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ORIGINAL ARTICLE

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High-priority event instructions affect implicit and explicit memory tests

Abstract Previous work has shown that instructing subjects to give special priority to one target event in a list enhances recall for that event, but impairs recall for the events immediately preceding it (Tulving, 1969). We examined the benefit of high-priority instructions, and the retrograde amnesia for previous items, in three experiments that included two explicit tests of memory (free recall and cued recall with word-stem cues) and an implicit test (word-stem completion). Experiments 1 and 2 revealed a beneficial effect of high-priority instructions on memory for the target events in both free recall and primed word-stem completion. Retrograde amnesia for previous events was either absent (Experiment 1) or modest (Experiment 2) in free recall; however, no evidence for amnesia occurred on the implicit test. In Experiment 3, we asked if the benefit of high-priority instructions on the implicit test was due to contamination from intentional recollection, by employing the logic of the retrieval-intentionality criterion via a levels-of-processing manipulation. The results showed a beneficial effect of high-priority instructions on free recall, word-stem cued recall, and word-stem completion. Level of processing affected the two explicit tests, but not the implicit test, indicating that it induced incidental retrieval. We conclude that the benefit of high-priority instructions occurred on all three tests used in these experiments. In contrast, the phenomenon of retrograde amnesia occurred in free recall, but not in primed word-stem completion.

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Introduction

Retrograde amnesia refers to impaired memory for events occurring before some traumatic event, one that usually damages the brain. Typical events are a stroke, a tumor, neurosurgery, or a blow to the head. All such events may cause impaired memory for events happening before the trauma. Anterograde amnesia, in contrast, refers to impaired memory for events occurring after the trauma.

Tulving (1969) developed a laboratory analog of retrograde amnesia by replacing the traumatic event with an experimental event that required distinctive processing. His method was to present subjects with lists of 15 items for free recall. Some lists contained 15 common words, whereas others contained 14 common words and the name of a famous person (e.g., Columbus, Freud, Aristotle). Subjects were instructed to remember the items for a subsequent memory test, but to be especially sure to remember the famous names and to recall them first on the test. Thus the famous names were deemed high-priority events (a type of distinctive event; see Schmidt, 1991).

In two experiments, Tulving (1969) found that famous names were recalled much better than other words in the same serial positions in control lists (i.e., lists containing 15 common items). More interesting was the finding that when items were presented at a fast rate (0.5 s or 1 s per item), recall for the one or two items immediately preceding the famous names was lower than recall for the items in the same serial positions in control lists. Tulving called this effect "retrograde amnesia in free recall" and showed that it disappeared at a slower rate of presentation (2 s per item).

Researchers have replicated and extended Tulving's (1969) results using a variety of manipulations to instantiate high-priority events. Methods have included: (a) inserting a famous name into a list of otherwise common items (Saufley & Winograd, 1970; Schulz, 1971; Schulz & Straub, 1972); (b) underlining items

(Bellezza & Hofstetter, 1974) or circling them (Schmidt, 1990), or presenting items against a different-colored background (van Dam, Peeck, Brinkerink, & Gorter, 1974); and (c) instructing subjects to remember an item from a particular taxonomic category (Epstein, Ruggieri, & Schermerhorn, 1980; Fisk & Wickens, 1979).

This research has extended Tulving's (1969) results by showing, for example, that both enhanced memory for the high-priority events and amnesia for the events immediately preceding also occur on a recognition test (Schulz, 1971; Schulz & Straub, 1972). Saufley and Winograd (1970) showed that it is not necessary to tell subjects to remember the famous names to obtain the effects in free recall and in recognition, nor is it necessary to instruct subjects to recall the names first to get the effects in free recall (see too Schulz, 1971).

The impetus for the present research was to examine these phenomena on implicit memory tests (Schacter, 1987). A considerable amount of neuropsychological research has indicated that amnesic patients, who by definition perform poorly on explicit memory tests, show intact priming on many implicit memory tests (see Moscovitch, Vriezen, & Gottstein, 1993; Schacter, Chiu, & Ochsner, 1993; and Shimamura, 1986, for reviews). A first question in our research was whether Tulving's (1969) retrograde amnesia in free recall would similarly disappear on an implicit memory test. A second question was whether the high-priority event instructions would produce beneficial effects on implicit memory tests as they do on explicit memory tests. Before discussion of predictions about these manipulations, some discussion of our theoretical background is necessary.

Performance on explicit memory tests is generally believed to demonstrate intentional recollection on the part of the subject, whereas performance on implicit memory tests is believed primarily to reflect incidental retrieval (Roediger & McDermott, 1993). Although explicit and implicit tests may not purely reflect intentional and incidental retrieval, respectively, much evidence supports the notion that these two modes of retrieval produce distinctive patterns of performance. Within the category of implicit memory tests, one important distinction is between perceptual and conceptual tests (Blaxton, 1989; Jacoby, 1983; Roediger & Blaxton, 1987; Tulving & Schacter, 1990). In this article we shall be referring solely to perceptual implicit memory tests.

