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# Implicit Memory and Test Awareness

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In three experiments we examined whether normal subjects can perform an implicit test without becoming aware that the test items were previously encountered in the study phase of the experiment. Experiment 1 assessed single word priming with the stem completion task, and subjects who reported awareness/unawareness that the test items were previously encoded in the study task showed equivalent priming. Experiments 2a–c and 3 assessed associative priming with the stem completion task, and in this case, only subjects who were aware that the test items were previously encountered showed associative priming effects. These findings suggest that single word priming and associative priming reflect different memory processes because the former and not the latter effect can be observed in unaware subjects.

Information acquired during a single episode can facilitate performance on a number of tests that do not make explicit reference to the study episode, such as word-stem and fragment completion (e.g., Graf, Mandler, & Haden, 1982; Tulving, Schacter, & Stark, 1982), word identification (e.g., Feustel, Shiffrin, & Salasoo, 1983, Jacoby & Dallas, 1981), and lexical decision (e.g., Scarborough, Gerard, & Cortese, 1979). This facilitation of test performance has been labeled *repetition* or *direct* priming (cf. Cofer, 1967), and it occurs without deliberate intent to recollect the past episode. Graf and Schacter (1985) have used the descriptive terms *explicit* and *implicit* to describe the forms of memory involved in recall/recognition and priming performance, respectively.

A growing body of evidence indicates that implicit and explicit memory can be dissociated experimentally in normal subjects (for review, see Richardson-Klavehn & Bjork, 1988; Schacter, 1987; Tulving & Schacter, 1990). Moreover, several studies have demonstrated robust and even normal priming in brain-damaged amnesic patients who perform at or close to chance levels on explicit recognition tests (e.g., McAndrews, Glisky, & Schacter, 1987; Squire, Shimamura, & Graf, 1985; Warrington & Weiskrantz, 1974). These findings are particularly striking because they suggest that amnesic patients can show priming on implicit tests without any awareness that the primed items were part of the prior study episode. In contrast, there is little direct evidence concerning this issue in normal subjects. As Schacter, Bowers, and Booker (1989) point out, the numerous demonstrations that experimental variables have different effects on implicit and explicit memory in normal subjects do not address the issue of awareness. It is quite conceivable that normal subjects are fully aware that test items came from the study list while they complete an implicit test, even though performance on the implicit test shows functional independence from performance on an explicit test (Schacter, 1987). Demonstrations of *stochastic* independence between recognition memory and various implicit tests (e.g., Hayman & Tulving, 1989; Jacoby & Witherspoon, 1982; Mitchell & Brown, 1988; Schacter, Cooper, & Delaney, 1990; Tulving et al., 1982; Witherspoon & Moscovitch, 1989) bear more directly on the awareness issue because they indicate that priming effects are just as large when subjects are not consciously aware that a particular test item appeared previously on the study list as when they are aware that a test item appeared on the study list. Nevertheless, findings of stochastic independence do not speak to the issue of whether subjects who show priming effects are unaware that *any* items on an implicit test represent study list targets. It is this feature of amnesic patients' performance that is especially striking.

In this article we investigate the relation between implicit memory and awareness/unawareness of the study episode during test performance in normal subjects. Specifically, we are concerned with phenomena that we will call *test awareness* and *test unawareness*, respectively. *Test awareness* refers to situations in which subjects realize during performance of an implicit task that test items were previously encountered during the study phase of the experiment. *Test unawareness*, in contrast, refers to situations in which subjects do not realize during test performance that some items were encountered at study.

Assessment of test awareness and test unawareness in normal subjects is important for at least three reasons. First, investigation of the issue should help to develop a fuller understanding of the nature of implicit memory in normal subjects. Schacter et al. (1989) provided criteria for distinguishing between implicit and explicit memory in terms of unintentional versus intentional retrieval processes. Additional work is necessary to determine whether criteria can be developed for distinguishing between implicit and explicit memory on the basis of test awareness/unawareness. Second, several investigators have used implicit memory phenomena as a basis for making inferences about the nature of the relation between memory and awareness (e.g., Schacter, 1989; Tulving, 1985). In the absence of information concerning test

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awareness and unawareness, however, the status of these inferences with respect to normal subjects is uncertain. Accordingly, it is important to come to grips with the awareness issue directly. Third, experiments that examine the relation between test awareness/unawareness and priming effects in normal subjects may help to tighten links with the study of implicit memory in amnesic patients. We know that amnesic patients show priming under conditions of test unawareness, but we do not know whether a similar phenomenon occurs in normal subjects.

A number of studies do provide relevant evidence regarding test awareness and unawareness in normal subjects. Eich (1984) presented subjects with a list of nonattended target words and then tested the subjects with both implicit (homophone spelling) and explicit (*yes/no* recognition) memory tests. Priming was observed under these study conditions, even though explicit memory for the nonattended target words was at chance level, thereby suggesting that subjects were test unaware during performance of the implicit test. Jacoby, Woloshyn, and Kelly (1989) presented subjects with a list of unfamiliar first and last names under study conditions of divided attention and tested subjects on implicit (fame judgement task) and explicit (*yes/no* recognition) memory tests. Priming was observed following these study conditions, even though explicit recognition was extremely low. Similarly, Kunst-Wilson and Zajonc (1980) tachistoscopically presented geometric shapes to subjects for 1 ms and observed priming in these subjects on a subsequent preference test despite the fact that they performed at chance on a forced choice recognition test.

The foregoing studies suggest that normal subjects can express implicit memory under conditions of test unawareness: The poor explicit memory performance of the subjects suggests that they do not consciously recall any study items at the time of performing the implicit memory test, as is the case with densely amnesic patients. Note, however, that the conditions discussed thus far in which there is evidence for implicit memory in test unaware subjects are relatively circumscribed, limited either to studies of amnesic patients or to studies of normal subjects who encoded target materials under restricted or "degraded" study conditions. Most implicit memory studies, on the other hand, have involved testing normal subjects under unrestricted encoding conditions. Consequently, it is quite possible that normal subjects are typically aware of the study episode during the performance of an implicit memory test. In fact, Oliphant (1983) reports data that are consistent with the view that priming on the word identification task is normally associated with test awareness (see MacLeod, 1989, for a related finding). As far as we know, the only evidence suggesting that implicit memory can be expressed by unaware subjects after unrestricted encoding conditions has been provided by Nissen and her colleagues (Nissen & Bullemer, 1987; Nissen, Knopman, & Schacter, 1987; Willingham, Nissen, & Bullemer, 1989). Subjects in these studies were exposed to a repeating spatial sequence of lights, and implicit memory for the sequence was observed after many learning trials—even in subjects who claimed to have no explicit knowledge of the pattern. This experimental paradigm, however, differs substantially from the single trial priming that is the major focus of this article.

