declined over the delay interval, and delay differentially affected priming on the two tests. This result was interpreted as supporting the need for further comparisons between tests that measure priming. A second experiment was an attempt to replicate the effect of delay on priming when the number of completions to the word fragments was free to vary. It turned out in this second experiment that delay did not differentially affect priming of word fragment and word stem completion. A third experiment looked at the effect of delay on priming when the number of words that could complete the stems was manipulated, and it was found that the effect did not differ on this variable. These experiments question the generalizability of priming detached from the test which manifests it and at the same time demonstrate that it is not clear what factors influence the degree of priming of word fragment and word stem completion.

Experiment 1

The primary purpose of Experiment 1 was to compare priming of word fragment completion and word stem completion. Tulving et al. (1982) and Light et al. (1986) reported facilitation of word fragment completion lasting one week, whereas Graf and Mandler (1984) and Graf et al. (1984) found facilitation of word stem completion to dwindle within a span of two hours. The discrepancy found for the effect of delay on priming of these two completion tests makes these tests ideal for comparing in the same experiment, and delay an ideal variable to manipulate.

The word fragment and word stem completion tests are ideal to compare not only because previous studies suggest priming may differ on the two, but also because the tests are so much alike. For example, on both tests subjects are given several letters and asked to produce a word that includes those letters in certain places within the word. Also, priming can be measured in the same way on both tests. For example, from a pool of words, called targets, the fragments and stems are constructed so that no other word in the pool completes them. Half of these targets are studied by a given subject, and all of the targets are tested. On the test, then, half of the items are cues of studied words and half are the cues of nonstudied words. Although other words not in the pool can complete the fragments or stems, correct completion is defined as completion of the cue with the target word. A priming effect is said to occur when the number of cue completions is greater for the studied

than the nonstudied words. With correct counterbalancing procedures, the effects of some cues having a greater likelihood of completion than others are eliminated, since cues appear equally often in the studied and the nonstudied conditions.

The present experiment made some changes to the methods used by the researchers who have employed these completion tests in the past. One change addressed the issue of cue difficulty. Graf and Mandler (1984) noted that a potential explanation for the discrepancy in the findings between the two tests is the fact that fragments are usually harder than stems to complete. Tulving et al. (1982) and Light et al. (1986) presented the fragments to subjects altogether in a list and gave the subjects time to go through the list, allowing them to return to more difficult fragments after the easy ones were completed. It is possible that subjects may have spent a lot of time on one fragment while spending little time on another. In contrast, with stems subjects move rapidly though the list, easily generating a completion to each stem, either because the stems were chosen to have many common completions or because it is easy to generate a word with initial letter cues. It is certainly possible that the words that come to mind readily do so by a different process than words that are produced by effort. These differences between the two cues are, however, not inherent to the tests, and it is possible to construct the two tests so that they are very similar with respect to ease of completion or amount of time spent on each cue. The latter factor can be controlled by the

experimenter simply fixing the time per cue, after which subjects must move on to the next cue whether they have completed the present one or not. With regards to the difficulty factor, fragment completion can be handled by either taking away more letters or adding more letters that are provided in the cue. It has also been implied by researchers that difficulty might also be handled by varying the number of response alternatives.

One way to assess the comparative difficulty of a set of fragments and stems is to look at baseline performance, that is, the number of cues that are completed with targets when they were not studied. When the baselines are nearly equal, we can assume that the likelihood of completion on the two tests is equal, and any difference found in the completion of cues of studied words is not due to likelihood of completion or, in other words, the difficulty of the cue being completed with the target.

Two pilot experiments were conducted prior to Experiment 1 to determine how completion performance for nonstudied words on the two tests could be made equivalent. It was found that by giving 6 seconds for each fragment that had only one completion, the number of fragment completions for nonstudied words was near those of stem completions.

Another change was made in the methodology of the word stem test relative to that reported in the literature. Graf and Mandler (1984) and Graf et al. (1984) instructed subjects to write the first, and only the first, word that they could think of beginning with each stem. In the present experiment, subjects

were instructed to write as many words as they could within 18 seconds. The response sheets and instructions were designed so that it would be known when the word was written--either first, second, third, or within 6 seconds, 12 seconds, or 18 seconds. This method allows for examination of when the target word was being produced. For example, when the target is not written first, is it still being produced more often when it is a studied word than when it is a nonstudied word? This procedure, then, provides information beyond what is already known about stem completion performance.

In addition to the delay manipulation, also varied in Experiment 1 was how the words at study were "processed." Each was rated for either how much subjects liked its sound (considered to be a shallow task) or how much they liked its meaning (considered to be a deep task). The effect of depth of processing variable has been studied by Graf and his colleagues with the word stem completion test. Generally, they have found that facilitation in stem completion occurs to the same degree for words processed nonelaboratively--that is, when the words' physical characteristics (e.g., number of voweis) were emphasized at study--as for words processed elaboratively--that is, when the words' meaning was emphasized (Graf & Mandler, 1984; Graf & Schacter, 1985; Graf et al., 1982; Schacter, 1985b). In light of this, in some of their research they did find a slight advantage, or a greater facilitation of stem completion, for elaboratively processed words (Graf & Schacter, 1985). But, there is no published data on the effect of depth of

processing on word fragment completion. Given this state of affairs, it was of interest how this variable would affect both stem and fragment completion.

Method

Materials. The materials consisted of 212 6-letter words. They were selected from a pool of words compiled from all 6-letter words in the Puzzle Solver's Handbook (1970), a word locator for solving crossword puzzles. Selection was based on the following criteria: a) two of the six letters in the word uniquely cued it so that no other word in the pool could complete the 2 letter fragment, and b) the initial three letters of each word were unique, so that none of the selected words began with the same three letters. All words that met the above criteria were then screened for selecting 212 (e.g., extremely low frequency words were rejected). Of these selected words, 192 were chosen as test items and 20 were used as primacy and recency items on the ratings lists but were not tested. A fragment was constructed by adding a third letter to the two already uniquely specifying cues; the choice was made by selecting the letter thought to provide most information about the fragment's identity. In this way every fragment contained three letters and three blanks. A list of the 192 words and the letters used in the fragments is given in Table A1.

Once the words were selected, 4"x11" booklets containing 4 rating lists, 4 stem tests, and 4 fragment tests were constructed. For each rating task, a column of 29 words and a column of corresponding lines for the ratings was typed 1 1/2 spaced on the sheet. Similarly, for the fragment test 24 fragments

were typed 1 1/2 spaced in a column, and a corresponding column of blank lines was typed to the right. The stem test had a different arrangement, with three blank lines assigned to each stem and the stem placed on the left margin of the first blank line. Each stem test occupied three pages.

An interval timer attached to a speaker was used to mark the time for each item on the pages.

Design. The 192 words were divided into 4 sets (A, B, C, and D) of 48 words each. Each set was then divided into 2 lists of 24 words each (e.g., A1 and A2). Each subject received 4 lists for the rating task, either A1, B1, C1, and D1 or A2, B2, C2, and D2. Five words that were not tested were assigned to each set to begin and end the two study lists for that set. To form the tests, 12 words from both study lists for each set were randomly selected to form 24-item tests: thus each test contained 12 studied and 12 nonstudied words. Two such tests were made for each set, one given immediately and one given after a delay. Each test list was composed of either all fragments or all stems, and, for any given set, the same form of test was given both immediately and after a delay test. Two fragment and 2 stem tests were given immediately and at delay. For immediate testing, each type of test was preceded once by a study list that was rated for liking of meaning and once by a study list that was rated for liking of sound. For the delay testing, the four tests were given in the same order as their immediate counterparts.

Counterbalancing across subjects allowed for every word to be either

studied or not studied, rated for subjects' liking of its meaning or its sound, tested immediately or after a delay, and tested in stem or fragment form. This required 16n subjects.

Subjects. Thirty-two Rice University undergraduates served as subjects.

Procedure. The subjects were tested individually or up to 4 at a time. The booklets were described as a set of word tasks, and subjects were told that instructions for each task would be given orally prior to the beginning of each new task. In addition to the booklets, subjects held a 8 1/2" x 11" blank sheet of paper folded lengthwise in half so as to cover the page in the booklet; subjects moved the cover sheet in accordance with the timer's beeps. Before opening the booklet, subjects were given a demonstration of the beep from the interval timer and how to move the sheet down after each beep.

The first task in all booklets was a rating task. Instructions were to read each word silently and to rate it on a scale of 1 to 3 for whether they liked the sound of the word or the meaning of the word, depending on condition (1 = disliked, 2 = neutral, and 3 = liked). Subjects wrote the number on the corresponding line across from the word. Three seconds were allowed for each rating, and 29 words were on the list. Subjects were told to proceed down the page, moving the blank sheet with the beep, and not to go back to any previous word in the list. When the last word was rated, subjects turned the page and covered it completely with the blank sheet and awaited

instructions for the next task. Subjects were also encouraged to use all numbers in the rating scale rather than sticking to one or two numbers. A page with 3 words was provided for practice before the initial rating task.

The next task was one of either fragment completion or stem completion. For the fragment test, subjects were told that the left column contained a fragment of a word, where letters in the word were replaced with underscored blanks, and their task was to complete the fragment to make a meaningful word and to write this word on the corresponding line on the right. No reference was made to the fact that previously rated words were included in the test. Subjects were told that if they thought of more than one word that completed the fragment they should write only the first one that came to mind. They were given 6 seconds per fragment. If they had not written a word when time was up, they were to leave the line blank and move the sheet down to uncover the next fragment. They were instructed not to go back and complete earlier fragments and also not to worry if they later realized that a word they had written did not actually complete a fragment, as the experimenter would simply ignore it. Subjects were also told that the task was not an easy one, and that they should not worry if they could not think of completions to many of the fragments. A practice page containing two fragments (p _ z z _ _ and i _ g _ _ t) was provided just prior to the subjects' first encounter with the fragment task in the booklet, to give them an idea of the time limit and also practice with the fragment completion task. The completions ("puzzle" and

"ingest") were listed at the bottom of the practice page, and when everyone indicated they understood the task, they turned the page to begin the task.

The instructions for the word stem completion task were to write down as many words as they could think of that began with the 3 letter string on the left margin. Three lines per stem were provided for this task, and subjects were given 6 seconds per line to write as many words as they could. When the 18 seconds were up, subjects were to finish the word they were writing and move the sheet down to uncover the next stem. Unlike the rating and fragment tasks, the word stem task covered 3 pages, and subjects were told to turn the page and continue on until reaching the end of the third page or until the experimenter told them to stop. It was pointed out that subjects should write the words in the order in which they came to mind, and to write left to right on each line so the experimenter would know which word was written first, second, and so on. It was also mentioned that some stems would bring to mind many words while others might not, and while subjects should write as many words as they could within the 18 sec limit, they should not go back to any earlier stems whenever they found themselves unable to think of words for a current stem. Practice was provided on two stems (aba__ and sin__) prior to the subjects' first encounter with the stem task in the booklet, and examples of possible completions were provided ("abacus, abate, abandon" and "sing, single, since, sine, sinister"). All questions were answered before turning the page to begin the task.