Perceptual implicit memory tests are distinguished from conceptual tests, both implicit and explicit, by the differential effects of many variables. For example, the standard manipulation of level of processing has a large effect on recall and recognition, but many experiments have shown little or no effect on perceptual priming (Graf & Mandler, 1984; Jacoby & Dallas, 1981; Roediger, Weldon, Stadler, & Riegler, 1992; but see Challis & Brodbeck, 1992, for an exception, and Brown & Mitchell, 1994, for further discussion). Similarly, Jacoby (1983) told subjects either to read or to generate words from conceptual clues at study. Generating benefited explicit memory as measured by a recognition test, but priming on a perceptual-identification test benefited more from reading words. Blaxton (1989) and Srinivas and Roediger (1990) found a similar dissociation using a free-recall test (generated words were recalled better than read words) and a word-fragment completion test (read words produced more priming than did generated words).

One interpretation of the dissociations between implicit and explicit measures of retention is in terms of the transfer-appropriate processing approach advocated by Roediger and his colleagues (e.g., Roediger, 1990; Roediger, Weldon, & Challis, 1989). This view is based on the notion that performance on a retention test benefits to the extent that the procedures required by the test recapture the initial encoding operations (the assumption of transfer-appropriate processing, or encoding specificity). Further, this approach distinguishes between perceptual (or data-driven) and conceptual (or conceptually driven) processes. Explicit and implicit tests may be either conceptual or perceptual, but in the great majority of previous research, there has been a correlation such that explicit memory tests have placed a heavy reliance on conceptual processing, whereas implicit memory tests have emphasized perceptual processing. The levels-of-processing manipulation for example, is considered to vary conceptual processing, and consequently to show large effects on conceptual tests. However, because the actual stimuli (or data) provided during encoding in the levels-of-processing manipulations are the same, little effect occurs on perceptual implicit tests. Similarly, generating a word is thought to involve more conceptual elaboration than reading it, and hence transfers better to conceptual tests. However, reading a word out of context involves focusing on perceptual features, or engaging in bottom-up processing. Therefore prior reading of words transfers better to data-driven tests such as identifying words from brief displays or from their fragmented forms than does generating words from conceptual clues (Blaxton, 1989; Jacoby, 1983; Srinivas & Roediger, 1990).

Applying the transfer-appropriate processing framework to Tulving's (1969) retrograde amnesia in free recall, we can make one unambiguous prediction: The retrograde-amnesia phenomenon should not occur on a perceptual implicit memory test. The reason is that perceptual processing of the earlier words has already been completed at the time the high-priority event is presented. Therefore, any effect of the high-priority event would be on rehearsal or elaboration or other post-perceptual processes. There should be intact priming on a perceptual implicit memory test for the items presented before the high-priority event. Experimentally induced amnesia should show the same pattern of performance as the clinical kind from brain-damaged patients: impaired retention on explicit tests, but intact retention on perceptual implicit tests.

Making predictions about the effect of high-priority processing of the target event itself is more difficult, because the nature of enhanced processing is uncertain. The effects of a high-priority event on an implicit memory test will probably depend on both the nature of the high-priority event and on the type of implicit memory test. Specifically, if high-priority instructions cause subjects to process conceptual features of the high-priority event more thoroughly than usual, then enhanced performance on a conceptual test would be expected. Alternatively, if high-priority instructions also cause subjects to engage in extra perceptual processing of the high-priority event, then enhanced performance on a perceptual test would be expected. We should note that Tulving's (1969) famous names were perceptually distinctive as well as conceptually distinctive, because the famous names were the only items that were capitalized, and they were from a different category than were the other items in the list.

The present experiments investigated the effects of high-priority events on a perceptual implicit memory test (word-stem completion), a conceptual explicit memory test (free recall), and an explicit test believed to have both perceptual and conceptual components (word-stem cued recall; see Weldon, Roediger, & Challis, 1989, for evidence that word-stem cued recall has both perceptual and conceptual components). Subjects studied lists of words, with each list containing one animal, one sport, and additional words from various other categories. In accordance with instructions, half of the subjects treated the animals as high-priority events and half treated the sports as high-priority events. We compared intentional recollection (on the free-recall and word-stem cued recall tests) and incidental priming (on the word-stem completion test) for both the high-priority events and several preceding and following events to recall and priming for these same events when subjects were not given high-priority instructions.

Experiment 1

Method

Design and subjects. Forty-eight Rice University undergraduates participated in partial fulfillment of a psychology course requirement and were tested in groups of 1 to 4.

Each subject studied 12 lists containing one animal, one sport, and 13 other words. Half of the subjects were told that animals were high-priority events, and half were told that sports were high-priority events. For subjects treating animals as high-priority events, the sports were control items, and for subjects treating sports as high-priority events, the animals were control items. The serial positions of interest were those corresponding to the animal, the sport, and the two items before and the two items after each animal and sport. The preceding and succeeding items permitted examination of experimental retrograde and anterograde amnesia, respectively. The animal and the sport always appeared in the 5th and 11th serial positions in a list, and animals and sports appeared in each of these serial positions equally often. Finally, subjects were given free-recall tests after half of the lists and word-stem completion tests after the other half of the lists.

To summarize, the design can be considered a $2 \times 5 \times 2$ within-subjects factorial, varying the factors of Type of Target (high-priority event, control event), Serial Position (two before, one before, target, one after, two after), and Type of Test (free recall, word-stem completion). The targets were the animal and the sport in each list, one of which was the high-priority event and the other of which was the control event, depending on instructions given to subjects.