The present experiments attempt to determine whether significant priming effects can be observed in normal subjects who exhibit test unawareness during the performance of an implicit memory task. The general strategy that we adopted was straightforward. Subjects studied a list of single words (Experiment 1) or word pairs (Experiments 2a–c & 3) and following a short delay were tested on a stem completion task. Immediately after subjects finished the test, they were given a questionnaire that probed their awareness during test performance and were categorized as "test aware" or "test unaware" on the basis of their responses. The questionnaire included questions that were rather open-ended (e.g., "What did you think was the purpose of the stem completion task that you just finished?"), as well as more constrained questions (e.g., "While doing the stem completion test, did you notice whether you completed some of the stems with the words studied in the earlier list?"). The key question was whether test-unaware subjects would demonstrate priming effects on a stem completion test.

It is perhaps worth noting that we used a questionnaire technique because of the special problems that arise when attempting to assess what we have defined as test awareness and unawareness, respectively. Because the major question of interest is whether subjects show priming even when they remain unaware *throughout the completion test* that some items were encountered during study, we cannot query about awareness of individual test items during completion performance: Such on-line probes would necessarily induce test awareness. On-line probes concerning specific test items (e.g., recognition judgments about individual items) are appropriate when one is concerned with whether awareness of the prior occurrence of a specific item is related to priming of that item (e.g., Jacoby & Witherspoon, 1982; Jacoby et al., 1989; Tulving et al., 1982). This approach is not suitable, however, for the study of test awareness and unawareness as we have defined them in this article—hence, the reliance on a posttest questionnaire. We acknowledge that use of a questionnaire entails methodological risks: It is difficult to know exactly when test-aware subjects become aware, and there is always the possibility that responding may be influenced by forgetting that occurs between task performance and administration of the questionnaire (see Eriksen, 1960, for discussion of similar issues in the learning-without-awareness literature). Nevertheless, use of a questionnaire provides a relatively direct way to examine test awareness without inducing the phenomenon and thus represents a useful beginning approach to empirical assessment of test awareness and unawareness.

## Experiment 1

The first experiment used standard stem-completion procedures: Subjects studied a list of single words and after a brief delay were asked to complete word stems with the first word that came to mind (e.g., REA_as REASON). Previous research has not formally assessed test awareness under these conditions, and consequently, we had no firm a priori expectations regarding the relative frequencies with which subjects would be categorized as test aware and unaware. In order to increase the likelihood that some subjects would be categorized as test unaware during the performance of the completion test, half of the subjects studied the to-be-remembered words under incidental encoding conditions: They were not informed at the time of study that their memory for the target words would be tested. The remaining subjects studied the words under intentional study conditions. Previous work by Greene (1986) has suggested that intentional/incidental study conditions do not affect the magnitude of priming on a stem completion test. Although the effects of these study conditions on the incidence of test awareness during completion performance has not been investigated, we reasoned that subjects in the incidental study condition would be categorized as test unaware more frequently than subjects in the intentional study condition.

In addition to manipulating the study instructions, the implicit test instructions were also varied. In previous stem completion experiments, subjects were typically informed that even though the occasional word stem could be completed with a study word, they should nevertheless complete the stems with the first word that came to mind (Graf & Mandler, 1984; Graf & Schacter, 1985, 1989; Schacter & Graf, 1986a, 1989). Consistent with these earlier procedures, half of the subjects were informed that some of the word stems could be completed as study words. The remaining subjects, however, were not given any indication that the stems were related to the study words. This latter condition was included in order to make it possible for subjects to be classified as test unaware, as determined by their responses to our questionnaire. Because subjects were classified as test unaware only when they indicated that they did not realize that the word stems could be completed with study-list items, subjects in the test informed condition were necessarily categorized as test aware.

One additional manipulation was included in the first experiment. Subjects encoded half of the words under semantic study conditions (rating the pleasantness of each word) and encoded the other half under structural conditions (counting the number of *t*-junctions in each word; cf. Graf & Mandler, 1984; Graf, Squire, & Mandler, 1984). Past research has shown that word priming effects in stem completion tests are not sensitive to levels of processing manipulations, whereas explicit memory performance is strongly affected by this variable (Graf & Mandler, 1984; Graf et al., 1982). Consequently, the inclusion of this manipulation provides an internal control that allows us to compare our results with the expected pattern obtained in previous studies.

## *Method*

*Subjects.* Eighty students from the University of Toronto participated in return for credits in an introductory psychology course. Subjects were all tested individually.

*Design and materials.* The experiment included two between-subjects factors and one within-subjects factor. The first between-subjects factor was the study instructions: Half of the subjects were informed that the study words would later be tested in a memory experiment (study informed), and half of the subjects were not told anything about a subsequent memory test (study uninformed). The second between-subjects factor was the test instructions. In this case, half of the subjects were informed that a number of word stems could be completed with study-list words (test informed), and the remaining subjects were not informed of this possibility (test uninformed). The within-subjects factor was the encoding condition: Each subject encoded half of the study words semantically and the remaining words structurally. Consequently, the design was a 2×2×2 mixed design.

The to-be-remembered materials included 24 words that were selected from the Kučera & Francis norms (1967). Three constraints were observed in the selection of the study words. First, the initial three letters of each target word had to be unique in the set of all study words that were presented to the subjects. Second, the initial three letters of each word were required to have at least 10 different completion possibilities. Third, the words had to be between 5 and 10 letters in length and of medium frequency (mean frequency = 93, range = 2–650 occurrences per million). In addition to these study words, 8 buffer words were included in the study word list—4 primacy buffers at the beginning of the list and 4 recency buffers at the end. The buffer words were also selected so that their initial three letters were different from the 24 target words.

The design of the experiment required two different forms of the stem completion task. Each form comprised 12 target word stems that could be completed as study items and 63 distractor items: The only difference between the two tests was that they contained different target stems. Subjects were presented with only one stem completion form, and consequently, they were tested on only half of the 24 target items. In contrast, the cued recall test consisted of the first three letters of all 24 study words. This procedure allowed the cued recall test to assess subjects' explicit memory for 12 target items that had not been tested previously on the stem completion task.

All variables and test materials were completely counterbalanced. Type of encoding (semantic vs. structural) was counterbalanced with respect to both study and test instructions and with respect to the two stem completion forms. This design assured that each word was studied semantically and structurally equally often in each of the different instruction conditions.

The awareness questionnaire included four questions that probed subjects' test awareness during performance of the stem completion test. The first two questions were rather open-ended ("What did you think was the purpose of the stem completion task that you just finished?"; "What was your general strategy in completing the word stems?"), and the latter two questions were more pointed ("Did you notice any relation between the words I showed you earlier and the words produced on the stem completion test?"; "While doing the stem completion test, did you notice whether you completed some of the stems with the words studied in the earlier list?"). Subjects who either spontaneously mentioned the study episode in response to the first two questions or responded positively to one of the latter questions were classified as test aware. Subjects who responded negatively to all of the questions were categorized as test unaware.

*Procedure.* In order to disguise the memory component of the study, subjects were recruited for the experiment by having them sign up for a "study of picture and word perception."

Subjects were first instructed to complete a face perception task. In this task, subjects were shown 18 portraits of faces (via a slide projector), and they were asked to judge each picture in one of two ways: (a) Rate the pleasantness of the face on a scale from 1 to 7, with 1 representing the *least pleasant* and 7 representing the *most pleasant* or (b) select the eyes versus mouth as the more distinctive feature of the portrait. Just before each portrait was displayed, the experimenter pronounced the word *trait* or *pleasantness*, and subjects were asked to make the corresponding rating. This first task was included in order to confirm subjects' expectations that the experiment was indeed a perception study.