For all tasks, performance was monitored to ensure compliance with task instructions. The booklet contained 12 tasks in all--4 rating lists, 4 word stem tests, and 4 fragment tests. The first half of the booklet contained 4 rating list-test combinations, and the last half of the booklet contained 4 tests. The session lasted 50-55 minutes.

Results

The number of times the fragment or stem was completed with a target was totalled for all conditions for each subject. The stem data were scored according to each of four criteria: whether the target word was written (a) first, (b) within the first 6 seconds (line 1), (c) within the first 12 seconds (lines 1 or 2), or (d) within the allotted 18 seconds (at all). The data for each subject are given in Table A2. The means for fragment and stem completion are given in Table 1. As desired, baseline performances on the stem task surround the baselines for fragments. That is, the mean number of completions for nonstudied words for the stems is slightly above or slightly below the mean number of completions for nonstudied words for fragments, depending on which level of stem completion is used for comparison. Thus the two types of cues can be considered to be of similar difficulty.

Priming was measured as the difference in completion of studied and nonstudied words. These differences are shown in Table 1. They are all positive, indicating more completion for studied words, and they are greater for immediate testing than for delayed testing. Also, comparison of the differences

Table 1

Mean number of targets completing the fragment and stem cues.

	Fragments	Stems			
		First	Line 1	Lines 1 &2	At All
SOUND					
Immediate					
Studied	9.13	5.91	6.53	7.38	7.66
Nonstudied	3.66	3.06	3.41	4.00	4.41
Difference	5.47	2.84	3.13	3.38	3.25
Delay					
Studied	6.47	5.00	5.56	6.34	6.72
Nonstudied	3.94	3.22	3.47	4.25	4.56
Difference	2.53	1.78	2.09	2.09	2.16
Difference of Differences	2.94	1.06	1.03	1.28	1.09
MEANING					
Immediate					
Studied	8.78	5.38	6.16	7.09	7.44
Nonstudied	3.31	2.88	3.16	3.84	4.34
Difference	5.47	2.50	3.00	3.25	3.09
Delay					
Studied	6.19	5.16	5.75	6.66	6.84
Nonstudied	3.75	3.13	3.31	4.03	4.31
Difference	2.44	2.03	2.44	2.63	2.53
Difference of Differences	3.03	0.47	0.56	0.63	0.56

Note: There were 12 items in each condition.

on the rating tasks indicates that manipulating how the words were studied had little effect on fragment or stem completion.

Although the major interest of this experiment is in the comparison of the degree of priming of the two types of word completion tests, the results of the effect of study, rating task, and delay on each test separately will be discussed first, beginning with the fragment completion data.

An analysis of variance was carried out, and the summary table is presented in Table A3. Throughout this thesis, a .001 significance level is adopted unless otherwise noted. Fragments of studied words were completed with the target word more than were fragments of nonstudied words, $F(1, 31) = 276.81$. Whether subjects rated the words according to their sound or their meaning made little difference to the degree of priming, $F(1, 31) = .02$, $p > .10$, and so the following results will be described collapsed across rating tasks. The facilitation of completion for studied words was reliable at immediate testing, $F(1, 31) = 276.06$, as well as at delayed testing, $F(1, 31) = 71.00$. There was a significant Study x Time interaction, $F(1, 31) = 54.97$, due to a decline in priming over the interval.

The stem data were analyzed according to each of four criteria: the First criterion whereby a stem was scored correct only if written first; the Line 1 criterion whereby a stem was scored correct if the target was written on line 1, the Lines 1 and 2 criterion, whereby a stem was scored correct if the target was written on lines 1 or 2, and the At all criterion whereby a stem was scored

correct if the target was written at all. The ANOVA summary tables for each criteria are presented in Tables A4, A5, A6, and A7. Giving subjects more time or chances to write the target did not greatly increase the likelihood that the target would be written for either studied or nonstudied words. Consequently, the same pattern of results was obtained for each criterion.

Stems of studied words were completed more than stems of nonstudied words, F's (1, 31) = 129.90, 191.38, 172.97, and 192.74 for the first, line 1, lines 1 and 2, and at all criteria. Rating for meaning or for sound made little difference to the degree of priming, F's (1, 31) = .02, .25, 1.35, and .31, respectively ($p > .10$ in each case). The priming effect was reliable at immediate testing, F's (1, 31) = 104.44, 158.61, 163.99, and 161.59, and at delayed testing, F's (1, 31) = 66.49, 88.57, 75.87, and 84.85, respectively. The decline in priming over time was also reliable, F's (1, 31) = 6.92 ($p < .01$), 6.88 ($p = .01$), 6.09 ($p < .02$), and 7.38 ($p = .01$), respectively.

We now turn to the comparison of fragment completion with each criterion of stem completion, and the ANOVA summary tables are presented in Tables A8, A9, A10, and A11. The first question of interest is whether the facilitation resulting from study differed for the two types of completion cues. The Study x Cue interaction was reliable, F's (1,31) = 36.22, 22.06, 12.06, and 17.31, for comparing fragment completion with stem completion for the criteria of first, line 1, lines 1 & 2, and at all, respectively. This interaction did not involve rating task, F's (1, 31) = .00, .24, 1.01, and .26, $p > .10$, respectively.

The difference in priming of the two cues did interact with the time of testing, F's (1, 31) = 20.35, 18.82, 17.85, and 18.47, respectively. This interaction came about because of a difference in priming of the two cues on the immediate test but not on the delayed test: F's (1, 31) = 49.56, 36.12, 23.52, and 28.62 on the immediate test for the respective comparisons, and F's (1, 31) = 2.79, .37, .13, and .18, $p > .10$ for the delayed test for the respective comparisons.

The results of Experiment 1 indicate that depth of processing had no discernible effect on the degree of priming manifested in word fragment or word stem completion. Delay, on the other hand, did have an effect: The amount of facilitation observed on the immediate test was reliably greater than the amount observed on the delay test. This was true for both fragments and stems. More importantly, the decline in priming over time was greater for fragment completion than for stem completion. This interaction supports the hypothesis that these tests vary in their sensitivity to the effect of delay on priming.

Experiment 2

The results of Experiment 1 showed that delay affected priming of fragment completion to a greater degree than priming of stem completion. It has been suggested by Graf and Mandler (1984) and Graf et al. (1984) that one possible factor influencing the effect of delay on priming of these two completion tests is the number of possible completions to the cue. Graf and his colleagues selected stems that had at least ten words in a pocket dictionary that could complete them, whereas Tulving et al. (1982) and Light et al. (1986) used fragments that had only one possible completion. In Experiment 1 of this thesis, fragments with one completion with respect to a large pool of 6-letter words were likewise used. In the present experiment, the effect of delay on priming of fragment and stem completion was examined again, but this time the fragments and stems were constructed without regard to the number of response alternatives. Also, fragments and stems were randomly mixed and presented on the same test. Since both types of cues could have several completions, subjects were asked to write as many words as they could think of in each case. Because depth of processing did not have an effect on priming on either type of cue in Experiment 1, it was not manipulated here.

Method

Materials. The 219 words were randomly selected from the Toronto Word Pool--a set of 1060 common bisyllabic words--with the restrictions that,

of those selected, no two words could begin with the same three letters, and no two words could have identical fragments. Fragments were constructed by replacing the first letter and all vowels with blanks. Whether a "y" was replaced depended on the word. Stems were constructed by using the first three letters of a word. Of these selected words, 192 were selected as test items, 20 were used as primacy and recency items on the study lists and were not tested, and 7 were used as practice items for the rating and word completion tasks. A list of the 192 words used in the tests is given in Table A12.

Booklets contained the 4 rating lists, 4 immediate tests, and 4 delay tests. The rating lists consisted of 29 words typed in a double-spaced column with lines in an adjacent column for the ratings. Each test consisted of 2 pages of 12 cues each, with the cues written on the left margin followed by a line for their answers. Another line was provided underneath, so that each cue had 2 lines belonging to it.

As in Experiment 1, an interval timer attached to a speaker was used to limit time spent on each item.

Design. The 192 words were divided into 4 study sets of 48 words each. Twenty-four of each set of 48 composed one study list that a given subject saw, and all 48 words were tested, half immediately and half after a delay. In each test, subjects saw 12 words that they had studied and 12 that they had not. Within these groups of 12, 6 were cued with a stem and 6 with a

fragment. Five non-tested words were assigned to each study set, and 2 were placed in the beginning of a study list and 3 were placed at the end. Balancing across subjects, a given word was either studied or not studied, tested immediately or at delay, and was cued by a fragment or a stem. The design was a 2 Study (studied or nonstudied) x 2 Time (immediate test or delay test) x 2 Cue (stems or fragments) within factors design.

Subjects. Forty Rice University undergraduates participated as subjects for course credit.

Procedure. The subjects were tested individually or up to 6 at a time in a session that lasted about 55 minutes. The booklets were described to them as pencil and paper tasks. In addition to the booklets, subjects were given an 8 1/2" x 11" blank sheet of paper folded lengthwise which covered the page they were working on. It was demonstrated how they should move the blank sheet down in synchrony with each beep of the timer to uncover the next item in the booklet.

The first task was the rating task. Instructions were identical to those used in Experiment 1, except that subjects were only asked to rate for their liking of the meaning of each word.

The second task was the word completion task. The subjects were told that we were interested in how many words they could write to cues. Cues were of two types. The first type was a 3 letter cue, where they were to write words that began with those letters in the order they appeared. The verbal

example CAT was given, with CATALOG, CATATONIC, and CATASTROPHE given as examples of correct responses. The other cue was a fragment, described as a word with several letters replaced by blanks. The task was to write words that would fit the fragment. For both types of cues, they were given 2 lines to write the responses, and 6 seconds per line. When they heard the beep, they were to uncover the first cue, begin writing words appropriate for that cue, and remain on that line until the next beep, then move to the next line, and continue writing words appropriate to the cue. On the following beep, they would uncover the next cue and begin working on it. A practice page containing 2 stems (jou__ and dri__) and 2 fragments (_ w _ k _ and _ _ s c _ s s) was given. After subjects practiced, they uncovered a duplicate practice test that showed examples of correct responses ("joust, journal, journalism"; "drive, driven, drip, drift, drifter"; "awake"; "discuss, abscess"). No reference was made concerning any relationship between the words in the rating list and the cues.