Materials and list construction. Eighteen lists, with 15 words per list, were constructed. Items were selected from several sources (Battig & Montague, 1969; McClelland & Pring, 1991; Snodgrass & Vanderwart, 1980; Weldon & Roediger, 1987). All items were common nouns or color names and were at least five letters in length. No two items of the 270-item pool began with the same first three letters, to insure that each three-letter word-stem in the word-stem completion tests would be unique in the experiment. Each 15-item list consisted of 13 items from various taxonomic categories, plus one item from the category *animals* and one item from the category *sports*.

Each subject studied 12 of the 18 lists. Six lists were followed by free-recall tests, and six by word-stem completion tests. Words from the remaining six lists comprised the nonstudied (i.e., baseline) items for the word-stem completion tests. Each set of six lists served each function (i.e., free recall, word-stem completion, nonstudied baseline) equally often.

Procedure. All instructions were presented orally by the experimenter. Subjects were instructed to try to remember the words, because they would be given a memory test after some lists. After other lists they would not be given a memory test, but instead they would be given word puzzles to solve. Subjects were informed that they would not know if they would be given a memory test until after a list had been presented. Subjects were also told to be especially sure to remember either the animal (animals condition) or the sport (sports condition) in each list.

Items for each list were presented one at a time, at a 1-s rate, on a computer monitor. Lists and items were presented in the same random order, except for the position of the animal and the sport in each list, for all subjects studying the same lists.

After each of six lists, subjects were told to free recall, on a blank sheet of paper, as many items from the preceding list as possible. Subjects were given 3 min and 20 s to do this task.

After each of the other six lists, subjects were given a word-stem completion test in which they were given 25 three-letter word stems and told to complete each stem with the first word that came to mind. Subjects were given 3 min and 20 s to do this task. Every 8 s during this period the computer beeped, at which time subjects began to work on the next word-stem.

On each word-stem completion test, 10 stems corresponded to words presented in the preceding list, and 15 were new (corresponding to items from one of the six nonstudied lists). The 10 old stems corresponded, specifically, to the animal, the sport, and the two items before and the two items after each animal and sport.

The first 5 stems were nonstudied words. Of the remaining 20 stems, no more than 3 corresponding either to studied words or to nonstudied words appeared consecutively. This procedure was followed to minimize subjects' noticing that studied words corresponded to stems on the test, and to discourage subjects' invoking conscious recollection in performing the test. Beyond these restrictions, the order of the stems was randomly determined and was the same for all subjects studying the same lists.

Subjects were told that their task was to complete each stem with the first word that came to mind, but that it was acceptable to write down a word that had been presented in a previous list. This instruction was similar to that of Tulving, Schacter, and Stark (1982), who told subjects that some word fragments at test did

Table 1 Performance on critical items and control items in free recall and in word-stem completion in Experiment 1

	Free Recall			Word-Stem Completion		
Item	Critical	Control	D	Critical	Control	D
− 2	.33	.36	− .03	.29	.29	.00
− 1	.34	.30	.04	.34	.33	.01
Animal/Sport	.88	.33	.55	.51	.32	.19
+ 1	.40	.34	.06	.40	.39	.01
+ 2	.37	.33	.04	.39	.40	− .01
Nonstudied				.22	.19	

Note. The word-stem completion scores are priming scores obtained by subtracting completion of nonstudied words from completion of studied words. D refers to the difference score obtained by subtracting proportion completed of control items from critical items

correspond to studied words, but that they should complete each fragment with the first word that came to mind. Bowers and Schacter (1990) have advocated the use of this instructional set.

The order of the 12 tests was as follows: 2 free recall, 1 word-stem completion, 1 free recall, 3 word-stem completion, 3 free-recall, and 2 word-stem completion. This order was determined randomly and was the same for all subjects.

At the end of the experiment, subjects answered a questionnaire asking if they had noticed any relation between studied words and words completed on the word-puzzle task, their strategy in completing word stems, if they had completed word stems with studied words, and if they had tried to complete word stems with studied words.

Results

The t tests used for data analysis were one-tailed, because all predictions specified the direction of the expected difference. The alpha level for inferring statistical significance was .05.

The primary results are presented in Table 1, with free recall on the left and word-stem completion on the right. Across subjects, the results are averaged over the animal or sport in each list and the two items preceding (− 2, − 1) and the two items following (+ 1, + 2) the animal and sport. The results are also collapsed across the high-priority event position (5th, 11th) in each list (and surrounding positions) because examination of the data showed little difference between these list positions. Critical items refer to animals (and surrounding items) for subjects given high-priority instructions involving animals and to sports (and surrounding items) for subjects given high-priority instructions involving sports. Control items refer to sports (and surrounding items) for subjects given high-priority instructions for animal names and to animals (and surrounding items) for subjects given high-priority instructions for names of sports. The difference scores indicate the effect of the high-priority event (presumably a positive difference score) and, for items in the surrounding positions, any indication of retrograde amnesia (for the − 2 and − 1 items) and anterograde amnesia (for the + 1 and + 2 items), as reflected by negative difference scores.

The results in Table 1 show a large effect of the high-priority event in free recall, with a .55 difference between the critical and control target items, $t(47) = 16.61$, $SE = .03$. On the other hand, there is little indication of amnesia for the background items. The − .03 difference score in the − 2 position was not significant, $t(47) = -.79$, $SE = .04$. Thus, although we obtained a sizable effect of the high-priority event instruction on the critical item, there was no hint of retrograde or anterograde amnesia for the background items.