The next task that subjects completed was described as a word perception test. In this task, subjects were shown 32 words that were each typed on a separate cue card. Subjects read each word aloud and then made one of two judgments. For the semantic study task, they rated the pleasantness of a word, again rating from 1 to 7, seven representing the *most pleasant*. For the structural study task, they counted the number of *t*-junctions in a word (cf. Graf & Mandler, 1984). The type of judgment (*t*-junction or pleasantness) was announced just prior to the presentation of each word, and subjects were given 5 s to write down their answer. Incidental/intentional encoding instructions for this task varied across subjects. Half of the subjects were informed that the words would be part of a later recall test (study informed), whereas the remaining subjects were given no such information (study uninformed).

Subjects next completed three filler tasks for 10 min. The purpose of these tasks was to induce an appropriate set for the word completion test. In the first task, subjects were presented with 18 letter fragments that represented names of cities, and they were asked to complete as many fragments as possible with city names in 3 min. The next test was identical to the cities task except subjects were presented with the fragments of famous first and last names. Finally, subjects were given 3 min to list as many countries as possible on a blank sheet of paper.

Subjects next performed the stem completion test. They were asked to complete 75 word stems with the first word that came to mind and were instructed that they could write any word except proper names; when a proper name was given, an alternative completion was requested. The instructions for the stem task varied across subject groups. Half of the subjects were informed that some of the 75 word stems could be completed with words from the previously studied list but were instructed to complete the stems with the first word that came to mind (test informed). The remaining subjects were not told anything about the relation between the stems and the previously studied words (test uninformed).

After the subjects completed this task, the awareness questionnaire was administered. On completion of the questionnaire, subjects were presented with the cued recall test. All subjects were given explicit memory instructions, and they were allowed as much time as necessary in order to remember study list words. After completing the recall test, subjects were debriefed concerning the nature of the experiment.

## *Results*

*Stem completion.* Baseline scores were collected by testing 20 control subjects on the completion test without any prior study of the target materials. These subjects completed .12 of the word stems as study words, a value comparable to baseline completion levels in experiments using similar materials (e.g., Graf & Mandler, 1984). Two separate analyses were conducted on the stem completion test data: The first analysis examined subjects' completion performance in each experimental condition, and the second analysis examined subjects' completion performance as a function of their responses to the test awareness questionnaire. The proportions of stems completed as study words in the various experimental conditions are displayed in Table 1. These data indicate that the probability of completing a stem as a study word increased substantially above baseline in all experimental conditions (all $t\,[19]$ values $> 3.56$, $p < .01$). Subjects completed a similar percentage of words in the study informed (.30) and uninformed (.29) conditions, as well as in the test informed (.28) and test uninformed conditions (.32). There was a trend toward a higher completion rate in the semantic (.32) than in the structural (.26) conditions.

Table 1
*Mean Proportion of Word Stems Completed as Study Words as a Function of Level of Encoding, Study Instructions, and Test Instructions*

| | Level of encoding | | | | |
|---|---|---|---|---|---|
| | Semantic | | Structural | | |
| Study condition | Test inf. | Test uninf. | Test inf. | Test uninf. | *M* |
| Study informed | .30 | .38 | .29 | .21 | .30 |
| Study uninformed | .23 | .38 | .26 | .28 | .29 |
| *M* | .27 | .38 | .28 | .25 | |

*Note.* Inf. = informed; uninf. = uninformed.

The data were examined in a 2×2×2 analysis of variance that treated study instructions and test instructions as between-subjects factors, and level of encoding as a within-subjects variable. There were no main effects of study instructions (incidental vs. intentional), $F(1, 76) < 1$, $MS_e = 1.68$, or test instructions (informed vs. uninformed), $F(1, 76) = 1.47$, $MS_e = 1.68$. Level of encoding (semantic vs. structural) also failed to produce a significant main effect on performance, although the effect did approach significance, $F(1, 76) = 3.72$, $MS_e = 1.32$, $p < .06$. There was, however, a significant interaction between test instructions and type of encoding, $F(1, 76) = 5.49$, $MS_e = 1.32$, $p < .05$. This interaction reflects the fact that the test uninformed subjects completed more semantically encoded words than structurally encoded words, whereas the test informed subjects completed a similar number of semantically/structurally encoded words. The remaining interactions did not approach significance (all *F*s < 1).

Analysis of the completion data in the test-uninformed condition, as a function of subjects' responses on the postexperimental questionnaire, revealed that 20 subjects were categorized as test aware and 20 were categorized as test unaware. Eleven of the aware subjects were in the study informed group, and the remaining 9 aware subjects were from the study-uninformed condition, thus indicating that the intentional/incidental study conditions did not influence the incidence of test awareness. Completion rates for the test and aware and unaware subjects are displayed in Table 2. These data indicate that both aware and unaware subjects showed robust priming effects (.33 and .31, respectively). Although aware and una-

Table 2
*Mean Proportion of Word Stems Completed as Study Words by Test-Uninformed Subjects as a Function of Self-Report on the Awareness Questionnaire*

| | | Level of encoding | | |
|---|---|---|---|---|
| Self-report | *N* | Semantic | Structural | *M* |
| Test aware | 20 | .43 | .23 | .33 |
| Test unaware | 20 | .33 | .28 | .31 |
| *M* | | .38 | .26 | |

ware subjects demonstrated similar overall levels of priming, aware subjects completed a higher proportion of semantically encoded words (.43) and a relatively low proportion of structurally encoded words (.23). In contrast, the unaware group completed a similar number of semantic and structural words (.33 and .28, respectively).

Because self-reported test awareness is not an independent variable that was experimentally manipulated in the design, the questionnaire data were examined with a nonparametric test for comparison of two proportions (Bennett & Franklin, 1954). The analysis revealed that the test-aware subjects completed more semantically encoded words than nonsemantically encoded words ($p < .01$). In contrast, the test unaware subjects completed a similar number of semantically and nonsemantically encoded word stems ($p > .05$).

*Cued recall.* Recall performance was first analyzed as a function of the intentional/incidental study instructions and the semantic/structural encoding levels. Subjects recalled a similar number of words in the study-informed (.34) and study-uninformed (.32) conditions and recalled many more words in the semantic encoding conditions (.47) than in the structural encoding conditions (.19). These data were examined in a 2×2 analysis of variance that treated study instructions as a between-subjects variable, and level of encoding as a within-subjects factor. The analysis indicated that there was a main effect of level of encoding, $F(1, 78) = 95.12$, $MS_e = 4.61$, $p < .01$, but no effect of study instructions and no interaction between level of encoding and study instructions (all $F$ values $< 1$).

The recall data were also analyzed with respect to subjects' responses on the awareness questionnaire. Subjects who were classified as test aware recalled .50 of the semantically encoded words and .22 of the structurally encoded words, whereas test-unaware subjects recalled .44 and .15, respectively. The Bennett/Franklin test revealed that recall performance of test aware and unaware subjects did not differ in either the semantic or structural encoding conditions (both $p$ values $>$ .05). However, both groups recalled significantly more words in the semantic than structural encoding conditions (both $p$ values $< .01$).