As in Experiment 1, the sequence of tasks in the booklets was: rating list A, Test A1, rating list B, Test B1, rating list C, Test C1, rating list D, Test D1, Test A2, Test B2, Test C2, and Test D2.

Results

The individual subject data are given in Table A13. Statistics were calculated for the cues being completed with targets first and also at all within the 12 seconds, although there was not much of an increase in number of

targets written with the additional time. The means for the conditions are presented in Table 2, along with the differences between studied and nonstudied words for each condition. In general, cues were completed with targets more often when the word had been studied and tested immediately. The baselines for nonstudied targets are most similar for fragments produced first and stems produced at all, but analyses were carried out on the four possible combinations of cue interactions. An analysis of variance was also carried out separately for each cue, whether the target completed the cue first or at all within the 12 seconds. The summary tables for the four ANOVAs are

Table 2

Mean number of targets completing fragment and stem cues.

	Fragments		Stems	
	First	At All	First	At All
Immediate				
Studied	13.88	14.55	11.78	15.15
Nonstudied	7.98	8.40	5.58	8.48
Difference	5.90	6.15	6.20	6.68
Delay				
Studied	9.95	10.63	9.03	12.65
Nonstudied	7.53	8.05	6.35	9.40
Difference	2.43	2.58	2.68	3.25
Difference of Differences	3.48	3.58	3.53	3.43

Note: There were 24 items in each condition.

listed in Tables A14, A15, A16, and A17. Before discussing the results of comparing fragment completion with stem completion, the results for each type of cue taken separately will be discussed first.

Fragments of studied words were completed by the target reliably more than were fragments of nonstudied words, F's (1, 39) = 117.68 and 112.04, for the fragments completed first and at all, respectively. This was true both at immediate testing, F's (1, 39) = 77.79 and 77.26, and at delayed testing, F's (1,39) = 15.21 and 13.69, respectively, but the priming effect was reliably smaller after the delay, F's (1, 39) = 11.21 ($p < .002$) and 10.10 ($p < .003$), respectively.

Stems of studied words were completed more than were stems of nonstudied words, F's (1, 39) = 101.52 and 156.68, for stems completed first and at all, respectively. This was true at immediate testing, F's (1, 39) = 39.69 and 34.57, and at delayed testing, F's (1, 39) = 11.70 ($p < .002$) and 9.24 ($p < .004$), respectively. The decline in priming over time was significant for stems completed first with the target, F (1, 39) = 5.21, $p < .03$, but this decline was not reliable for stems completed at all, F (1,39)= 2.77, $p = .10$.

Of primary interest is the comparison of the effect of Study, Delay, and Study x Delay interaction between fragment and stem completion. Four comparisons were possible, depending on which level (first or at all) was used, and the four comparisons yielded basically the same results. The ANOVA summary tables are in Tables A18, A19, A20, and A21.

There was a main effect of Study, F's (1, 39) = 169.03, 205.73, 176.39, and 215.73, for the respective comparisons of fragments and stems completed first, fragments completed first and stems completed at all, fragments completed at all and stems completed first, and fragments and stems completed at all. The effect of Cue was also reliable, F's (1, 39) = 20.71, 21.91, 30.79, and 7.58, respectively. The Time x Study interaction was reliable, F's (1, 39) = 40.06, 22.21, 46.11, and 25.76, respectively. More importantly, there was no Cue x Study interaction, F's (1, 39) = .31 ($p > .10$), 3.14 ($p = .08$), .02 ($p > .10$), and 1.43 ($p > .10$), for the respective comparisons: The priming effect arising from prior study for the two cues did not differ at immediate testing, F's (1, 39) = .05, .24, .00, and .10, $p > .10$, or at delayed testing, F's (1, 39) = .04, .31, .01, .19, $p > .10$, for the respective comparisons. Unlike the reliable Type of Cue x Time x Study interaction found in Experiment 1, the decline in priming over time also did not differ between the two cues, F's (1, 39) = .00, .00, .00, and .00, $p > .10$, respectively.

The results from Experiment 2 indicate that priming of word fragment completion and word stem completion did not differ from each other, and, contrary to what was found in Experiment 1, the decline in priming over time did not differ for the two types of cues.

Since we did not control for the number of possible completions when constructing the fragments and stems, it is of interest to look at whether this factor contributed to cue completion with the target and to the priming effect.

To this end, a word analysis was conducted to determine the effect of the number of different completions produced to the fragment and stem cues for each word. Each word other than the target that was written to each cue was counted as a completion if it did indeed complete the cue correctly and was a word in a Webster's pocket dictionary. In this way, the number of completions available for each cue for a given word was empirically defined as the total number of different words written to complete the cue. For fragments and stems separately, three groups were formed based on the total number of different words other than the target that completed the cue. Each group contained roughly one-third of the 192 words. For fragments, the three groups were: 0 completions, 1 to 3 completions, and 4 to 17 completions. For stems, the three groups were: 0 to 7 completions, 8 to 13 completions, and 14 to 33 completions. Means were then calculated for each group for the number of subjects completing the cue with the target when it was of a studied word and when it was of a nonstudied word. Since 5 subjects contributed data to each combination of study and time of testing for each cue, the maximum value possible was 5 and the minimum was 0. The means of this word analysis are reported in Table 3.

It appears from the means from this word analysis that the difference between the completion of studied words and nonstudied words in general increased with the number of possible completions for both fragments and stems. In particular, the priming effect seemed to follow this trend more at

Table 3

Word Analysis Results: Mean number of subjects completing the cue with the target, grouped according to the number of completions.

	Fragments					
	First			At All		
	Group 1	Group 2	Group 3	Group 1	Group 2	Group 3
# completions:	(0)	(1 to 3)	(4 to 17)	(0)	(1 to 3)	(4 to 17)
# of words:	n = 71	n = 65	n = 56	n = 71	n = 65	n = 56
Immediate						
Studied	3.80	2.74	1.96	3.80	2.89	2.23
Nonstudied	2.73	1.46	0.57	2.73	1.55	0.73
Difference	1.07	1.28	1.39	1.07	1.34	1.50
Delay						
Studied	3.28	1.72	0.98	3.28	1.89	1.21
Nonstudied	2.75	1.20	0.46	2.75	1.40	0.64
Difference	0.54	0.52	0.52	0.54	0.49	0.57
Difference of Differences	0.54	0.75	0.88	0.54	0.85	0.93

	Stems					
	First			At All		
	Group 1	Group 2	Group 3	Group 1	Group 2	Group 3
# completions:	(0 to 7)	(8 to 13)	(14 to 33)	(0 to 7)	(8 to 13)	(14 to 33)
# of words:	n = 67	n = 66	n = 59	n = 67	n = 66	n = 59
Immediate						
Studied	3.31	2.45	1.44	3.87	3.27	2.15
Nonstudied	2.18	0.95	0.22	2.88	1.76	0.51
Difference	1.13	1.50	1.22	0.99	1.52	1.65
Delay						
Studied	3.07	1.59	0.86	3.78	2.58	1.41
Nonstudied	2.45	0.98	0.39	3.09	1.67	0.98
Difference	0.62	0.61	0.47	0.69	0.91	0.42
Difference of Differences	0.51	0.89	0.75	0.30	0.61	1.23

Note: There were 5 subjects contributing data in each condition.

immediate testing than at delayed testing, again for both types of cues. The discrepancy in the literature between priming of fragment completion and stem completion concerns the case where fragments with one completion are compared with stems with many completions. Two issues are involved: whether priming is as pronounced after a delay as it is at immediate testing, and whether the decline in priming is greater for one cue than for the other. Note that for fragment completion at delayed testing, the priming effect is roughly invariant across the three groups. For stem completion, however, the priming effect at delay is smallest for stems with many completions. The difference between Tulving et al.'s (1982) and Graf and Mandler's (1984) and Graf et al.'s (1984) findings, then, may not be due so much to the fact that Tulving et al. used unique fragments, but that Graf and his associates used stems with many completions. There is a problem, however, in relying on the results from this analysis as an explanation. While the number of possible completions seems to explain the difference found in the literature, it does not explain the difference found in Experiment 1, specifically with the decline in priming over time for the two cues. In Experiment 1, the decline in priming measured for fragments with one completion was greater than the decline in priming measured with stems with many completions. According to the word analysis means from Experiment 2, however, the decline in priming of fragment completion (0.54) is smaller than the decline for priming of stem completion with many completions (0.75 or 1.23). It seems unlikely, then, that

the number of possible completions that fragments or stems have can provide a ready explanation of the differences in priming of the two kinds of completions. It should be kept in mind that this word analysis was based on subjects' responses, and that the absolute number of possible completions may not correspond to the number of completions subjects were able to write within 12 seconds.

Experiment 3

One difference in methodology between Experiment 1 and 2 concerned the fragment completion task. In Experiment 1, the fragments were presented as having few, if not only one, completions. This was perhaps emphasized by having subjects write only one word to the fragments while in the same experiment they were writing many words to stem cues. In Experiment 2, the fragments were presented as potentially having as many completions as the stems. This was emphasized by having subjects write as many words as they could to fragments and stems alike. It is possible, therefore, that subjects' perceptions of the number of possible completions for a fragment affects the way they complete them. Experiment 3 was designed to test this hypothesis using word stem completion. Specifically, word stem completion with stems having only one completion was compared with stems having ten or more completions as a function of prior study and delay. Such a comparison has not been made before. Graf and his colleagues have always used stems with at least ten completions. Word stems were selected for testing that could be completed by either one entry in a pocket dictionary or at least ten entries. One group of subjects received the stems with unique completions and were told to think of only one word to complete them. Another group of subjects received the stems with multiple completions and were told to write as many words as they could think of that completed them. The effect of delay on priming of completion with these two types of word stems was examined.

Method

Materials. A search through a pocket dictionary (Webster's II New Riverside Dictionary, 1984) resulted in finding about 190 words that had no other entry beginning with the word's initial 3 letters. Of these, 128 were chosen as suitable for testing, and an additional 20 words were chosen for buffer items on the study lists. For the multiple completion group, 148 words that had 10 entries in the dictionary and did not share their stems with each other were chosen. (Most of these words came from Experiments 1 and 2, and the rest were randomly chosen from the dictionary.) A listing of the 128 words used in the unique stem group and in the multiple stem group is given in Table A22.

The rating lists for the study phase consisted of 29 words typed in a double-spaced column with lines for the ratings in an adjacent column. The stem tests consisted of one page of 24 stems, and the three letters were followed by a blank line for the responses. The 4 rating lists, 4 immediate stem tests, and 4 delay stem tests were assembled in 4"x11" booklets. An interval timer attached to a speaker was used to limit time spent on each item.