The primed word-stem completion results appear on the right side of Table 1 and were computed in a similar way to those for free recall. The nonstudied baseline measures were obtained by computing the probability of completing 10 word stems for items from comparable positions in lists that had not been studied. Note that all priming scores in Table 1 were far greater than zero, indicating considerable overall priming. There was an effect of the high-priority event in primed word-stem completion, with a .19 difference between the critical and control target items, $t(47) = 3.06$, $SE = .06$. There was no indication of any difference in priming for the critical and control background items, as the − .01 difference score in the + 2 position was not significant, $t(47) = -.26$, $SE = .05$.

In summary, the results of Experiment 1 showed a large high-priority event effect in free recall and a smaller effect in primed word-stem completion. However, no evidence of retrograde amnesia occurred in free recall. Given that we were not able to replicate Tulving's (1969) results in free recall, it hardly comes as a surprise that retrograde amnesia was not obtained in primed word-stem completion. We conducted Experiment 2 in another attempt to produce retrograde amnesia in free recall.

The important details of Experiment 2 were identical to those of Experiment 1, except that we increased the presentation rate from 1 s per item to .5 s per item. Tulving (1969) showed that the phenomenon of retrograde amnesia in free recall was sensitive to rate of presentation. Although the 1-s rate of Experiment 1 fell

Table 2 Performance on critical items and control items in free recall and in word-stem completion in Experiment 2

	Free Recall			Word-Stem Completion		
Item	Critical	Control	D	Critical	Control	D
-2	.17	.16	.01	.29	.33	$-.04$
-1	.13	.19	$-.06$	.36	.35	.01
Animal/Sport	.83	.25	.58	.69	.42	.27
$+1$	.18	.13	.05	.34	.30	.04
$+2$	.13	.11	.02	.31	.32	$-.01$
Nonstudied				.16	.17	

Note. The word-stem completion scores are priming scores obtained by subtracting completion of nonstudied words from completion of studied words. D refers to the difference score obtained by subtracting proportion completed of control items from critical items.

within the boundary conditions under which Tulving had obtained the effect, we decided to increase the rate of presentation in Experiment 2 in hopes of producing robust retrograde amnesia in free recall.

Experiment 2

Method

Design and subjects. The design was identical to that of Experiment 1. Subjects were 48 Air Force recruits on their 11th day of basic training at Lackland Air Force Base who participated as part of a basic training requirement. Subjects were tested in a group of 40 subjects on one day and another group of 8 subjects on the next day.

Materials. The materials were identical to those in Experiment 1.

Procedure. The procedure was identical to that in Experiment 1, with the following exceptions: (1) all instructions were presented on the computer; (2) subjects were given one practice trial with each type of test; (3) list items were presented at a .5-s rate; and (4) no mention was made of the relation between study words and test stems.

Results

The results for both free recall and primed word-stem completion are presented in Table 2. Data were computed as described for Experiment 1. Free-recall results showed a .58 high-priority event effect, $t(47) = 16.60$, $SE = .04$. In addition, retrograde amnesia is apparent for the item immediately preceding the critical target item. Recall in the control condition averaged .19, whereas in the critical condition it was .13, for a difference of .06. The retrograde amnesia for the item immediately preceding the critical target item was significant, $t(47) = -2.10$, $SE = .03$.

Word-stem completion results showed a .27 high-priority event effect, $t(47) = 5.03$, $SE = .05$. However, no retrograde or anterograde amnesia was apparent. Neither the $-.04$ difference at position -2, $t(47) = -.75$, $SE = .06$, nor the $-.01$ difference at position $+2$, $t(47) = -.15$, $SE = .05$, was significant.

Another comparison of interest occurs between the data of Experiment 1 (Table 1) and those of Experiment 2 (Table 2). The primary change between experiments was in presentation rate, which was doubled in Experiment 2 (from 1 s per item to 0.5 s per item). This change had a large effect on free recall, but no effect on priming in the word-stem completion test. Averaging over the background and control items, the mean proportion of items free recalled was .34 in Experiment 1, but only .16 in Experiment 2. Amount of priming from these two experiments was the same, however, at .35 and .34, respectively. From this cross-experiment comparison, we see that presentation rate has a large effect on an explicit memory test, but no effect on priming. The results agree with other findings (Roediger & McDermott, 1993).

In summary, the results of Experiment 2 showed a large effect of high-priority event instructions in free recall and a modest retrograde amnesia effect for items in the preceding position in free recall. In word-stem completion, there was a high-priority event effect on the critical target items, but no amnesia for the background items. Therefore, in Experiment 2 we succeeded in showing retrograde amnesia in free recall and its elimination in primed word-stem completion. However, the retrograde-amnesia effect was not particularly striking in free recall. In both Experiments 1 and 2 we did find a high-priority event effect in primed word-stem completion (.19 in Experiment 1 and .27 in Experiment 2) and thus we made this the object of our study for Experiment 3.

Experiment 3

The finding of a high-priority event effect in primed word-stem completion in Experiments 1 and 2 is difficult to interpret in terms of transfer-appropriate processing theory, because the nature of the encoding operations for high-priority events is unclear. If subjects process high-priority events more conceptually or elaborately, then obtaining a high-priority event effect in primed word-stem completion (a perceptual implicit-memory test) is inconsistent with Roediger's (1990) transfer-appropriate processing theory. One could imagine, however, that high-priority event instructions also affect the perception of the target word, leading to more thorough perceptual processing (people might examine the word longer and encode more perceptual features). If this is the case, then a high-priority event effect would be interpretable within transfer-appropriate processing theory. We see no easy way to decide between these two possibilities. However, a third interpretation is also possible: The effect may have arisen because subjects invoked intentional recollection during the course of the experiment and recalled the high-priority event better than the control items. If so, then the effect would have arisen in word-stem completion for the same reason that it occurred in free recall, that is, via intentional recollection.