The cued recall task included words that had been previously tested in the stem completion task. In order to examine possible test carry-over effects, the recall performance of words previously tested in the stem completion task was examined separately from words that were not earlier tested. Subjects' recall scores were virtually identical in the two conditions: The probabilities of recalling words that were previously tested on the stem completion test were .47 and .19 following semantic and structural encoding, respectively; the corresponding probabilities of recalling words that had not been tested previously were .46 and .18, respectively.

### *Discussion*

The results of Experiment 1 indicate that 50% of the test-uninformed subjects were categorized as test unaware. The critical results of Experiment 1, however, are that the overall level of priming in test-aware and test-unaware subjects did not differ and that test-unaware subjects showed about the same amount of priming as did the test-informed subjects. These results indicate that normal priming effects can be observed in test-unaware subjects. Previous research has demonstrated priming effects in amnesic patients who lack explicit memory for study list items (Graf et al., 1984; Squire et al., 1985) and in normal subjects who perform extremely poorly on explicit tests following degraded encoding conditions (Eich, 1984; Jacoby et al., 1989; Kunst-Wilson & Zajonc, 1980). The present results extend these findings by providing a demonstration of priming in test-unaware normal subjects following both semantic and nonsemantic study conditions. Furthermore, because approximately half of the test-unaware subjects encoded the words under incidental study conditions and because incidental versus intentional encoding conditions had no effect on completion performance, the data also indicate that subjects who were at no time aware that they were participating in a memory experiment showed robust priming effects.

It should be noted, however, that the test-aware subjects completed a higher proportion of semantically encoded words than structurally encoded words, whereas the performance of test-unaware subjects was not affected by semantic versus structural encoding like that of subjects in other stem completion studies (e.g., Graf & Mandler, 1984). One possible interpretation of these latter results is that the aware subjects adopted explicit memory strategies as soon as they "caught on" to the memory nature of the stem completion task. Such a strategy would result in an enhanced ability to recall and thus complete semantically encoded words, because level of explicit recall is generally higher following semantic than structural encoding (Craik & Tulving, 1975; Graf & Mandler, 1984; Roediger & Blaxton, 1987). Consistent with this suggestion, cued recall performance was considerably higher after semantic encoding than structural encoding in the test-aware subjects.

An alternative possibility, however, must also be considered: Test awareness may be a *consequence* of high levels of stem completion performance. That is, those subjects who were classified as "aware" on the questionnaire may simply be the subjects who produced the largest number of correct completions and thus had the greatest number of opportunities to become aware. This sort of subject selection effect would be expected to operate most strongly in the semantic study condition because items that had been encoded semantically would be much more likely to induce explicit recognition or awareness when produced on the completion test than would items that had been encoded structurally. Thus, the finding that test-aware subjects showed higher completion for semantically than structurally encoded words may be attributable to a subject selection artifact. Consideration of one critical aspect of our data, however, leads us to reject this hypothesis. If our questionnaire simply classified subjects as "aware" who were from the high end of the performance distribution on the completion test—that is, the subjects who showed the most priming following semantic encoding—then the *overall* performance of the test-uninformed group from which these subjects were selected should be about the same as that of subjects in the test-informed group. Alternatively, if the elevated performance of test-aware subjects in the test-uninformed group reflects the use of explicit retrieval strategies, then the test-uninformed group should show higher levels of completion performance in the semantic study condition than the test-informed group, who were specifically instructed not to use such strategies. Results indicate that test-uninformed subjects showed significantly higher completion performance (.38) than did test-informed subjects (.27) in the semantic study conditions, $t(78) = 2.34$, $p < .05$. These results argue against the subject selection interpretation.

The foregoing pattern of results suggests that elaborate attempts to disguise the nature of a completion test can backfire if subjects catch on to the nature of the test and are not prohibited from using explicit strategies, as our test-uninformed subjects were not. That is, if subjects are informed that some test stems can be completed with previously studied words but are instructed to nevertheless complete stems with the first word that comes to mind, they appear to be less likely to adopt explicit strategies than are subjects who are uninformed about the study–test relation and instead "discover" it for themselves.

The important result of Experiment 1 was that substantial priming of single words was observed in subjects who reported no awareness of a prior study episode during performance of a completion test. In the next set of experiments we examined whether priming of newly acquired associations can occur in test-unaware subjects.

## Experiments 2a–c

A number of recent experiments have suggested that newly acquired associations between normatively unrelated word pairs can influence the magnitude of priming on a word completion test (Graf & Schacter, 1985, 1987, 1989; Schacter & Graf, 1986a, 1986b, 1989). In these experiments, subjects studied unrelated word pairs (WINDOW–REASON) and were then given a completion test in which some stems were paired with their study list cue (e.g., WINDOW–REA______; same-context condition), and others were paired with some other cue (e.g., OFFICER–REA______; different-context condition). Graf and Schacter found significantly more priming in the same- than different-context condition. This observation is of theoretical significance because it suggests that priming is not attributable to the temporary activation of preexisting representations, knowledge structures, or logogens (Graf & Mandler, 1984; Mandler, 1980; Morton, 1979; Rozin, 1976). Instead, these results suggest that newly established memory representations can be expressed on implicit memory tests.

It should be noted, however, that Graf and Schacter have reported these effects in a limited number of experimental conditions. For example, several experiments have found that associative priming requires some degree of elaborative study processing (Graf & Schacter, 1985; Schacter & Graf, 1986a). This result contrasts with the finding that single-word priming can occur following nonsemantic study conditions. In addition, associative priming has not been consistently observed in densely amnesic patients, whereas single-word priming is robust even in patients with severe amnesia (Cermak, Bleich, & Blackford, 1988; Schacter & Graf, 1986b; Shimamura & Squire, 1989; but see Cermak, Blackford, O'Connor, & Bleich, 1988). These differences between associative priming and single-word priming suggest that the two phenomena are based in part on different underlying mechanisms. The question thus arises as to whether associative priming, like single-word priming, can be observed in test-unaware subjects.

To investigate this issue, we used an experimental procedure based on the paradigm described in the Graf and Schacter studies. The same basic paradigm, with minor procedural variations, was used to examine the relation between associative priming and test awareness in three separate populations of college undergraduates. For purposes of clarity and economy of exposition, we will describe the design and results of these experiments together and refer to them as Experiments 2a, 2b, and 2c, respectively.

The general designs of Experiments 2a–c were similar. In each study, subjects studied a list of unrelated word pairs and, following a delay period that varied from 25 to 30 min, were presented with a stem completion task that assessed priming in same- and different-context conditions. Experiments 2a–b employed incidental study conditions, whereas Experiment 2c employed an intentional study condition. Following the stem completion test, subjects in Experiments 2a–c were classified as test aware or unaware on the basis of the same questionnaire used in Experiment 1. Subjects were then tested on a cued recall test that assessed explicit memory for newly acquired associations.