Design. For each type of stem, the 128 targets word were divided into 4 study sets of 32 words each. Sixteen of each set of 32 words comprised one study list that a given subject saw, and all 32 words were tested, half immediately and half at delay. Five additional words were assigned to each study set--two at the beginning of each study list and three at the end; these 5

buffer items were similar to the study words in terms of the number of completions to their stems, but they were not tested. Counterbalancing across subjects, a given word was either studied or not studied and was either tested immediately or after a delay. The type of stem (having unique or multiple completions) was a between subjects variable.

Subjects. Thirty-two Rice University undergraduates, 16 in each stem group, served as subjects.

Procedure. Subjects were tested individually or up to 6 at a time. The subjects were told that each page of the booklet contained a task, that the time spent on each word on a page was controlled by a timer, and that the blank sheet was used to cover the page so the items could not be seen ahead of time. The subjects were shown how to move down the blank sheet to uncover the next word with each beep of the timer.

The instructions for the rating task were the same as in Experiments 1 and 2, except that the words were only rated for how much subjects liked the sound of the word (1 = disliked, 2 = neutral, and 3 = liked).

Each rating list was followed by the stem completion test. The instructions varied depending on the group being tested. The group that received stems with unique completions was told the task was to complete the three letters with a word. To increase perceptions that these cues did not have many completions, it was emphasized that not too many words completed the stems, but the subjects were to try to think of one word that did and to write it

on the line next to the stem. If they could not think of a word in 6 seconds then they were to leave the line blank. No proper nouns or names were allowed. The group that received the stems with multiple completions was told to write as many words as they could think of that began with the three letters. It was emphasized that many words began with the three letters, and of interest was how many and what words they wrote in 6 seconds. For both groups, the instructions included the verbal example stem CAT, with CATALOG, CATATONIC, and CATASTROPHE given as possible correct completions. A practice page containing three stems of the type appropriate for the group was given the first time the subjects encountered the stem test. For the unique completion group, the practice stems were epa__, fev__, and nif__, and for the multiple completion group, the practice stems were shr__, att__, and beh__. After they practiced, they uncovered a duplicate practice test that showed examples of correct responses (for the unique group, epaulet, fever and nifty; for the multiple group, shrewd, shriek; attend, attack; and behind). No reference was made concerning any relationship between the words in the rating list and the words that could complete the stems. When subjects indicated they understood the task, they turned the page and waited for the beep, which signalled them to begin.

The sequence of tasks in the booklets was: Rating list A, Test A1, Rating list B, Test B1, Rating list C, Test C1, Rating list D, Test D1, Test A2, Test B2, Test C2, and Test D2. The delay interval was approximately 15 minutes, and

the experiment lasted 35 minutes.

Results

One word in the unique group was entered in error and actually shared its stem with many words. This error was not discovered until after the data were scored. Subjects' data are given in Table A23.

The means for both types of stems, as well as the differences between studied and nonstudied words, are presented in Table 4. Cues for both unique stems and multiple stems were completed with the target words more often when the word had been studied and tested

Table 4

Mean number of targets completing stems with unique and multiple completions.

	Unique	Multiple (first)	Multiple (at all)
Immediate			
Sudied	25.38	15.94	18.88
Nonstudied	13.81	4.19	6.81
Difference	11.56	11.75	12.06
Delay			
Studied	21.19	9.94	12.06
Nonstudied	14.19	4.56	5.69
Difference	7.00	5.38	6.38
Difference of Differences	4.56	6.38	5.69

Note: There were 32 items in each condition.

immediately. It should be noted that the baselines for the two groups differ. Unequal baselines probably do not reflect a difference in task difficulty, but rather reflect the fact that the probability of completing a stem with the target is much higher when no other word can be written in its place. Although the critical comparison is between the stem completion groups, the statistics for each group will be discussed first. As in the earlier experiments, the multiple stem completion group was scored both when the target was written first and also when written at all (within 6 seconds). The five ANOVA summary tables are presented in Tables A24, A25, A26, A27, and A28.

Stems of studied words were completed more than stems of nonstudied words, F's (1, 15) = 344.66, 137.00, and 183.78, for unique stems, multiple stems completed first and multiple stems completed at all, respectively. This advantage was found in immediate testing, F's (1,15) = 213.74, 125,96, and 146.10, and in delayed testing, F's (1,15) = 59.95, 29.18, and 51.42, respectively. There was an interaction between Study and Time, F's (1,15) =11.05 (p = .005), 20.00, and 18.78, respectively. Fewer stems of studied words were completed after a delay than immediately, F's (1,15) = 12.51, 27.85, and 36.61, but, as would be expected, there was no effect of delay for nonstudied words, F's (1, 15) = .10, .23, and 2.46, p > .10, respectively.

Now for the comparisons of interest between types of stems. There was an effect for type of Stem, F (1, 30) = 85.91 and F (1, 30) = 49.70, for comparing stems with unique completions with multiple stems completed first

and stems completed at all, respectively. Looking at the means, this was due to the fact that unique stems had a greater likelihood of completion with targets than multiple stems for both studied and nonstudied words. There was also an effect of Study, $F(1, 30) = 405.56$, and $F(1, 30) = 480.44$, for unique stem completion compared with multiple stems completed first and completed at all respectively, as well as an effect of Time, $F(1, 30) = 16.00$, and 24.45, respectively. Of more interest are the type of stem interactions with time and study. None of the possible interactions were significant: Stem x Time, F's (1, 30) = .59, $p > .10$ and 3.01, $p = .09$; Stem x Study, F's (1, 30) = .66 and .01, $p > .10$; Stem x Time x Study, F's (1, 30) = .84 and .35, $p > .10$, for stems completed first and at all, respectively.

The results of Experiment 3 indicate that the decline in priming of stem completion over the delay did not differ significantly for the two types of stem completion groups. The data do not, therefore, support the hypothesis that differential effects of delay on the measurement of priming would be found if cues with one completion were presented as such and separately from cues with more than one completion.

General Discussion

Previous research investigating the facilitation of performance that results from prior study, the phenomenon known as direct priming, has concerned itself with the effects of experimental manipulations on performance on a single test. It has not considered the role of the type of priming test and yet has tended to generalize the results across different tests. The reasons for comparing priming on more than one test were buttressed by an apparent discrepancy in findings concerning the effect of delay when the measurement of priming is one of word fragment completion as compared with word stem completion. In this thesis, three experiments were conducted to compare the effect of delay on priming of word fragment and word stem completion when type of test was manipulated within experiments.

In the first experiment, the effect of depth of processing and delay on priming of word fragment completion and word stem completion was examined using fragments with only one completion and stems with multiple completions of which subjects wrote as many as they could. While the depth of processing manipulation had no appreciable effect on priming of the two types of completion, delay did. The magnitude of the priming effect declined over the 20 minute delay interval on both completion tests. The decline in priming was expected for stem completion, since, for example, Graf and Mandler (1984) and Graf et al. (1984) found such declines in stem completion with short time intervals. The decline in fragment completion was also not

entirely unexpected. Although Tulving et al. (1982) reported no decline in priming of fragment completion over a seven day retention interval, their initial testing occurred one hour after study, so the possibility of a decline in priming soon after study was not tested. Light et al. (1986) found a reliable decline in priming of word fragment completion from an immediate to a seven-days delayed test. They hypothesized that priming might decline soon after study and stabilize by one hour, thus accommodating Tulving et al.'s results. Since they did not make a comparison between immediate and one hour testing, a decline in priming of fragment completion over a short time interval is certainly consistent with the findings.

An unexpected finding in Experiment 1 was that delay affected priming of fragment completion more than priming of stem completion. Given that priming of word fragment completion has been found by two separate groups of researchers to occur one week after study, the decline over delay might be thought to be less sharp than the decline for priming of stem completion, which has been found to sharply decline or disappear in the much shorter span of two hours (Graf & Mandler, 1984; Graf et al., 1984). Nonetheless, the results of Experiment 1 do support the notion that these tests can differ in their measurement of priming.

Experiment 2 examined two factors that might have influenced the results of Experiment 1. Fragments were constructed without regard to the number of possible completions, and this was allowed to vary as it did for

stems. Also, the fragments and stems appeared on the same test. The results showed that priming declined over time for both cues, and this decline did not differ significantly for the two types of cues. It would seem that whether a subject completes a cue with a studied word is not dependent upon the type of cue but perhaps on some strategy the subject was using. For example, having all fragments on one test may change the way fragments are completed as compared with when they are mixed with stem cues. Also, subjects may change their strategy for completing fragments when the fragments are presented as having only one completion than when they are presented as possibly having many completions. Curiously, such a strategy change seems to affect completion with studied targets more so than completion with nonstudied targets. An explanation to account for differences in cue completion dependent upon the number of completions must also account for the differential effect between completion of cues of studied words and nonstudied words.

Experiment 3 examined whether priming of stem completion would be affected by the number of words that could complete the stems. The results showed that priming of stem completion was not influenced by the number of possible completions: stems having one completion and stems having at least ten completions were facilitated to the same degree by the prior presentation of targets that completed them. More importantly, delay of testing similarly affected priming on both types of stems.

In some respects, the results from these experiments cloud the picture rather than clarify it. Specifically, Experiment 2 did not show a difference between the effect of delay on priming of word fragment and word stem completion, a difference reported in the literature across experiments. Such a difference was found in Experiment 1, but it was not in the expected direction--priming declined to a greater degree over time for fragment completion than for stem completion. Possible explanations such as completion difficulty, word frequency, and number of cue completions do not seem adequate. Despite the similarities between fragment and stems--both require subjects to complete letters to make a word, both can require equal time per item resulting in similar baselines, both involve steady visual presentations across all subjects, and both can be scored in the same way--and despite the differences--fragments define word length while stems do not, errors are more common in fragment completion than in stem completion, and completing fragments is more akin to puzzle solving than is stem completion--accurate predictions concerning the effect of prior study on completion cannot be made. While we can state with confidence that priming of completion does occur for fragments and stems and that it declines over time for both, we cannot predict which type of completion will show more priming.

What this may mean for priming research in general is that failure to find an effect of an experimental variable using either a word fragment or word

stem completion test does not preclude finding such an effect with the other test. This situation may apply to other priming tests as well. Further, studies which draw conclusions from experiments using only one test may be incorrect, since other results may be found with a different test. Theories developed from these faulty conclusions will risk being unable to account for findings that are equally as important as the findings for which they do account.

Research on priming is relatively new. It began with the demonstration of the phenomenon by exploring conditions whereby an effect of prior study can be observed on tests that do not specifically require subjects to remember the prior occurrence. The time has come to begin evaluating the conditions under which the degree of priming can be influenced. This type of research will yield information concerning the characteristics of priming. One major factor in this research should be the role of the type of test and the characteristics of the test in the manifestation of priming. One goal should be to learn what factors are to be accounted for in order to predict priming of performance on a given test.