Many researchers have worried that ostensibly implicit memory tests may be compromised by subjects' invoking intentional recollection during the course of the test. That is, once subjects notice a relation between the study list and the items they are producing on the test, they may abandon the strategy of generating the first word that comes to mind and instead deliberately try to recollect items in response to test cues.

We believe that this problem is not too serious in most experiments, but the conditions of our first two experiments were atypical and they may have served to encourage deliberate recollection. For example, in most implicit-memory experiments, subjects study one long list of items and take one test. However, in our experiments, subjects studied 12 lists and we interleaved free-recall tests with word-stem completion tests. Because the relation between study and test was transparent to subjects in the case of free recall, they may have been more likely to adopt a similar retrieval strategy in word-stem completion. We assumed that subjects would not invoke intentional recollection, however, because word-stem completion is so easy without reference to the study list. Each stem can be completed by many words, so we assumed that subjects would follow the law of least effort and obey our instructions.

We provided post-experimental questionnaires to subjects about their strategies, but the data we obtained were complex and difficult to interpret. Subjects reported various strategies, but these did not seem to correlate with their overt behavior. We suspect that it is difficult or impossible for subjects to report accurately, retrospectively, about processes used during the test.

One bit of evidence that subjects did not use intentional recollection was reported in the comparison of Experiments 1 and 2. Presentation rate greatly affected free recall, but not primed word-stem completion. If the word-stem completion tests were compromised by intentional recollection, we would have expected to see an effect of presentation rate on performance (see Roediger & McDermott, 1993). This outcome provides some evidence that the implicit tests were not compromised, but we sought more evidence in Experiment 3.

To this end, we used a procedure introduced by Graf and Mandler (1984) to index the degree of contamination by intentional recollection on a priming test. Schacter, Bowers, and Booker (1989) referred to their logic as "the retrieval intentionality criterion".

In Graf and Mandler's (1984) Experiment 3, subjects studied a list of words and, through instructions, processed each word either semantically (subjects rated how much they liked or disliked each word) or non-semantically (subjects counted the number of totally enclosed spaces and the number of times that two lines intersected in each word). At test, subjects were given word stems corresponding to the studied words. Half of the subjects were told to complete each stem with the first word that came to mind (implicit-test instructions) and half were told to use the stems as cues to recall the studied words (explicit-test instructions).

Graf and Mandler (1984) found a levels-of-processing effect (i.e., semantic processing produced better performance than did nonsemantic processing) when subjects were given explicit-test instructions, but little or no effect when subjects were given implicit-test instructions. Because all study and test conditions were held constant except for the instructions given before the test, Graf and Mandler concluded that the implicit memory test was not compromised by intentional recollection. If it had been, then a levels-of-processing effect should have occurred on the implicit test as it did on the explicit test. Therefore, the implicit and explicit tests were dissociated through manipulation of test instructions, with all other conditions held constant. Roediger et al. (1992) replicated Graf and Mandler's (1984) results and extended them to primed word-fragment completion, which was also shown to be an implicit test under their conditions. Others have also successfully met the retrieval-intentionality criterion (e.g., Craik, Moscovitch, & McDowd, 1994; Java, 1994).

In Experiment 3, we applied the logic of the retrieval-intentionality criterion to determine if the high-priority event effect in word-stem completion in Experiments 1 and 2 was due to contamination by intentional recollection. We conducted an experiment similar to the first two, but we manipulated level of processing at study, and we gave subjects word-stem cues with either explicit or implicit instructions at test. We expected a high-priority event effect, and a levels-of-processing effect, in both explicit memory tests of free recall and word-stem cued recall. A high-priority event effect in word-stem completion, with no levels-of-processing effect on this test, would indicate that the high-priority event effect in word-stem completion in

Experiments 1 and 2 was not due to intentional recollection. A high-priority event effect accompanied by a levels-of-processing effect in word-stem completion would indicate, however, that the high-priority event effect in word-stem completion in Experiments 1 and 2 might be due to intentional recollection.

Method

Design and subjects. Ninety-six Air Force recruits on their 11th or 20th day of basic training at Lackland Air Force Base in San Antonio, TX, participated as part of a basic training requirement. Each subject studied lists containing one animal, one sport, and 14 other words. Half of the subjects were told that animals were high-priority events, and half were told that sports were high-priority events. For subjects treating animals as high-priority events, the sports were control items, and for subjects treating sports as high-priority events, the animals were control items. The serial positions of interest were those corresponding to the animal and the sport. However, for continuity with our earlier experiments, we also examined the two items before and the two items after each animal and sport. The animal and sport always appeared in the 6th and 11th serial positions in a list, and animals and sports appeared in each of these serial positions equally often.

Subjects answered an orthographic question about half of the items in each list (i.e., How many vowels are in the word?), to induce a shallow level of processing, and a semantic question about the other items (i.e., How pleasant is the word?), to induce a deep level of processing. Across all subjects, each item was accompanied by each type of question equally often. Subjects were given free-recall tests after half of the lists and word-stem tests after half of the lists, with 72 subjects receiving word-stem completion tests and 24 subjects receiving word-stem cued recall tests.