### *Method*

*Subjects.* The three experiments employed different subject populations. Experiment 2a tested 24 University of Toronto students, Experiment 2b tested 36 University of Minnesota students, and Experiment 2c tested 24 University of Arizona students. Subjects in Experiment 2a were paid $5 for their participation; subjects in Experiments 2b and 2c participated in return for course credits. All subjects were tested individually.

*Design and materials.* The design of each experiment included test context (same vs. different) as the only within-subjects factor.

The critical test materials were identical in Experiments 2a–c. The to-be-remembered materials included a set of 18 cue-target pairs selected from the Kučera and Francis norms (1967) according to the same three criteria that were employed in Experiment 1. The mean frequency of these words was 48, with a range from 2 to 225 occurrences per million. All 18 word pairs appeared in uppercase letters in the context of a meaningful sentence. For instance, the word pair RAIN–TENNIS was presented to the subjects in the sentence "The RAIN caused the TENNIS match to be delayed." In addition to these sentences, eight filler sentences were included in the study materials. These filler sentences related the two filler words in a less meaningful fashion. For example, the filler word pair BRAIN–PSYCHOLOGY was presented to the subjects as "You need a BRAIN to have a PSYCHOLOGY." The filler word pairs were also selected so that their initial three letters were different from the 18 critical word pairs. Subjects rated how well the two capitalized words were related in the context of the sentence.

The stem completion task contained 120 test items, each consisting of a context word and a three-letter word stem. The initial three letters of each context word and three-letter word stem were unique in the set of all test items. Eighteen of the word stems could be completed as study target words (critical word stems), while the remaining 102 stems were filler items, which could not be completed as study words. These filler items were included in order to disguise the memory nature of the stem completion test. Of the 18 critical word stems, 9 stems were presented in the same-context condition (i.e., if RAIN–TENNIS was studied, then the completion item would be RAIN–TEN______). The remaining 9 critical word stems were tested in the different-context condition (i.e., if RAIN–TENNIS was studied, the completion item might be JACKET–TEN______); different-context cues (e.g., JACKET) had not appeared on the study list.

The stem completion test consisted of four pages, each page containing 30 cue–stem pairs. The first page of each test contained only filler pairs, but the next three pages each contained 24 filler pairs and six critical word stems that could be completed as study words. Three of the six critical word stems appeared next to their respective study-list cue (same-context condition), while the remaining three critical word stems appeared next to a filler cue word (different-context condition). In order to control for test order effects, the last three pages of the stem completion test were arranged in all possible combinations. Two forms of the stem completion task were required in order to test each critical word stem in both the same and different contexts.

The cued recall test consisted of the same 18 critical test items that were presented in the stem completion test—that is, 9 same-context items and 9 different-context items. Two forms of the cued recall test were required in order to test each critical word stem in both the same and different contexts. Subjects were given explicit recall instructions and were allowed as much time as necessary in order to remember as many study words as possible.

The experiments were counterbalanced so that the 18 critical words stems appeared equally often in each experimental condition defined by the orthogonal combination of test context and test order.

*Procedures.* The procedures in Experiments 2a–c were identical except where mentioned below. In order to focus subjects on the allegedly perceptual nature of the experiments, subjects were recruited for the experiment after they had signed up for a "study of picture and word perception." Following some introductory remarks, subjects were presented with the sentence rating task. They were instructed to read each sentence out loud and then to rate how meaningfully the sentence related the two capitalized words that were embedded within the sentence. It was pointed out that some sentences would be highly meaningful, whereas others would be relatively meaningless and that they should make their ratings on a 5-point scale, ranging from *the sentence does not relate the words at all meaningfully* (1), to *the sentence relates the words quite meaningfully* (5). Subjects were then given two practice sentences: one that related the words in a meaningful fashion and another that did not. Following this practice, subjects were presented with the 18 target and 8 buffer sentences and asked to rate them. Subjects in Experiment 2a rated the sentences at their own pace, whereas subjects in Experiments 2b–c were required to think about each rating for 6 s before responding. The key procedural difference between the studies, however, was that the subjects in Experiment 2c were informed that the words would later be tested in a memory experiment (study informed), and the subjects in Experiments 2a–b were not told anything about a subsequent memory test (study uninformed).

After the subjects had been exposed to all 26 cards, they were presented with a number of filler tasks that were intended to keep them busy for 25 to 30 min. In the first distractor task, subjects in Experiments 2a–c were presented with 50 photographs one at a time, and they were asked to rate each photograph on a number of dimensions. Each photograph was presented for 15 s, and the entire task took approximately 15 min to complete. The next four filler tasks were the famous cities, famous names, country generation task, and face perception tasks from Experiment 1. Subjects in Experiments 2b–c did not complete the country generation test, and consequently, the delay between the study phase and the stem completion test was approximately 3 min shorter in these experiments.

Following the distractor tasks, subjects were presented with the stem completion task. Subjects were informed that they had to read each cue word aloud and then complete each word stem with the first word that came to mind. As in Experiment 1, subjects were instructed that they could write any word except proper names, and when a proper name was given, an alternative completion was requested. Subjects were told that the context word would sometimes help them generate a completion but that it was unimportant whether or not their completion was related to the context word. They were encouraged to finish the completion test as quickly as possible and were not informed that some of the word stems could be completed as study words.

After subjects completed this task, they were given the awareness questionnaire in the same manner as described for Experiment 1. Following completion of the questionnaire, subjects were presented with the cued recall test. Subjects were given explicit recall instructions and allowed as much time as necessary in order to recall as many words as possible. After completing the recall test, subjects were debriefed concerning the nature of the experiment and thanked for their participation.

## *Results*

The results of Experiments 2a–c are displayed together in Table 3. A clear and consistent pattern of results can be observed across experiments. On the completion test in each experiment, subjects who were categorized as test aware completed more stems in the same- than different-context conditions, whereas subjects who were categorized as test unaware completed a similar percentage of word stems in both context conditions. Consequently, there was no evidence of associative priming in the unaware subjects. On the cued recall tests, more words were recalled in the same-context condition than in the different-context condition, and aware subjects recalled many more words than unaware subjects. The results of each experiment are analyzed separately below.

*Experiment 2a: Stem completion.* Fifteen of the 24 subjects were categorized as test unaware on the basis of the questionnaire, and these subjects completed .13 of the word stems in the same-context condition and .13 of the word stems in the different-context condition. The remaining 9 test-aware subjects completed .26 and .12 of the word stems in the same- and different-context conditions, respectively. Analysis of these data with the nonparametric Bennett/Franklin test revealed that the test-aware subjects completed more stems in the same-context condition than in the different-context condition ($p < .05$).

Baseline scores were collected by testing 30 control subjects on the completion test without any prior study of the target materials. These subjects completed .08 of the word stems as study words in the same-context condition and .07 of the word stems in the different-context condition. The Bennett/Franklin test revealed that test-aware subjects completed a higher percentage of word stems in the same-context condition than in baseline ($p < .01$). Performance in the remaining experimental conditions, however, did not exceed the baseline measures (all $p$ values $> .05$).