The tendency in recent years has been to develop theories concerning priming and its relation to memory. This relation has great interest and importance to both priming and memory researchers. Before its relation can be discerned, however, we need to study priming as we have studied memory--to explore the gradations of priming performance. To do so requires

a change in focus from trying to prove that priming exists to studying its conduct.

References

Carroll, M., & Kirsner, K. (1982). Context and repetition effects in lexical decision and recognition memory. Journal of Verbal Learning and Verbal Behavior, 21, 55-69.

Clarke, R., & Morton, J. (1983). Cross modality facilitation in tachistoscopic word recognition. Quarterly Journal of Experimental Psychology, 35A, 79-96.

Craik, F. I. M., & Tulving, E. (1975). Depth of processing and the retention of words in episodic memory. Journal of Experimental Psychology: General, 104, 268-294.

Graf, P., & Mandler, G. (1984). Activation makes words more accessible, but not necessarily more retrievable. Journal of Verbal Learning and Verbal Behavior, 23, 553-568.

Graf, P., & Schacter, D. L. (1985). Implicit and explicit memory for new associations in normal and amnesic subjects. Journal of Experimental Psychology: Learning, Memory, and Cognition, 11, 501-518.

Graf, P., Mandler, G., & Haden, P. E. (1982). Simulating amnesic symptoms in normal subjects. Science, 218, 1243-1244.

Graf, P., Shimamura, A. P., & Squire, L. R. (1985). Priming across modalities and priming across category levels: Extending the domain of preserved function in amnesia. Journal of Experimental Psychology: Learning, Memory, and Cognition, 11, 386-396.

Graf, P., Squire, L. R., & Mandler, G. (1984). The information that amnesic patients do not forget. Journal of Experimental Psychology: Learning, Memory, and Cognition, 10, 164-178.

Jacoby, L. L. (1983a). Remembering the data: Analyzing interactive processes in reading. Journal of Verbal Learning and Verbal Behavior, 22, 485-508.

Jacoby, L. L (1983b). Perceptual enhancement: Persistent effects of an experience. Journal of Experimental Psychology: Learning, Memory, and Cognition, 9, 21-38.

Jacoby, L. L. (1984). Incidental versus intentional retrieval: Remembering and

awareness as separate issues. In N. Butters & L. Squire, (Eds.), The neuropsychology of memory. New York: Guilford Press.

Jacoby, L. L., & Dallas, M. (1981). On the relationship between autobiographical memory and perceptual learning. Journal of Experimental Psychology: General, 110, 306-340.

Jacoby, L. L., & Witherspoon, D. (1982). Remembering without awareness. Canadian Journal of Psychology, 36, 300-324.

Johnston, W., Dark, V., & Jacoby, L. L. (1985). Perceptual fluency and recognition judgments. Journal of Experimental Psychology: Learning, Memory, and Cognition, 11, 3-11.

Light, L., Singh, A., & Capps, J. (1986). Dissociation of memory and awareness in young and older adults. Journal of Clinical and Experimental Neuropsychology, 8, 62-74.

Kirsner, K., Milech, D., & Standen, P. (1983). Common and modality-specific processes in the mental lexicon. Memory & Cognition, 11, 621-630.

Puzzle Solver's Handbook. (1970). Tuscon, AZ: Douglas R. Corron.

Schacter, D. L. (1985a). Priming of old and new knowledge in amnesic patients and normal subjects. Annals of the New York Academy of Sciences, 444, 41-53.

Schacter, D. L. (1985b). Multiple forms of memory in humans and animals. In D. Weinberger, J. McGaugh, & G. Lynch (Eds.), Memory systems of the brain: Animal and human cognitive processes (pp. 351-379). NY: Guilford Press.

Schacter, D. L., & Graf, P. (1986). Effects of elaborative processing on implicit and explicit memory for new associations. Journal of Experimental Psychology: Learning, Memory, & Cognition.

Squire, L., Shimamura, A. P., & Graf, P. (1985). Independence of recognition memory and priming effects: A neuropsychological analysis. Journal of Experimental Psychology: Learning, Memory, and Cognition, 11, 37-44.

Tulving, E. (1983). Episodic memory. New York: Oxford University Press.

Tulving E. (1984). Precis of Elements of episodic memory. The Behavioral and

Brain Sciences, 7, 223-268.

Tulving, E. (1985). How many memory systems are there? American Psychologist, 40, 385-398.

Tulving, E., Schacter, D. L., & Stark, H. A. (1982). Priming effects in word-fragment completion are independent of recognition memory. Journalof Experimental Psychology: Learning, Memory, and Cognition, 8, 336-342.

Warrington, E. K., & Weiskrantz, L. (1968). New method of testing long-term retention with special reference to amnesic patients. Nature, 217, 972-974.

Warrington, E. K., & Weiskrantz, L. (1970). The amnesic syndrome: Consolidation or retrieval? Nature, 228, 628-630.

Warrington, E. K., & Weiskrantz, L. (1974). The effect of prior learning effect in amnesic patients. Neuropsychologia, 12, 419-428.

Warrington, E. K., & Weiskrantz, L. (1978). Further analysis of the prior learning effect in amnesic patients. Neuropsychologia, 16, 169-177.

Webster's II New Riverside Dictionary. (1984). New York: Berkeley Books.

Winnick, W. A., & Daniel, S. A. (1970). Two kinds of response priming in tachistoscopic recognition. Journal of Experimental Psychology, 84, 74-81.

Woods, R. T., & Piercy, M. (1974). A similarity between amnesia memory and normal forgetting. Neuropsychologia, 12, 437-445.

APPENDIX

Table A1

Words used in Experiment 1, with underlined letters specifying the unique cues

abduct	behave	evolve	instep	myself	python	sphinx	upmost
abroad	biceps	exhume	inward	native	quaint	squirm	usable
accord	boxing	exotic	italic	nearby	queasy	stanza	useful
acquit	buying	expect	itself	needle	ravage	stigma	utmost
acting	cleave	facade	jammed	nobody	rebuke	strata	utopia
adhere	climax	fathom	jovial	notify	recipe	stucco	vanish
admire	cobweb	flying	joyous	novena	reflex	swivel	viewer
affair	convex	frizzy	karate	nutmeg	rehash	syntax	volume
afghan	cutoff	galaxy	kidnap	object	remark	taking	voyage
agenda	dazzle	gasket	knives	oblige	renown	tariff	waking
aghast	disown	ghetto	larynx	occupy	retina	tavern	waylay
alcove	duplex	giving	layoff	oddity	rhythm	thorax	whisky
always	eclair	growth	leeway	omelet	runway	thrown	wizard
amends	editor	having	libido	onward	salami	tricky	yearly
amoeba	effigy	hijack	loathe	opaque	scrawl	twelve	yellow
anyway	eggnog	homage	lojter	ordeal	scurvy	typify	yogurt
asleep	eleven	hybrid	luxury	output	sewage	umpire	yonder
aspect	elixir	icebox	making	oxygen	sexton	unique	zealot
assess	engulf	icicle	marvel	oyster	shadow	unjust	zenith
asthma	enjoin	idiocy	matrix	papaya	shrewd	unveil	zigzag
attack	enzyme	impend	mayhem	paying	silver	upbeat	zipped
autumn	equity	indigo	midway	pickup	sizzle	update	zodiac
avenue	escape	influx	modify	prompt	sketch	upkeep	zombie
bakery	ethics	inning	motive	psyche	slowly	uplift	zygote

Table A2

Data from Experiment 1

S = Studied words
NS = Nonstudied words

Fragment Completion Data

	Immediate				Delay			
	Sound		Meaning		Sound		Meaning	
Subject	S	NS	S	NS	S	NS	S	NS
1	6	4	9	3	6	3	3	2
2	10	2	8	2	5	4	7	5
3	7	4	10	2	7	1	4	5
4	9	3	8	5	3	4	8	4
5	10	2	7	3	5	3	8	4
6	7	3	9	4	7	5	3	5
7	10	2	10	5	7	6	6	3
8	6	4	11	3	7	6	2	4
9	7	2	7	4	4	6	5	5
10	10	1	9	5	5	3	3	2
11	9	1	9	4	7	4	5	0
12	11	5	8	3	9	7	8	4
13	9	1	7	4	5	4	7	5
14	12	5	11	2	7	2	5	4
15	12	4	10	2	6	3	4	1
16	9	6	9	3	9	6	8	4
17	11	2	10	0	6	3	5	2
18	8	4	4	3	5	2	5	2
19	8	5	9	4	6	1	6	3
20	11	5	11	7	9	5	10	7
21	10	7	8	0	5	2	10	4
22	6	3	6	2	4	3	3	1
23	9	4	8	0	5	2	5	2
24	10	4	10	6	11	6	10	5
25	8	6	10	6	9	1	10	4
26	9	3	8	5	6	2	4	5
27	12	6	10	3	5	6	8	2
28	7	7	10	3	10	7	9	7
29	9	2	6	3	6	4	6	3
30	10	0	8	3	6	4	6	1
31	11	2	12	1	6	3	7	4
32	9	8	9	6	9	8	8	11

Table A2 (continued)

Stem Completion Data --when target was written first

	Immediate				Delay			
	Sound		Meaning		Sound		Meaning	
Subject	S	NS	S	NS	S	NS	S	NS
1	4	2	4	1	7	5	3	3
2	10	3	6	2	6	3	6	1
3	5	1	4	7	4	7	3	2
4	7	4	7	3	6	1	5	4
5	5	3	3	3	4	3	10	5
6	4	2	6	4	4	2	1	4
7	7	4	8	3	4	4	8	5
8	6	3	4	3	4	5	5	4
9	7	3	3	1	5	4	5	3
10	6	4	8	3	3	2	4	3
11	7	1	6	3	7	3	6	5
12	4	1	5	2	5	2	5	3
13	5	4	2	3	8	4	5	5
14	8	4	6	3	5	3	5	2
15	6	3	5	2	7	4	4	2
16	6	6	6	3	7	2	5	2
17	10	4	6	3	9	5	8	3
18	7	2	3	3	2	1	4	2
19	6	3	3	4	3	3	4	2
20	5	5	6	4	6	3	4	3
21	6	3	7	2	6	3	6	5
22	8	4	11	4	3	1	3	2
23	3	3	6	0	6	3	9	4
24	5	4	4	4	6	5	6	3
25	5	2	4	2	6	6	4	4
26	5	5	5	3	6	1	1	3
27	5	1	6	3	5	4	4	2
28	7	3	5	2	4	2	8	3
29	3	4	4	1	3	5	7	3
30	5	2	7	4	3	3	4	2
31	6	4	4	3	4	2	7	3
32	6	1	8	4	2	2	6	3

Table A2 (continued)