To summarize, the design can be considered a $2 \times 2 \times 5 \times 2$ within-subjects factorial, varying the factors of Level of Processing (orthographic, semantic), Type of Target (high-priority event, control event), Serial Position (two before, one before, target, one after, two after), and Type of Test (free recall, word stem), with 72 subjects getting implicit tests of word-stem completion, and 24 getting explicit tests of word-stem cued recall. The targets were the animal and the sport in each list, one of which was the high-priority event and the other of which was the control event, depending on instructions given to subjects.

Materials. Twelve lists, with 16 words per list, were constructed. Items were a subset of those used in Experiments 1 and 2. Each 16-item list consisted of 14 items from various taxonomic categories, plus one item from the category *animals* and one item from the category *sports*.

Each subject studied 8 of the 12 lists; 4 lists were followed by free-recall tests, and 4 were followed by either word-stem completion tests or word-stem cued-recall tests. Words from the remaining 4 lists comprised the nonstudied (i.e., baseline) items for the word-stem completion and word-stem cued-recall tests. Each set of 4 lists served each function (i.e., free recall, word-stem completion and word-stem cued recall, nonstudied baseline) equally often.

Procedure. All instructions were presented on the computer. Subjects were told that they would be asked a question about each word to appear on the screen. Specifically, they would be asked either to count the number of vowels in the word or to rate the pleasantness of the word. Subjects responded to both questions by pressing a key, from 1 to 7, on the keyboard, to indicate either the number of vowels or the pleasantness of the word (1 = very unpleasant, 7 = very pleasant).

Subjects in the word-stem cued-recall group were instructed to try to remember the words because they would be given a memory test after every list. Subjects were also told to be especially sure to remember either the animal (animals condition) or the sport (sports condition) in each list. Subjects in the word-stem completion group were given the same instructions as in Experiments 1 and 2.

After subjects had been given one practice trial with each type of list (free recall and either word-stem completion or word-stem cued recall), items for each list were presented one at a time, for 8 s, on a computer monitor. (We used the longer presentation time because we were no longer interested in producing retrograde amnesia, and to provide enough time for subjects to answer the orienting question.) Lists and items were presented in the same random order, except for the position of the animal and the sport in each list, for all subjects studying the same lists.

After each of four lists, subjects were told to free recall, on a blank sheet of paper, as many items from the preceding list as possible. Subjects were given 5 min and 20 s to do this task.

After each of the other four lists, subjects were given either a word-stem completion test or a word-stem cued-recall test, consisting of 40 three-letter word stems. Subjects in the word-stem completion group were told to complete each stem with the first word that came to mind. Subjects in the word-stem cued-recall group were told to use the 40 stems as cues for recall of the studied words, and not to complete a stem with a word unless the word had been studied in the immediately preceding list. Subjects were given 5 min and 20 s to do this task.

On each word-stem test, 16 stems corresponded to words presented in the preceding list, and 24 stems were new (corresponding to 8 filler items and 16 items from one of the four nonstudied lists). The proportion of old stems was the same in this experiment (16/40 = .40) as in Experiments 1 and 2 (10/25 = .40). The first 8 stems were the filler items, and of the remaining 32 stems, no more than 3 corresponding either to studied words or to nonstudied words appeared consecutively. Beyond these restrictions, the order of the stems was randomly determined and was the same for all subjects studying the same lists.

The order of the eight tests was as follows: two free recall, two word-stem completion or cued recall, one free recall, two word-stem completion or cued recall, and one free recall. This order was determined randomly and was the same for all subjects.

Results and discussion

The levels-of-processing results for Experiment 3 are presented in Table 3. The data are based on the background items in each list, that is, the eight items surrounding the animal and the sport items. Half of these received shallow, orthographic processing (vowel counting), and the other half received deep, semantic processing (pleasantness rating). The results show a .11 levels-of-processing effect in free recall, a .11 effect in word-stem cued recall, but no effect in word-stem completion (actually, shallow processing led to .01 greater performance than deep processing), $t(95) = 5.98$, $SE = .02$ (free recall), $t(23) = 2.51$, $SE = .04$ (word-stem cued recall), and $t(71) = -.19$, $SE = .03$ (word-stem completion). The instructions to subjects therefore succeeded in meeting the retrieval-intentionality criterion.

We did not examine data from the background items for retrograde amnesia. Because of the slow presentation rate (8 s per item) necessary for subjects to complete the levels-of-processing task, no amnesic effect was expected.

Table 3 Levels-of-processing effects for the eight background items in Experiment 3 on the three types of test

	Shallow	Deep	Difference
Free Recall	.29	.40	.11
Word-Stem Cued Recall	.55	.66	.11
Word-Stem Completion	.37	.36	−.01

Note. The word-stem completion and word-stem cued-recall scores are priming scores obtained by subtracting completion of nonstudied words from completion of studied words. Difference refers to the difference score obtained by subtracting proportion completed of control items from critical items. The average nonstudied base rate was .20 in word-stem completion and .02 in word-stem cued recall

The only difference between word-stem completion and word-stem cued recall was in the nature of the instructions given just before the test, which were obviously quite effective. In word-stem cued recall, subjects completed only .02 of nonstudied items and showed a levels-of-processing effect. In word-stem completion, subjects completed .20 of nonstudied items and did not show any levels-of-processing effect. Given that the experiment succeeded in eliminating intentional retrieval from the word-stem completion test, we examined whether a high-priority event effect occurred under these conditions.