Table 3
*Proportion of Word Stems Completed and Recalled in Experiments 2a–c as a Function of Self-Report on the Awareness Questionnaire and Test Context*

| Experiment no. | Self-report | *N* | Context | Completion | Recall |
|---|---|---|---|---|---|
| 2a | | | | | |
| | Aware | 9 | Same | .26 | .43 |
| | Aware | 9 | Different | .12 | .12 |
| | Unaware | 15 | Same | .13 | .20 |
| | Unaware | 15 | Different | .13 | .06 |
| 2b | | | | | |
| | Aware | 15 | Same | .28 | .52 |
| | Aware | 15 | Different | .15 | .18 |
| | Unaware | 21 | Same | .10 | .17 |
| | Unaware | 21 | Different | .11 | .06 |
| 2c | | | | | |
| | Aware | 15 | Same | .30 | .66 |
| | Aware | 15 | Different | .13 | .18 |
| | Unaware | 9 | Same | .15 | .27 |
| | Unaware | 9 | Different | .14 | .07 |

*Experiment 2a: Cued recall.* The 15 subjects who were categorized as test unaware recalled .20 and .06 of the study words word in the same- and different-context conditions, respectively. The remaining 9 test-aware subjects recalled .43 and .12 of the study words, respectively. The Bennett/Franklin test revealed that more words were recalled in the same-context condition than in the different-context condition ($p < .01$), and aware subjects recalled more words than unaware subjects ($p < .01$).

*Experiment 2b: Stem completion.* The results of Experiment 2b were similar to Experiment 2a. Twenty-one of the 36 subjects were classified as test unaware, and these subjects completed .10 of the word stems in the same-context condition and .11 of the word stems in the different-context condition. The remaining 15 test-aware subjects completed .28 and .15 of the word stems in the same- and different-context conditions, respectively. The Bennett/Franklin test revealed that test-aware subjects completed more stems in the same-context condition than in the different-context condition ($p < .01$). The Bennett/Franklin test was used to compare subjects' performance on the stem completion task with the baseline measures employed in Experiment 2a. Subjects who were classified as test aware completed .28 of the word stems in the same-context condition compared with a baseline score of .08 ($p < .01$), and they completed .15 of the word stems in the different-context condition, compared with a baseline rate of .07 ($p < .05$).. Performance of test-unaware subjects, however, did not exceed baseline measures in either the same- or different-context conditions (both $p$ values $> .05$).

*Experiment 2b: Cued recall.* The test-unaware subjects recalled .17 and .06 of the study words in the same and different contexts, respectively. The test-aware subjects, on the other hand, recalled .52 and .18 of the study words, respectively. The Bennett/Franklin test revealed that more words were recalled in the same-context condition than in the different-context condition ($p < .01$), and aware subjects recalled more words than unaware subjects ($p < .01$).

*Experiment 2c: Stem completion.* The results of Experiment 2c were almost identical to the results of Experiments 2a–b. Fifteen of the 24 subjects were classified as test aware on the basis of the questionnaire, and these subjects completed .30 and .13 of the word stems in the same- and different-context conditions, respectively. The remaining 9 test-unaware subjects completed .15 and .14 of the word stems, respectively. Analysis of these data with the Bennett/Franklin test revealed that test-aware subjects completed more word stems in the same-context condition than in the different-context condition ($p < .01$).

We also compared subjects' performance on the stem completion task with the baseline measures employed in Experiment 2a. Subjects who were classified as test aware completed .30 of the word stems in the same-context condition, compared with a baseline rate of .08 ($p < .01$). Performance in the remaining experimental conditions, however, did not exceed the baseline measures (all $p$ values $>.05$).

*Experiment 2c: Cued recall.* The test-aware subjects recalled .66 and .18 of the study words in the same- and different-context conditions, respectively. On the other hand, the test-unaware subjects recalled .27 and .07 of the study words, respectively. The Bennett/Franklin test revealed that more words were recalled in the same-context condition than in the different-context condition ($p < .01$), and aware subjects recalled more words than unaware subjects ($p < .01$).

### *Discussion*

The key finding in Experiments 2a–c is that there was no associative priming in the test unaware subjects: In each experiment, test-unaware subjects completed a similar proportion of word stems in the same- and different-context conditions. In contrast, robust associative priming was observed in test-aware subjects. The fact that the results of Experiment 2c were similar to Experiments 2a–b suggests that the intentional/incidental study conditions did not affect subjects' performance on the stem completion test.

The failure to observe associative priming in test-unaware subjects contrasts sharply with the finding from Experiment

1 that demonstrated priming effects in test-unaware subjects. It is possible that this contrasting pattern of results indicates a fundamental difference between single word priming on the one hand and associative priming on the other. The results of the cued recall test, however, suggest another explanation of the findings. In each of Experiments 2a–c, test-unaware subjects recalled relatively few words compared with test-aware subjects, and consequently, it is possible that the test-unaware subjects did not demonstrate associative priming because they did not encode the study words properly in the first place. Thus, the failure to observe associative priming may be attributable to a subject selection effect.

One way to assess the possibility that subject selection factors were responsible for the present results is to compare the priming performance of test-aware and unaware subjects who performed similarly on the cued recall test. If a subset of test unaware subjects is matched to the test-aware subjects with respect to performance on the cued recall test and if these test-unaware subjects still fail to show associative priming, then there would be evidence against the subject selection interpretation. In line with this argument, 9 test-unaware subjects were selected from Experiments 2a–c whose performance on the cued-recall test approximated that of test-aware subjects: These test unaware subjects recalled .53 and .06 in the same- and different-context conditions, respectively, whereas test-aware subjects recalled .55 and .17, respectively. Although the recall performance of the selected test-unaware subjects did not differ significantly from that of test-aware subjects in the same context condition ($p > .05$, Bennett/Franklin test), the test-unaware subjects nevertheless failed to demonstrate associative priming: They completed .14 of the same-context word stems with study words and .15 of the different-context stems. This result suggests that the lack of associative priming in the unaware subjects cannot be attributed to inadequate encoding operations in a subset of selected subjects.

Although the foregoing analyses fail to support a subject selection interpretation, they do not rule it out conclusively. One possible problem is that the matching procedure may be subject to regression to the mean effects: Unaware subjects who were selected for high levels of recall performance may have achieved such levels partly because of noise or error in test measurement (see Experiment 3 for further discussion). Nevertheless, it must be pointed out that any subject selection account of the lack of associative priming in test-unaware subjects in Experiments 2a–c must explain why such factors were not operating in Experiment 1, where substantial word priming effects were observed in test-unaware subjects. That is, if selecting subjects on the basis of a postexperimental questionnaire somehow inevitably results in the inclusion of generally "poor" or "weak memory" subjects in the unaware group, with lack of priming in these subjects as a necessary consequence of the selection procedure, then we should not have observed priming in test-unaware subjects in Experiment 1. But we did. Note, however, that in Experiment 1, the delay between study and completion testing was 10 min, whereas in Experiments 2a–c, the study test delay was 25–30 min. It is conceivable that length of retention interval plays a significant role in whether or not priming is observed in test-unaware subjects. If so, it is possible that associative priming could be observed in test-unaware subjects if the same 10-min delay were used as in Experiment 1. Experiment 3 examined this possibility.