Stem Completion Data--when target was written on line 1

	Immediate				Delay			
	Sound		Meaning		Sound		Meaning	
Subject	S	NS	S	NS	S	NS	S	NS
1	6	2	3	1	8	5	4	3
2	10	3	6	2	6	3	6	1
3	6	2	6	7	6	8	3	2
4	7	4	8	2	6	1	5	4
5	5	3	5	3	5	4	10	5
6	6	2	8	3	4	4	3	4
7	9	4	8	3	5	4	9	7
8	7	3	5	4	6	5	6	5
9	7	3	3	1	5	4	5	3
10	7	5	8	3	4	2	5	3
11	8	5	6	4	9	3	7	5
12	5	3	7	4	5	4	5	4
13	4	4	2	3	8	4	6	5
14	9	6	6	4	6	4	7	2
15	6	4	6	3	7	4	5	2
16	6	6	6	3	7	2	5	3
17	10	3	6	3	9	4	8	3
18	7	2	4	3	2	1	5	2
19	6	3	5	4	5	4	4	2
20	7	5	7	4	7	3	5	4
21	6	3	11	3	7	3	8	4
22	6	4	11	4	3	1	3	2
23	5	3	7	0	6	3	8	4
24	7	4	7	5	7	5	7	3
25	7	2	4	2	7	7	5	4
26	5	5	6	1	6	1	1	3
27	5	3	7	4	5	4	5	4
28	7	2	5	2	3	2	8	3
29	3	4	5	2	4	5	7	3
30	5	2	6	5	3	3	3	2
31	7	4	5	3	3	2	7	2
32	8	3	8	6	4	2	9	3

Table A2 (continued)

Stem Completion Data--when target was written on lines 1 or 2

	Immediate				Delay			
	Sound		Meaning		Sound		Meaning	
Subject	S	NS	S	NS	S	NS	S	NS
1	8	3	4	2	9	6	4	4
2	11	4	7	4	6	3	6	1
3	7	3	7	8	6	9	4	2
4	8	5	9	4	7	2	7	4
5	6	3	5	3	5	4	11	5
6	6	2	8	5	4	6	4	5
7	10	4	8	5	5	5	9	8
8	7	4	8	4	6	6	7	6
9	7	3	4	1	6	5	6	4
10	8	5	8	3	5	2	7	3
11	8	5	6	4	9	3	7	5
12	6	3	9	5	5	5	17	5
13	7	4	3	3	9	5	10	7
14	10	6	7	5	6	5	8	3
15	6	4	7	4	7	4	6	5
16	8	6	7	3	7	3	7	3
17	10	4	7	3	10	5	9	4
18	8	3	6	3	2	1	5	2
19	6	3	6	4	6	4	5	2
20	9	5	8	5	8	6	7	5
21	6	3	11	4	8	3	8	6
22	9	4	11	4	3	1	3	2
23	5	3	8	0	7	3	9	4
24	8	4	8	5	8	6	8	4
25	7	4	6	2	9	7	5	4
26	6	6	7	3	7	3	1	3
27	5	3	7	4	8	5	7	5
28	9	4	9	2	7	3	9	4
29	3	5	5	4	6	5	7	4
30	5	5	7	7	3	3	4	2
31	8	4	6	4	3	3	7	3
32	9	4	8	6	6	5	9	5

Table A2 (continued)

Stem Completion Data--when words were written at all

	Immediate				Delay			
	Sound		Meaning		Sound		Meaning	
Subject	S	NS	S	NS	S	NS	S	NS
1	8	3	5	2	9	7	5	5
2	11	5	8	5	7	3	7	2
3	7	3	7	8	6	9	4	2
4	8	5	10	5	7	3	7	4
5	6	3	5	3	6	4	11	6
6	6	2	8	7	4	6	4	5
7	10	4	8	5	5	6	10	8
8	7	4	8	4	6	6	7	6
9	7	3	5	1	6	5	6	4
10	8	5	8	3	5	2	7	3
11	8	5	6	5	9	4	7	5
12	6	3	9	6	5	6	7	5
13	7	4	4	3	9	5	10	7
14	11	7	7	6	6	5	8	3
15	6	5	8	4	7	4	6	5
16	8	6	8	4	8	4	7	3
17	10	5	8	3	10	5	9	4
18	8	3	7	3	3	1	5	2
19	6	4	6	4	6	4	6	3
20	10	6	8	7	8	6	7	5
21	7	5	11	4	8	4	8	7
22	9	4	11	4	3	1	3	2
23	6	3	9	0	7	4	9	4
24	8	5	8	6	9	6	8	5
25	7	4	6	3	10	7	5	4
26	8	8	7	3	7	3	3	4
27	6	3	7	4	8	5	7	5
28	9	5	9	4	8	5	9	5
29	4	5	5	4	6	5	7	4
30	5	5	8	8	5	3	4	2
31	9	4	6	4	4	3	7	3
32	9	5	8	6	8	5	9	6

Table A3

ANOVA summary table for fragment completion, Experiment 1

Source	df	ss	ms	F	prob
Subjects	31	338.434	10.917		
Study	1	1012.035	1012.035	276.805	.000
Error	31	113.340	3.656		
Rating Task	1	5.348	5.348	2.857	.101
Error	31	58.027	1.872		
Rating Task x Study	1	.035	.035	.022	.882
Error	31	49.340	1.592		
Time	1	82.129	82.129	30.401	.000
Error	31	83.746	2.701		
Study x Time	1	142.504	142.504	54.965	.000
Error	31	80.371	2.593		
Rating Task x Time	1	.191	.191	.055	.816
Error	31	107.684	3.474		
Study x Rating Task x Time	1	.035	.035	.010	.920
Error	31	106.840	3.446		

Table A4

ANOVA summary table for stem completion when target was written first, Experiment 1

Source	df	ss	ms	F	prob
Subjects	31	89.059	2.873		
Study	1	335.348	335.348	129.903	.000
Error	31	80.027	2.582		
Rating Task	1	1.723	1.723	.662	.422
Error	31	80.652	2.602		
Study x Rating Task	1	.035	.035	.022	.882
Error	31	48.840	1.575		
Time	1	2.066	2.066	.452	.507
Error	31	144.809	4.574		
Study x Time	1	9.379	9.379	6.923	.013
Error	31	41.996	1.355		
Rating Task x Time	1	2.441	2.441	.997	.326
Error	31	75.934	2.449		
Study x Rating Task x Time	1	1.410	1.410	.587	.449
Error	31	74.465	2.402		

Table A5

ANOVA summary table for stem completion when target was written on line 1, Experiment 1

Source	df	ss	ms	F	prob
Subjects	31	126.715	4.088		
Study	1	448.910	448.910	191.381	.000
Error	31	72.715	2.346		
Rating Task	1	1.723	1.723	.578	.453
Error	31	92.402	2.981		
Rating Task x Study	1	.316	.316	.253	.619
Error	31	38.809	1.252		
Time	1	5.941	5.941	1.454	.237
Error	31	126.684	4.087		
Study x Time	1	9.379	9.379	6.882	.013
Error	31	42.246	1.363		
Rating Task x Time	1	2.066	2.066	.753	.392
Error	31	85.059	2.744		
Study x Rating Task x Time	1	.660	.660	.237	.630
Error	31	86.465	2.789		

Table A6

ANOVA summary table for stem completion when target was written on lines 1 or 2, Experiment 1

Source	df	ss	ms	F	prob
Subjects	31	154.340	4.979		
Study	1	543.473	543.473	172.970	.000
Error	31	97.402	3.142		
Rating Task	1	.004	.004	.001	.976
Error	31	127.871	4.125		
Rating Task x Study	1	2.066	2.066	1.354	.253
Error	31	47.309	1.526		
Time	1	2.066	2.066	.333	.568
Error	31	192.309	6.204		
Study x Time	1	10.160	10.160	6.090	.019
Error	31	51.715	1.668		
Rating Task x Time	1	2.848	2.848	.929	.343
Error	31	95.027	3.065		
Study x Rating Task x Time	1	3.754	3.754	1.354	.253
Error	31	83.621	2.697		

Table A7

ANOVA summary table for stem completion when target was written at all, Experiment 1

Source	df	ss	ms	F	prob
Subjects	31	159.000	5.129		
Study	1	489.516	489.516	192.736	.000
Error	31	78.734	2.540		
Rating Task	1	.766	.766	.281	.600
Error	31	84.484	2.725		
Rating Task x Study	1	.250	.250	.310	.582
Error	31	25.000	.806		
Time	1	7.563	7.563	1.249	.272
Error	31	187.688	6.054		
Study x Time	1	11.391	11.391	7.378	.011
Error	31	47.859	1.544		
Rating Task x Time	1	.141	.141	.048	.828
Error	31	91.109	2.939		
Study x Rating Task x Time	1	1.000	1.000	.490	.489
Error	31	63.250	2.040		

Table A8

ANOVA summary table for fragment and stem completion when target was written first, Experiment 1

Source	df	ss	ms	F	prob
Subjects	31	231.617	7.472		
Type of Cue	1	264.500	264.500	41.861	.001
Error	31	195.875	6.319		
Study	1	1256.258	1256.258	337.566	.001
Error	31	115.367	3.722		
Cue x Study	1	91.125	91.125	36.216	.001
Error	31	78.000	2.516		
Time	1	55.125	55.125	13.196	.001
Error	31	129.500	4.177		
Cue x Time	1	29.070	29.070	9.382	.005
Error	31	96.055	3.099		
Time x Study	1	112.500	112.500	55.912	.001
Error	31	62.375	2.012		
Cue x Time x Study	1	39.383	39.383	20.350	.001
Error	31	59.992	1.935		
Rating task	1	6.570	6.570	3.143	.086
Error	31	64.805	2.090		
Cue x Rating task	1	.500	.500	.210	.650
Error	31	73.875	2.383		
Time x Rating task	1	2.000	2.000	.541	.468
Error	31	114.625	3.698		
Rating task x Study	1	.070	.070	.038	.848
Error	31	58.055	1.873		
Cue x Rating x Study	1	.000	.000	.000	1.00
Error	31	40.125	1.294		
Cue x Time x Rating	1	.633	.633	.284	.598
Error	31	68.992	2.226		
Time x Rating x Study	1	.500	.500	.206	.653
Error	31	75.375	2.431		
Cue x Time x Rating x Study	1	.945	.945	.277	.603
Error	31	105.930	3.417		

Table A9

ANOVA summary table for fragment and stem completion when target was written on line 1, Experiment 1