The data relevant to the high-priority event effect are presented in Table 4. The critical target item refers to the item in each list to which subjects were to pay special attention, whereas the control target item is the one that was critical for other subjects. The high-priority event effect refers to the difference between the critical and control target items. The free-recall results indicate, once again, a large high-priority event effect, with a .40 effect in the shallow processing condition, $t(95) = 9.37$, $SE = .04$, and a .48 effect in the deep processing condition, $t(95) = 12.49$, $SE = .04$.[1] The word-stem cued-recall results also show a consistent high-priority event effect, with a .19 effect in the shallow-processing condition, $t(23) = 1.99$, $SE = .09$, and a .17 effect in the deep-processing condition, $t(23) = 1.88$, $SE = .09$.The intrusion rate for the stems presented on the test for items that were not studied averaged between .00 and .02 for the various conditions, so the high-priority event effect in word-stem cued-recall seems to be a genuine effect of intentional recollection.

The word-stem completion results are not as consistent as the free-recall and word-stem cued-recall results, yet they seem to agree with the results of Experiments 1 and 2 in showing that a high-priority event effect exists in primed word-stem completion. The effect was .15 in the shallow-processing condition, $t(71) = 1.88$, $SE = .08$, but only .03 in the deep-processing condition, $t(71) = .34$, $SE = .08$. However, there are several reasons for suspecting that the results for the deep-processing condition are anomalous and that a true effect of high-priority instructions exists in primed word-stem completion. First, the conditions of Experiment 3, and especially the deep-processing condition, were similar to the intentional-learning conditions of Experiments 1 and 2, where there was a beneficial effect of high-priority instructions. Second, examination of the word-stem completion data in Table 4 indicates that the lack of a high-priority event effect in the deep-processing condition was due to especially good performance on control items (compared to the earlier experiments and to the background and other control items of Experiment 3), and not to especially poor performance on critical items. Third, as there was no overall effect of level of processing in word-stem completion in Experiment 3 for the background items, the difference between the control items processed to shallow (.36) and deep (.47) levels seems curious. We conclude that a true effect of high-priority instructions probably exists in primed word-stem completion, even under deep-processing conditions.

In conclusion, the results of Experiment 3 showed that the word-stem completion test was not compromised by intentional recollection, because no levels-of-processing effect was observed for the background items. However, an effect of high-priority events remained, at least under shallow-processing conditions, so a genuine effect exists in a perceptual implicit memory test. Although the high-priority event effect in word-stem completion in the deep-processing

Table 4 The high-priority event effect for the three tests in Experiment 3 as a function of type of processing at study

	Target		Background	
	Critical	Control	Critical	Control
Free Recall				
Shallow	.80	.40	.26	.31
Deep	.85	.37	.39	.40
Word-Stem Cued Recall				
Shallow	.88	.69	.57	.52
Deep	.94	.77	.67	.64
Word-Stem Completion				
Shallow	.51	.36	.36	.37
Deep	.50	.47	.36	.35

Note. The word-stem completion and word-stem cued recall scores are priming scores obtained by subtracting completion of nonstudied words from completion of studied words. The average nonstudied base rate was .20 in word-stem completion and .02 in word-stem cued recall

[1]The terms *shallow* and *deep* are probably misnomers for the critical high-priority items. Instructions directing subjects to pay special attention to these items encouraged deep processing in all cases, regardless of whether subjects performed the semantic or the nonsemantic task. For this same reason, it makes little sense to examine levels-of-processing effects for critical items

condition of Experiment 3 was not significant, the effect appears to be genuine because of convergence of the results of Experiments 1 and 2 where the results were significant. Although we did not have conditions built into Experiments 1 and 2 to rule out the possibility of intentional recollection producing the results, the conditions of Experiment 3 were generally the same (except for the presentation rate and the manipulation of levels of processing) as those of Experiments 1 and 2. Indeed, the critical condition in Experiment 3, where word-stem completion tests were interleaved with free-recall tests, employed the same arrangement as in Experiments 1 and 2. In Experiment 3, under these conditions, no effect of intentional recollection was apparent. Thus we conclude that the high-priority event effect does occur in primed word-stem completion.

General discussion

The primary impetus for the present experiments was to replicate the phenomenon of retrograde amnesia in free recall discovered by Tulving in 1969 and to see if it would disappear on a perceptual implicit memory test. Unfortunately the retrograde-amnesia phenomenon did not occur in free recall in Experiment 1, and therefore its absence in primed word-stem completion was not surprising. In Experiment 2, we increased the rate of presentation, and retrograde amnesia did occur, but only for the item immediately preceding the high-priority event. Although the phenomenon was slight, it did (as was predicted) disappear on the word-stem completion test.

So, pending further research, another analog between clinical and experimental amnesia has been established: Retrograde amnesia in free recall from a high-priority event does not extend to a perceptual implicit memory test. Performance on the implicit memory test was intact under the same conditions that produced amnesia in free recall. Of course, this conclusion remains tentative, given our slight effect in free recall, and must be examined in future research.