## Experiment 3

The design of Experiment 3 was similar to Experiment 1 in two important respects. First, Experiment 3 included a 10-min delay between study and test, as was the case in Experiment 1. This test delay was deemed appropriate because we wanted to investigate whether associative priming could be observed in test-unaware subjects following a delay that supported single word priming in test-unaware subjects. Second, Experiment 3 manipulated test instructions (test informed vs. test uninformed), as was the case in Experiment 1. Previous research by Schacter and Graf (1986a) has suggested that some subjects can remain test unaware following test informed instructions—that is, even though they are informed that test stems can be completed with study list words, some subjects report that they do not notice that they completed any stems with target words. Consequently, we manipulated the test informed/uninformed conditions in order to examine whether the instructions would affect the incidence of test awareness in the associative priming paradigm. In order to assess test awareness in the test informed condition, subjects were presented with the final question from the awareness questionnaire: "Did you notice whether you completed some of the stems with the words studied in the earlier list?" Subjects were classified as test aware/unaware if they responded affirmatively/negatively, respectively. The first three questions of the awareness questionnaire were not presented to the subjects in the test-informed condition because they would necessarily respond affirmatively to these questions on the basis of what the experimenter had told them, even though they may not have noticed completing word stems with the study-list words.

### *Method*

*Subjects.* Forty-eight subjects from the University of Arizona participated in return for credits in an introductory psychology course. Subjects were all tested individually.

*Procedure.* Experiment 3 provided a close replication of Experiment 1. As in Experiment 1, subjects began the experiment with the face perception test, a task that emphasized the perceptual nature of the experiment. Following this task, subjects encoded the list of 18 unrelated word pairs in the incidental study condition that was used in Experiments 2a–b. Following the study task, subjects completed the same set of distractor tests that were employed in Experiment 1. Subjects then performed the stem completion test. Half of the subjects performed the stem completion test under test-informed conditions, and consequently, they were told that some of the word stems could be completed as study words. The remaining subjects were in the test-uninformed condition, and they were not told that the word stems could be completed as study words. Following this task, subjects were presented with the awareness questionnaire and then presented with the cued recall test.

### Results

*Stem completion.* The overall pattern of results is displayed in Table 4. As can be seen from this table, the pattern of results in Experiment 3 is similar to the results from Experiments 2a–c. Overall, 23 subjects were categorized as test aware, and they completed .23 and .15 of the word stems in the same- and different-context conditions, respectively. The remaining 25 subjects were categorized as test unaware, and they completed .12 and .13 of the word stems in the same- and different-context conditions, respectively. Analysis with the Bennett/Franklin test revealed that the test-aware subjects completed more word stems in the same context than in the different context ($p < .05$), a result that replicates the basic finding in Experiments 2a–c.

The data were also analyzed separately for the test-informed and uninformed conditions. In the test-informed condition, 14 subjects were categorized as test aware, and 10 were categorized as test unaware. The test aware subjects completed .25 and .15 of the word stems in the same- and different-context conditions, respectively. The test-unaware subjects, on the other hand, completed .13 and .14 of the word stems, respectively. Test-aware subjects completed significantly more word stems in the same- context than in the different-context condition ($p < .05$). In the test-uninformed condition, 9 subjects were categorized as test aware, and 15 were categorized as test unaware. The test-aware subjects completed .20 and .16 of the word stems in the same and different context, respectively, and the test-unaware subjects completed .10 and .13 of the word stems, respectively. Although there is a trend for the test-aware subjects to complete more word stems in the same context than in the different context, the analysis did not reveal a significant context effect ($p > .05$). The nonsignificant result may be attributable to the relatively small number of subjects who were categorized as test unaware.

*Cued recall.* The recall data were analyzed separately for the test informed/uninformed conditions. In the test-uninformed condition, the subjects who were categorized as test aware recalled .54 of the word stems in the same-context condition, and .19 of the word stems in the different-context condition, whereas the test-unaware subjects recalled .46 and .16 of the word stems in the same- and different-context conditions, respectively. In the test-informed condition, the subjects who were categorized as test aware recalled .50 of the word stems in the same-context condition, and .07 of the word stems in the different-context condition, whereas the test-unaware subjects recalled .42 and .09 of the word stems in the same- and different-context conditions, respectively. Although there is a trend for higher recall performance in test-aware than test-unaware subjects, these differences were not significant (all $p$ values $> .05$). Thus, the aware and unaware subjects recalled a similar number of study words, in contrast to Experiments 2a–c.

### Discussion

The key finding in Experiment 3 is that there was no associative priming in the unaware subjects following a 10-min delay between study and test. This result is important because test-aware and unaware subjects performed comparably on the cued recall test, and consequently, it is difficult to argue that the lack of associative priming in the unaware subjects was the result of subject selection factors. In fact, the same results were obtained when we examined the associative priming performance of 20 test-unaware subjects who performed nearly identically to test-aware subjects on the cued recall test: these test-unaware subjects recalled .53 and .16 in the same- and different-context conditions, respectively, whereas test-aware subjects recalled .52 and .12, respectively. Although the recall performance of the selected test-unaware subjects was matched as closely as possible to the performance of the test-aware subjects, these test-unaware subjects nevertheless failed to demonstrate associative priming. They completed .12 of the same-context word stems with study-list words, and .13 of the different-context stems, thus providing additional evidence that the lack of associative priming in the test-unaware subjects cannot be attributed to subject selection factors. As noted earlier, this sort of matching procedure raises the issue of regression to the mean effects. However, the fact that *overall* recall performance of aware and unaware subjects did not differ in this experiment and that analysis of the overall results and the results from the matching procedure yielded similar outcomes suggests that regression to the mean is likely not a significant factor in our experiments. It is also interesting to note that the test informed/uninformed manip-

Table 4
*Mean Proportion of Word Stems Completed and Recalled by Test-Informed and Uninformed Subjects as a Function of Self-Report on the Awareness Questionnaire and Test Context*

| Test instructions | Self-report | *N* | Context | Completion | Recall |
|---|---|---|---|---|---|
| Test informed | Aware | 14 | Same | .25 | .50 |
| Test informed | Aware | 14 | Different | .15 | .07 |
| Test informed | Unaware | 10 | Same | .13 | .42 |
| Test informed | Unaware | 10 | Different | .14 | .09 |
| Test uninformed | Aware | 9 | Same | .20 | .54 |
| Test uninformed | Aware | 9 | Different | .16 | .19 |
| Test uninformed | Unaware | 15 | Same | .10 | .46 |
| Test uninformed | Unaware | 15 | Different | .13 | .16 |

ulation did not substantially affect subjects' performance on the stem completion test. A similar proportion of subjects in both conditions was classified as test aware and test unaware, and the aware and unaware subjects in both conditions demonstrated similar priming effects.

## General Discussion

The present experiments have yielded two main results. First, equivalent single word priming was observed in subjects who were categorized as test aware and test unaware, thus indicating that normal single word priming can be observed in test-unaware subjects following both semantic and nonsemantic study conditions. Second, associative priming was observed in subjects who were categorized as test aware but not in subjects who were categorized as test unaware. The fact that associative priming was observed in test-aware but not test-unaware subjects following incidental and intentional study conditions, under test-informed and uninformed conditions, and after test delays of 10 and 30 min suggests that these results are quite general.