Source	df	ss	ms	F	prob
Subjects	31	311.617	10.052		
Type of Cue	1	124.031	124.031	25.767	.001
Error	31	149.219	4.814		
Study	1	1411.133	1411.133	401.821	.001
Error	31	108.867	3.512		
Cue x Study	1	55.125	55.125	21.666	.001
Error	31	78.875	2.544		
Time	1	64.695	64.695	16.705	.001
Error	31	120.055	3.873		
Cue x Time	1	22.781	22.781	7.679	.009
Error	31	91.969	2.967		
Time x Study	1	114.383	114.383	62.629	.001
Error	31	56.617	1.826		
Cue x Time x Study	1	38.281	38.281	18.479	.001
Error	31	64.219	2.072		
Rating task	1	6.125	6.125	3.081	.089
Error	31	61.625	1.988		
Cue x Rating task	1	.633	.633	.223	.640
Error	31	88.117	2.842		
Rating task x Study	1	.031	.031	.018	.894
Error	31	53.969	1.741		
Time x Rating task	1	1.531	1.531	.462	.502
Error	31	102.719	3.314		
Cue x Rating x Study	1	.195	.195	.162	.690
Error	31	37.305	1.203		
Cue x Time x Rating	1	.383	.383	.133	.718
Error	31	89.367	2.883		
Time x Rating x Study	1	.281	.281	.122	.729
Error	31	71.219	2.297		
Cue x Time x Rating x Study	1	.633	.633	.162	.690
Error	31	120.867	3.899		

Table A10

ANOVA summary table for fragment and stem completion when target was written on lines 1 or 2, Experiment 1

Source	df	ss	ms	F	prob
Subjects	31	374.680	12.086		
Type of Cue	1	5.281	5.281	1.598	.216
Error	31	102.469	3.305		
Study	1	1485.125	1485.125	406.076	.001
Error	31	113.375	3.657		
Cue x Study	1	41.633	41.633	14.164	.001
Error	31	91.117	2.939		
Time	1	61.883	61.883	12.974	.001
Error	31	147.867	4.770		
Cue x Time	1	24.500	24.500	6.547	.016
Error	31	116.000	3.742		
Time x Study	1	124.031	124.031	61.798	.001
Error	31	62.219	2.007		
Cue x Time x Study	1	33.008	33.008	15.624	.001
Error	31	65.492	2.113		
Rating task	1	4.500	4.500	2.514	.123
Error	31	55.500	1.790		
Cue x Rating task	1	1.320	1.320	.410	.527
Error	31	99.930	3.224		
Rating task x Study	1	.195	.195	.134	.717
Error	31	45.305	1.461		
Time x Rating task	1	1.125	1.125	.333	.568
Error	31	104.625	3.375		
Cue x Rating x Study	1	.500	.500	.473	.497
Error	31	32.750	1.056		
Cue x Time x Rating	1	.195	.195	.064	.802
Error	31	94.805	3.058		
Time x Rating x Study	1	.633	.633	.253	.619
Error	31	77.617	2.504		
Cue x Time x Rating x Study	1	1.125	1.125	.349	.559
Error	31	99.875	3.222		

Table A11

ANOVA summary table for fragment and stem completion when target was written at all, Experiment 1

Source	df	ss	ms	F	prob
Subjects	31	411.000	13.258		
Type of Cue	1	2.258	2.258	.824	.371
Error	31	84.992	2.742		
Study	1	1451.258	1451.258	421.473	.001
Error	31	106.742	3.443		
Cue x Study	1	47.531	47.531	17.290	.001
Error	31	85.219	2.749		
Time	1	70.508	70.508	13.704	.001
Error	31	159.492	5.145		
Cue x Time	1	19.531	19.531	5.348	.028
Error	31	113.219	3.652		
Time x Study	1	116.281	116.281	54.851	.001
Error	31	65.719	2.120		
Cue x Time x Study	1	37.195	37.195	18.433	.001
Error	31	62.555	2.018		
Rating task	1	4.883	4.883	2.863	.101
Error	31	52.867	1.705		
Cue x Rating task	1	1.125	1.125	.388	.538
Error	31	89.875	2.899		
Rating task x Study	1	.031	.031	.021	.885
Error	31	45.719	1.475		
Time x Rating task	1	.281	.281	.077	.784
Error	31	113.469	3.660		
Cue x Rating x Study	1	.195	.195	.210	.650
Error	31	28.805	.929		
Cue x Time x Rating	1	.008	.008	.003	.958
Error	31	83.992	2.709		
Time x Rating x Study	1	.383	.383	.161	.691
Error	31	73.867	2.383		
Cue x Time x Rating x Study	1	.781	.781	.248	.622
Error	31	97.719	3.152		

Table A12

Words used in Experiment 2; the first letter and all vowels were replaced by blanks for fragment cues

above	cover	hidden	mistake	puzzle	striking
absence	cradle	himself	modern	question	suffer
accord	creature	honest	monarch	quiver	suggest
active	cunning	humble	mortal	refuse	summer
admit	daughter	husband	mountain	regard	survey
adopt	declare	ideal	murder	rejoice	system
advance	delight	illness	narrow	remark	taken
affair	derive	image	nearly	repeat	temper
against	deserve	immense	nervous	research	theater
alter	detail	impulse	noble	retreat	thinking
amuse	devil	include	northern	revenge	timber
ancient	diamond	indeed	notion	rider	torture
apple	direct	inquire	ocean	rifle	truly
arise	dollar	involve	offer	rocky	tunnel
arrow	doorway	iron	olive	sacred	under
ashore	embrace	island	onion	safety	until
attach	engage	jealous	open	sailor	upper
balance	explain	justice	oyster	salute	utmost
banner	extent	kingdom	painter	saving	valley
barrel	fabric	lawyer	parent	science	velvet
basin	fancy	leader	pasture	settle	village
because	feather	legend	peaceful	shaken	visit
behind	firmly	lemon	permit	signal	wander
belief	foolish	letter	picture	silver	weapon
blessing	fortune	likewise	pigeon	simple	wicked
bother	freely	linger	player	single	widow
briefly	friendly	liquid	pointed	soldier	willing
campaign	funny	mainly	pony	sometime	window
candle	fury	major	portion	sparrow	wisdom
carry	gallant	marvel	possess	speaker	within
chimney	going	measure	powder	spirit	worthy
circuit	gracious	meeting	prayer	splendid	
climate	greatly	menace	prevent	sprinkle	
clothing	happen	message	procure	standing	
compound	harvest	metal	punish	steamer	
county	hasten	mirror	purchase	story	

Table A13

Data from Experiment 2

S = Studied Words
N = Nonstudied Words

	Fragment Completion Data							
	Completed First				Completed At All			
	Immediate		Delay		Immediate		Delay	
Subject	S	NS	S	NS	S	NS	S	NS
1	8	5	11	7	12	8	5	12
2	9	7	12	5	10	8	13	5
3	11	11	12	8	13	13	13	9
4	16	10	9	6	17	11	10	7
5	11	10	12	5	11	10	13	5
6	15	10	9	10	15	11	9	12
7	11	9	8	7	13	9	8	8
8	10	9	7	6	10	9	9	6
9	18	7	9	8	18	8	9	8
10	16	4	13	4	16	5	14	4
11	16	11	15	7	16	11	16	7
12	15	6	5	6	15	7	5	6
13	10	6	11	5	10	7	11	5
14	15	4	9	8	18	5	10	9
15	17	8	11	13	19	9	11	13
16	10	7	7	4	10	7	8	3
17	16	4	3	5	16	4	4	6
18	10	6	14	8	10	6	14	8
19	15	9	12	8	15	10	14	8
20	21	8	10	5	23	8	12	6
21	12	6	12	3	12	6	13	3
22	19	10	12	12	21	11	12	15
23	17	6	9	8	17	6	10	8
24	11	6	6	6	11	6	7	7
25	13	7	7	10	14	7	8	11
26	12	7	13	7	12	7	13	10
27	13	12	12	6	14	13	13	6
28	18	5	6	7	18	5	7	7
29	8	7	9	4	9	7	9	4
30	18	9	12	14	21	9	14	15
31	19	8	9	12	19	9	9	14
32	10	10	11	7	10	11	11	7
33	13	10	7	9	13	10	7	9
34	15	11	15	8	15	11	15	8
35	9	10	13	7	10	10	14	7
36	18	10	14	8	20	10	14	10
37	13	10	12	5	13	10	13	5
38	19	6	10	10	19	6	12	10
39	15	6	11	12	16	6	11	12
40	10	9	5	7	11	10	5	7

Table A13 (continued)

	Stem Completion Data							
	Completed First				Completed At All			
	Immediate		Delay		Immediate		Delay	
Subject	S	NS	S	NS	S	NS	S	NS
1	5	4	10	5	7	7	12	6
2	14	5	3	4	17	7	4	10
3	8	7	3	6	18	10	8	9
4	5	6	12	4	7	13	20	4
5	12	4	8	7	17	5	14	14
6	10	8	10	6	11	13	16	7
7	10	11	13	6	12	13	14	9
8	17	2	9	10	17	4	10	13
9	6	2	12	5	7	2	12	7
10	17	3	7	9	20	6	9	12
11	18	7	5	9	19	8	8	13
12	10	6	17	4	12	9	20	6
13	14	5	8	6	17	6	16	9
14	9	10	15	3	14	13	18	6
15	11	8	9	4	14	12	14	9
16	16	4	7	12	18	4	11	14
17	9	9	12	6	10	13	19	11
18	23	5	9	6	26	8	10	14
19	14	8	5	8	16	8	7	13
20	6	5	13	2	11	7	17	4
21	14	3	10	9	20	4	12	11
22	5	9	9	4	11	13	15	5
23	12	7	14	5	13	12	16	6
24	14	4	5	11	17	4	10	15
25	6	6	8	6	11	11	14	8
26	19	4	7	9	22	5	8	10
27	12	4	6	7	21	9	6	13
28	5	4	13	3	8	8	20	6
29	15	1	10	5	19	4	11	8
30	6	14	7	5	12	19	15	6
31	15	3	13	7	17	10	19	8
32	16	3	9	10	21	3	13	12
33	8	6	12	9	9	9	14	11
34	17	4	2	8	20	7	5	13
35	12	4	5	5	16	10	6	6
36	9	6	11	7	12	9	17	8
37	18	3	10	8	21	5	16	16
38	10	11	10	3	12	14	13	5
39	13	5	11	6	17	11	12	8
40	11	3	2	5	17	4	5	11

Table A14

ANOVA summary table for fragment completion when target was written first, Experiment 2

Source	df	ss	ms	F	prob
Subjects	39	468.194	12.005		
Study	1	693.056	693.056	117.675	.001
Error	39	229.694	5.890		
Time	1	191.406	191.406	48.054	.001
Error	39	155.344	3.983		
Time x Study	1	120.756	120.756	11.213	.002
Error	39	419.994	10.769		

Table A15

ANOVA summary table for fragment completion when target was written at all, Experiment 2

Source	df	ss	ms	F	prob
Subjects	39	591.844	15.175		
Study	1	761.256	761.256	112.037	.001
Error	39	264.994	6.795		
Time	1	182.756	182.756	47.999	.001
Error	39	148.494	3.808		
Time x Study	1	127.806	127.806	10.101	.003
Error	39	493.444	12.652		