It is unclear why we did not obtain more robust retrograde amnesia in free recall. Unlike Tulving's (1969) experiments and others, the high-priority events in our experiments were physically similar to the other events subjects studied. The events were of high priority because of instructions to subjects to pay special attention to the items representing either animals or sports. However, this change does not seem to have been too important, in that the high-priority event effect was quite robust in free recall. In all of the experiments, subjects recalled the high-priority events over 50% better than they recalled the control events, and even then we were probably flirting with a ceiling effect in the high-priority event condition. Although the retrograde-amnesia phenomenon was not as striking in free recall as in most previous work, the important point is that when it did occur, it did not occur on the word-stem completion test. This prediction is in line with Roediger's (1990) transfer-appropriate processing notion, as well as related ideas of Tulving and Schacter (1990). Perceptual implicit memory tests rely on data-driven processing – or, as Kirsner and Dunn (1985) put it, the perceptual record of experience – and therefore should be affected by perceptual factors. The high-priority event occurred after preceding items had been accurately perceived and therefore should not have affected performance on these tests, which is just what happened.

Predictions were less clear for the high-priority event effect itself. The high-priority events were recalled well in all three experiments in free recall and, in Experiment 3, in word-stem cued recall. In addition, all three experiments showed a high-priority event effect in primed word-stem completion, although the magnitude of the effect varied across experiments. In Experiments 1 and 2, we could not rule out the possibility that the high-priority event effect was due to subjects' invoking intentional recollection while performing the test, although the fact that changes in the presentation rate in Experiments 1 and 2 did not affect priming made it seem unlikely. In Experiment 3, we employed the logic of the retrieval-intentionality criterion to examine this possibility. We manipulated level of processing at study, and provided subjects with word stems with either explicit or implicit instructions at test. The high-priority event effect occurred in word-stem cued recall, but it was more variable in word-stem completion (a .15 effect in the shallow-processing condition and a .03 effect in the deep-processing condition). Although the latter effect was not significant, we conclude from all three experiments that a high-priority event effect probably exists in primed word-stem completion, although it is of smaller magnitude than in free recall, to the extent that one can directly compare the tests.

The high-priority event effect in primed word-stem completion may be due to: (a) enhanced perceptual processing of the high-priority event; (b) enhanced conceptual processing of the event; or (c) to both factors. If the high-priority event effect was due to perceptual factors, then the effect could readily be encompassed by Roediger's (1990) transfer-appropriate processing view of dissociations between implicit and explicit tests. However, if the high-priority event effect was due to conceptual factors, and these appeared on a perceptual priming test, then the evidence would be interpreted against Roediger's theory. However, at present it is impossible to decide between these alternatives. Our best guess is that the high-priority event effect is due both to conceptual factors and to perceptual factors, because it occurred both in free recall and in primed word-stem completion.

A further contribution of the present research, if it can be confirmed in future studies, is that it is possible to conduct implicit memory tests over multiple

Table 5 Proportion of items recalled in free recall and priming in word-stem completion for background and control items as a function of presentation rate in Experiments 1, 2, and 3

	Presentation Rate (s)		
	.5[a]	1[b]	8[c]
Free Recall	.16	.34	.39
Word-Stem Completion	.34	.35	.37

[a]Experiment 2 data
[b]Experiment 1 data
[c]Experiment 3 data, deep-processing condition

study-test trials on different lists. In the three experiments, implicit memory tests were given after each of either four or six lists. In addition, these tests were interleaved with explicit (free-recall) tests that followed other lists. Although this procedure would seem to alert subjects to the fact that test stems were related to the words they had recently studied, we were able to show that even this procedure met the retrieval-intentionality criterion. In Experiment 3, we manipulated the level of processing and showed that semantic processing produced better performance than did orthographic processing on the word-stem cued-recall test, but no difference (actually a slight and nonsignificant reversal) occurred on the implicit word-stem completion test. Therefore, even under conditions in which implicit and explicit tests were interleaved repeatedly, subjects did not appear to invoke intentional recollection in completing the word stems. This may be because word-stem completion is a relatively easy task and subjects can complete the stems with numerous words. Subjects probably become aware that items completed on the word-stem completion test are from the list recently studied, but if they do not alter their approach to the test, it still measures incidental retrieval (see Richardson-Klavehn, Gardiner, & Java, 1994).

Another aspect of the data that bolster this conclusion is the differential effect of presentation rate on the two tests. Shown in Table 5 are free recall and primed word-stem completion for the three experiments as a function of presentation rate, combining over the other variables.[2] Changing the rate had a huge effect on free recall (an increase of 150% from 0.5 s to 8 s), but a negligible effect on primed word-stem completion. Because presentation rate typically affects performance on explicit tests, but not on perceptual priming tests (Roediger & McDermott, 1993), we again conclude that the word-stem completion test was not affected by conscious recollection in our experiments.

[2]We used only the semantically processed items from Experiment 3, on the assumption that they were the more appropriate comparison for the intentional-learning conditions of Experiments 1 and 2

In summary, we showed that retrograde amnesia in free recall did not extend to a primed word-stem completion task. The item immediately preceding the high-priority event in Experiment 2, which showed poorer free recall, produced just as much priming as did a control item. However, the high-priority event effect itself did extend from free recall to primed word-stem completion, even under conditions in which intentional retrieval could be ruled out as producing the effect. The interpretation of the high-priority event effect as an implicit memory phenomenon is ambiguous at this point and must await future research.

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