The finding that single word priming was observed in test-unaware subjects is consistent with previous studies showing that such priming occurs normally in severely amnesic patients (Graf et al., 1984; Squire et al., 1985). Taken together, the present findings and the amnesia data indicate clearly that robust implicit memory for familiar words can be observed in subjects who either do not or cannot remember the study episode during completion test performance.

A quite different picture is observed when we consider associative priming effects on the stem completion test. Our failure to observe evidence for associative priming in test-unaware subjects is consistent with the results of neuropsychological studies that have shown that this type of priming is not readily observed in severely amnesic patients (Cermak, Talbot, Chandler, & Wolbarst, 1985; Schacter & Graf, 1986b; Shimamura & Squire, 1989), whom we assume would be characterized as test unaware by our criteria. However, some amnesic patients *do* show associative priming effects on stem completion performance, although most of these patients have relatively mild memory impairments (Schacter & Graf, 1986b; but see Cermak, Blackford, et al., 1988).

One interpretation of the above findings is that associative priming on the stem completion test reflects the use of explicit memory strategies by subjects who have caught on to the nature of the stem completion test. Such a strategy would result in an enhanced ability to recall and thus complete word stems in the same-context condition compared with the different-context condition because level of explicit cued-recall was found to be higher in the same- than different-context condition. If it turns out that explicit strategies affected the performance of the test-aware subjects, then it would suggest that the associative effects on the stem completion test do not reflect implicit memory for new associations, as argued by Graf and Schacter (1985).

There are good reasons, however, to reject the hypothesis that context effects are simply the product of explicit retrieval strategies. Graf and Schacter (1985, 1987, 1989; Schacter & Graf, 1986a; 1986b, 1989) have demonstrated that associative effects on stem completion can be dissociated from associative effects on cued recall by a number of experimental variables, including level of processing manipulations, proactive/retroactive interference effects, and modality shifts. These dissociations were observed even though the nominal or external cues provided to the subjects were identical on the implicit and explicit tests, and only the test instructions varied: The implicit instructions required subjects to perform a task that did not require the subjects to think back to the study episode, whereas the explicit instructions did require the subjects to think back to the study episode. The fact that experimental dissociations were observed between implicit and explicit test performance under conditions in which the external cues were held constant across tests indicates that associative effects were not the result of explicit memory strategies. If associative effects were the result of explicit strategies, then it should not have been possible to dissociate stem completion and cued recall performance (See Schacter et al., 1989).

To sum up to this point, the fact that single word priming occurs in test-unaware subjects while associative priming does not suggests that single word priming and associative priming reflect different memory processes. However, there is good evidence that the memory processes that mediate associative priming and cued recall are also distinct because performance on these two types of tests can be dissociated in a number of experimental conditions. Consequently, single word priming, associative priming, and cued recall may all tap different memory processes (see Schacter, in press, for a detailed discussion concerning the nature of these processes).

Given the observed lack of associative priming in test-unaware subjects, questions can be raised about whether it is appropriate to describe associative priming as an instance of implicit memory. The fact that associative priming is not consistently observed in severely amnesic patients (Cermak, Bleich, & Blackford, 1988b; Schacter & Graf, 1986b; Shimamura & Squire, 1989) raises similar questions. Note, however, that the present experiments do not allow us to determine whether test awareness is a necessary *condition* of associative priming or whether it is a *consequence* of such priming. As discussed with respect to Experiment 1, subjects who produce target items on a completion test are provided with opportunities to become test aware; subjects who do not produce any target items have fewer such opportunities. Thus, test-aware subjects may have become aware because they produced many target items, whereas test-unaware subjects may have remained unaware because they failed to produce any targets. Such an argument cannot be ruled out for Experiments 2 and 3, but it does not handle the data from Experiment 1, where overall levels of priming did not differ in test-aware and unaware subjects. Although the question of whether test awareness is a condition or consequence of associative priming thus requires further study, the important new fact established by the present research is that under conditions similar to those in previously reported experiments (e.g., Graf & Schacter, 1985, 1987; Schacter & Graf, 1986a,b, 1989), associative priming is not observed in test-unaware subjects.

In view of these considerations, a few further points ought to be noted. First, although our experiments failed to yield evidence of associative priming in test-unaware subjects, it is entirely conceivable that such evidence could be obtained under appropriate experimental conditions. A second, related point is that one study has reported evidence of associative priming in the stem completion test in a severely amnesic patient (Cermak, Bleich, & Blackford, 1988), thereby suggesting that associative priming may be observed in some test-unaware subjects. Moreover, associative priming has been documented in severely amnesic patients with tests other than stem completion (McAndrews et al., 1987; Moscovitch, Winocur, & McLachlan, 1986).

A third consideration is that our criterion for test unawareness is extremely conservative. Only those subjects who *never* realized that test stems could be completed with study-list items were classified as test unaware. It is therefore possible that some subjects who noticed that one or two test stems were completed with study list words, and were thus classified as test aware, nevertheless completed other test stems with study list words without any conscious reexperiencing of the study episode. Thus, classification of a subject as test aware is not inconsistent with the possibility that the subject expressed implicit memory for new associations on a subset of these items. Clearly, this issue merits careful attention in future research.

Finally, we should discuss briefly an anomalous result that was obtained in Experiments 2–3: the absence of priming in the different-context condition in the test-unaware subjects and in some conditions for test-aware subjects as well. There are at least two previous findings that suggest that different context priming should have been observed in test-unaware subjects. First, priming in the different-context condition of the stem completion paradigm has been found in densely amnesic subjects (Schacter & Graf, 1986b). Second, different context priming has been observed even following nonsemantic encoding tasks that yield extremely low levels of explicit recall (Graf & Schacter, 1985; Schacter & Graf, 1986a). In these respects, the priming observed in the different-context conditions of the paired-associate paradigm is quite similar to single word priming of the kind we observed in Experiment 1. Yet Experiment 1 showed that single word priming can be observed in test-unaware subjects, in contrast to the absence of different-context priming in these subjects revealed by subsequent experiments. We have no ready explanation for this apparent paradox and view it as an empirical puzzle that should be explored by future studies of the relation between implicit memory and test awareness.

The absence of priming in the different-context condition in the test-unaware subjects raises an interesting possibility: Significant priming in the different-context condition may be necessary in order to observe associative priming. The failure to observe priming in the different-context condition in test-unaware subjects might thus preclude the possibility of observing associative priming effects. Although this conjecture cannot be rejected unequivocally, evidence against it is provided by the finding that test-aware subjects in Experiments 2a and 2c demonstrated robust associative priming but nevertheless failed to demonstrate different context priming. Similarly, Schacter and Graf (1986a) observed significant associative priming in the absence of different-context priming after a long retention interval. These considerations cast doubt on the notion that lack of associative priming in test-unaware subjects is a necessary consequence of the absence of different-context priming and at the same time underscore the need for more extensive scrutiny of the relation between test awareness and various forms of priming.

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