Table A16

ANOVA summary table for stem completion data when target was written first, Experiment 2

Source	df	ss	ms	F	prob
Subjects	39	591.844	15.175		
Study	1	761.256	761.256	112.037	.001
Error	39	264.994	6.795		
Time	1	182.756	182.756	47.999	.001
Error	39	148.494	3.808		
Time x Study	1	127.806	127.806	10.101	.003
Error	39	493.444	12.652		

Table A17

ANOVA summary table for stem completion when target was written at all, Experiment 2

Source	df	ss	ms	F	prob
Subjects	39	342.194	8.774		
Study	1	985.056	985.056	156.681	.001
Error	39	245.194	6.287		
Time	1	24.806	24.806	2.446	.126
Error	39	395.444	10.140		
Time x Study	1	117.306	117.306	2.771	.104
Error	39	1650.944	42.332		

Table A18

ANOVA summary table for fragment and stem completion when target was written first, Experiment 2

Source	df	ss	ms	F	prob
Subjects	39	356.988	9.154		
Study	1	1479.200	1479.200	169.027	.001
Error	39	341.300	8.751		
Cue	1	217.800	217.800	20.707	.001
Error	39	410.200	10.518		
Cue x Study	1	1.513	1.513	.309	.582
Error	39	190.988	4.897		
Time	1	201.613	201.613	81.576	.001
Error	39	96.388	2.471		
Time x Study	1	245.000	245.000	40.063	.000
Error	39	238.500	6.115		
Cue x Time	1	28.800	28.800	3.144	.084
Error	39	357.200	9.159		
Cue x Time x Study	1	.013	.013	.000	.984
Error	39	1112.488	28.525		

Table A19

ANOVA summary table for fragment completion when target was written first and stem completion when target was written at all, Experiment 2

Source	df	ss	ms	F	prob
Subjects	39	451.500	11.577		
Study	1	1665.313	1665.313	205.733	.001
Error	39	315.688	8.095		
Type of Cue	1	201.613	201.613	21.909	.001
Error	39	358.888	9.202		
Type of Cue x Study	1	12.800	12.800	3.136	.084
Error	39	159.200	4.082		
Time	1	177.013	177.013	59.264	.001
Error	39	116.488	2.987		
Time x Study	1	238.050	238.050	22.213	.001
Error	39	417.950	10.717		
Type of Cue x Time	1	39.200	39.200	3.520	.068
Error	39	434.300	11.136		
Cue x Time x Study	1	.012	.012	.000	.986
Error	39	1652.988	42.384		

Table A20

ANOVA summary table for fragment completion when target was written at all and stem completion when target was written first, Experiment 2

Source	df	ss	ms	F	prob
Subjects	39	389.138	9.978		
Study	1	1548.800	1548.800	176.385	.000
Error	39	342.450	8.781		
Cue	1	396.050	396.050	30.787	.000
Error	39	501.700	12.864		
Cue x Study	1	.113	.113	.019	.890
Error	39	225.138	5.773		
Time	1	195.313	195.313	78.986	.000
Error	39	96.438	2.473		
Time x Study	1	252.050	252.050	46.107	.000
Error	39	213.200	5.467		
Cue x Time	1	26.450	26.450	2.945	.094
Error	39	350.300	8.982		
Cue x Time x Study	1	.012	.012	.000	.984
Error	39	1211.238	31.057		

Table A21

ANOVA summary table for fragment and stem completion when target was written at all, Experiment 2

Source	df	ss	ms	F	prob
Subjects	39	512.050	13.129		
Study	1	1739.113	1739.113	215.738	.001
Error	39	314.388	8.061		
Cue	1	82.013	82.013	7.580	.009
Error	3	421.988	10.820		
Cue x Study	1	7.200	7.200	1.434	.238
Error	39	195.800	5.021		
Time	1	171.113	171.113	51.777	.001
Error	39	128.888	3.305		
Time x Study	1	245.000	245.000	25.755	.001
Error	39	371.000	9.513		
Cue x Time	1	36.450	36.450	3.425	.072
Error	3	415.050	10.642		
Cue x Time x Study	1	.113	.113	.002	.961
Error	39	1773.388	45.471		

Table A22

Words used in Experiment 3

Multiple Stems Group

above	devil	message	salute
absence	diamond	metal	shaken
accord	direct	mistake	signal
active	dollar	modern	silver
admit	drought	monarch	simple
advance	embrace	mortal	single
alter	explain	mountain	soldier
apple	extent	narrow	sometime
arrow	factor	notion	sparrow
attach	foolish	offer	speaker
balance	fortune	parent	spirit
banner	freely	pasture	splendid
barrel	friendly	peaceful	sprinkle
basin	funny	permit	standing
blessing	fury	picture	steward
briefly	gallant	pigeon	story
bureau	gracious	player	striking
campaign	greatly	please	suffer
candle	harvest	pony	summer
carry	illness	prevent	temper
chimney	immense	procure	theater
circuit	impulse	punish	thinking
clothing	include	question	timber
compound	inspire	quiver	torture
county	involve	refuse	truly
cradle	kingdom	regard	valley
creature	leader	remark	visit
declare	legend	repeat	weapon
delight	linger	research	willing
derive	marvel	retreat	window
deserve	measure	revenge	within
detail	menace	sacred	worthy

Table A22 (continued)

Unique Stems Group

acme	dwarf	meow	scythe
acne	dying	miff	soybean
afar	either	nadir	tavern
ahoy	emcee	niece	tiara
aisle	esquire	nozzle	tissue
already	ewer	nuance	tizzy
anvil	fiord	nuisance	token
aplomb	fodder	nylon	toss
arpeggio	foyer	nymph	tuition
asocial	gaol	oasis	tuxedo
auburn	geyser	obnoxious	tycoon
aunt	gopher	odyssey	tyke
awry	gown	okra	ubiquitous
azalea	guppy	ombudsman	udder
azure	hiatus	onboard	ulster
bebop	hutch	onrush	umlaut
beyond	hyena	onto	upgrade
biweekly	igloo	onus	upkeep
biyearly	igneous*	onyx	utmost
bovine	inmate	oodles	vodka
bygone	itself	oomph	vomit
bystander	ivory	osprey	wacky
byte	jute	ouch	wept
cahoots	kegler	ounce	wrung
cephalic	kiwi	oxtail	wurst
cider	koala	oyster	yahoo
cipher	kosher	ozone	yolk
coke	krypton	pajamas	yonder
cygnet	lake	poverty	yore
cymbal	lizard	pylon	yowl
cypress	llama	python	yucca
doff	lozenge	roil	zenith

* erroneously included in unique group

Table A23

Data from Experiment 3

S = Studied Words
NS = Nonstudied Words

Unique Completion Stems

	Immediate		Delay	
Subject	S	NS	S	NS
1	27	11	22	17
2	26	11	21	18
3	31	16	22	13
4	24	17	22	17
5	31	20	31	20
6	25	18	26	12
7	28	20	20	16
8	23	12	24	11
9	25	16	23	19
10	30	18	27	18
11	27	11	24	18
12	16	6	10	4
13	24	14	17	7
14	22	11	24	20
15	24	8	7	5
16	23	12	19	12

Multiple Completion Stems

	Completed First				Completed At All			
	Immediate		Delay		Immediate		Delay	
Subject	S	NS	S	NS	S	NS	S	NS
1	19	4	8	4	25	8	11	5
2	20	3	5	7	22	6	7	7
3	20	2	15	4	20	4	16	6
4	17	7	10	5	21	10	15	5
5	13	4	10	1	18	9	12	4
6	16	2	9	7	18	6	11	8
7	16	2	14	4	17	2	14	4
8	15	6	16	2	19	8	18	4
9	14	6	8	5	14	9	9	6
10	21	6	7	3	22	7	7	3
11	9	1	8	5	11	4	10	5
12	19	3	9	2	19	4	10	4
13	15	2	10	7	20	3	11	7
14	14	11	10	7	18	12	13	9
15	16	4	11	5	18	9	14	8
16	11	4	9	5	20	8	15	6

Table A24

ANOVA summary table for unique stem completion with target, Experiment 3

Source	df	ss	ms	F	prob
Subjects	15	1023.984	68.266		
Study	1	1378.266	1378.266	344.656	.000
Error	15	59.984	3.999		
Time	1	58.141	58.141	3.823	.069
Error	15	228.109	15.207		
Study x Time	1	83.266	83.266	11.054	.005
Error	15	112.984	7.532		

Table A25

ANOVA summary table for multiple stem completion when target was written first, Experiment 3

Source	df	ss	ms	F	prob
Subjects	15	89.938	5.996		
Study	1	1173.063	1173.063	137.000	.000
Error	15	128.438	8.563		
Time	1	126.563	126.563	17.920	.001
Error	15	105.938	7.063		
Study x Time	1	162.563	162.563	19.997	.001
Error	15	121.938	8.129		

Table A26

ANOVA summary table for multiple stem completion when target was written at all, Experiment 3

Source	df	ss	ms	F	prob
Subjects	15	145.484	9.699		
Study	1	1359.766	1359.766	183.778	.000
Error	15	110.984	7.399		
Time	1	252.016	252.016	34.138	.000
Error	15	110.734	7.382		
Study x Time	1	129.391	129.391	18.778	.001
Error	15	103.359	6.891		

Table A27

ANOVA summary table for unique stem and multiple stem completion when target was written first, Experiment 3

Source	df	ss	ms	F	prob
Type of Stem	1	3190.008	3190.008	85.913	.000
Error	30	1113.922	37.131		
Study	1	2547.195	2547.195	405.557	.000
Stem x Study	1	4.133	4.133	.65	.424
Error	30	188.422	6.281		
Time	1	178.133	178.133	15.998	.000
Stem x Time	1	6.570	6.570	.590	.448
Error	30	334.047	11.135		
Study x Time	1	239.258	239.258	30.554	.000
Stem x Study xTime	1	6.570	6.570	.839	.367
Error	30	234.922	7.831		

Table A28

ANOVA summary table for unique stem and multiple stem completion when target was written at all, Experiment 3

Source	df	ss	ms	F	prob
Type of Stem	1	1937.531	1937.531	49.703	.000
Error	30	1169.469	38.982		
Study	1	2738.000	2738.000	480.439	.000
Stem x Study	1	.031	.031	.005	.942
Error	30	170.969	5.699		
Time	1	276.125	276.125	24.447	.000
Stem x Time	1	34.031	34.031	3.013	.093
Error	30	338.844	11.295		
Study x Time	1	210.125	210.125	29.138	.000
Stem x Study x Time	1	2.531	2.531	.351	.558
Error	30	216.344	7.211		