Implicit and Explicit Memory for New Associations in Normal and Amnesic Subjects

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Two experiments examined whether repetition priming effects on a word completion task are influenced by new associations between unrelated word pairs that were established during a single study trial. On the word completion task, subjects were presented with the initial three letters of the response words from the study list pairs and they completed these fragments with the first words that came to mind. The fragments were shown either with the paired words from the study list (*same context*) or with other words (*different context*). Both experiments showed a larger priming effect in the same-context condition than in the different-context condition, but only with a study task that required elaborative processing of the word pairs. This effect was observed with college students and amnesic patients, suggesting that word completion performance is mediated by implicit memory for new associations that is independent of explicit recollection.

Remembering is commonly assumed to involve the conscious or explicit retrieval of information about particular experiences. This assumption derives largely from traditional memory tests, such as free recall, cued recall, and recognition; a defining characteristic of these tests is the explicit instruction to retrieve information about a particular experience. However, this assumption is not consistent with the results of studies that have assessed performance with tests that make no reference to particular experiences. On these tests memory is expressed by a facilitation in performance that need not be accompanied by conscious recollection. For example, on a word completion test subjects are presented word fragments (e.g., BRE ___ or B ___ E ___ D for BREAD) and are instructed to complete them with the first words that come to mind. When required to complete

fragments of recently presented words and of new words, subjects succeed more often with presented words than with new words. This facilitation in completion performance is referred to as a *repetition* or *direct priming* effect (cf. Cofer, 1967; Cramer, 1966).

Direct priming effects have also been demonstrated with other tasks, such as word identification, which requires subjects to identify words that are presented very briefly, and lexical decision, which requires subjects to decide whether or not a presented letter string constitutes a word. A variety of terms has been used to distinguish between the type of memory that is tapped by priming tests on the one hand, and by recall and recognition tests on the other hand (e.g., Baddeley, 1982; Bruner, 1969; Cohen & Squire, 1980; Graf, Squire, & Mandler, 1984; Jacoby & Witherspoon, 1982; Mandler, 1980; Moscovitch, 1982; O'Keefe & Nadel, 1978; Schacter, in press-a; Schacter & Moscovitch, 1984; Tulving, 1983; Warrington & Weiskrantz, 1982; Wickelgren, 1979). For descriptive purposes, we use the terms *implicit* memory and *explicit* memory to distinguish between these forms of memory. Implicit memory is revealed when performance on a task is facilitated in the absence of conscious recollection; explicit memory is revealed when performance on a task requires conscious recollection of previous experiences. The term *priming effect* is

used in the present article to refer to the facilitative effects of a learning episode on performance of a word completion or similar task.

Three converging lines of evidence suggest that implicit memory differs fundamentally from explicit memory. First, performance on implicit and explicit memory tasks is affected differentially by a variety of experimental manipulations (e.g., Graf & Mandler, 1984, 1985; Graf, Mandler, & Haden, 1982; Graf, Squire, & Mandler, 1984; Jacoby & Dallas, 1981; Roediger & Blaxton, 1983; Scarborough, Gerard, & Cortese, 1979; Tulving, Schacter, & Stark, 1982). Second, performance on tests of implicit retention can be statistically independent of recognition performance (Eich, 1984; Jacoby, & Witherspoon, 1982; Schacter, McLachlan, Moscovitch, & Tulving, 1984; Tulving et al., 1982). Third, patients with organic amnesia, who are severely impaired on explicit memory tests, are less impaired, and frequently normal, on various implicit tests (e.g., Brooks & Baddeley, 1976; Cohen, 1984; Cohen & Squire, 1980; Graf, Shimamura, & Squire, 1984; Graf, Squire, & Mandler, 1984; Jacoby & Witherspoon, 1982; Moscovitch, 1982, 1984; Schacter, in press-a; Schacter, Harbluk, & McLachlan, 1984; Warrington & Weiskrantz, 1968, 1970, 1974; Weiskrantz & Warrington, 1979).

A widespread interpretation of the foregoing findings is that implicit memory is based on the activation of preexisting memory representations (e.g., Graf et al., 1982; Graf, Squire, & Mandler, 1984; Mandler, 1980; Mortensen, 1980; Morton, 1969, 1979; Rozin, 1976; Warrington & Weiskrantz, 1982; Wickelgren, 1979). The study materials used in most previous experiments were familiar items, such as individual words, that are represented in long-term or semantic memory prior to their appearance in a study list. It has been argued that these preexisting representations are activated as a result of presenting the study items, and that activation occurs automatically and thus independently of processes that mediate explicit remembering.

An activation interpretation receives support from several studies of amnesic patients. Amnesia occurs as a consequence of various neurological dysfunctions. Amnesic patients show a pattern of cognitive functioning that is typically characterized by poor memory for recent events along with relatively normal intellectual functions and premorbid knowledge and skills (e.g., Moscovitch, 1982; Schacter, 1983; Squire, 1982; Squire, Cohen, & Nadel, 1984; Warrington & Weiskrantz, 1982). One of the hallmarks of anterograde amnesia is the patients' inability to acquire and remember new associations; failure to remember a list of unrelated word pairs on an immediate recall test is diagnostic of amnesia (e.g., Meyer & Yates, 1955; Rozin, 1976; Scoville & Milner, 1957; Starr & Phillips, 1970). Nevertheless, amnesic patients show relatively normal priming or implicit retention, when the study materials are familiar items that have a preexisting memory representation, such as words (e.g., Graf, Squire, & Mandler, 1984; Rozin, 1976; Warrington & Weiskrantz, 1970), highly related paired associates (e.g., Shimamura & Squire, 1984; Winocur & Weiskrantz, 1976), or linguistic idioms (e.g., Schacter, in press-a). The finding of normal priming effects, in conjunction with the observation that amnesic patients seem unable to acquire new associations, is consistent with the view that implicit memory is mediated by activation of preexisting representations. The reasoning here is straightforward. A new association has no preexisting memory representation that can be activated and thus mediate implicit memory.

It is important to observe, however, that the negative evidence for the retention of new associations in amnesia has been obtained on explicit memory tasks, such as paired associate learning; these findings thus do not preclude the possibility that there is implicit memory for new associations. Several recent studies are relevant to this issue, but the findings are inconsistent. On the one hand, there is some evidence for the implicit retention of newly acquired associations in amnesic patients who exhibit profound deficits on tests of explicit memory (e.g., Moscovitch, 1984; Schacter, Harbluk, & McLachlan, 1984; Weiskrantz & Warrington, 1979). To illustrate, Moscovitch required patients to memorize word pairs and later to read these words, either in the same or in different

pairings, from a degraded display. He found that amnesic patients were faster at reading the words in the same pairs than in different pairs, suggesting that they had acquired new associations between the paired words in the study list. On the other hand, several studies with college students provide conflicting evidence concerning the implicit retention of new associations (Carroll & Kirsner, 1982; Franks, Plybon, & Auble, 1982; McKoon & Ratcliff, 1979). For example, McKoon and Ratcliff had subjects study unrelated and related word pairs and then gave a lexical decision task in which some of the target words were preceded by the paired words from the study list. They found that latency in making a lexical decision was reduced when a target was preceded by the paired word from the study list, for both related and unrelated pairs. This finding suggests that new associations can influence performance on a task that is sensitive to implicit memory. However, Carroll and Kirsner (1982) used a similar design and they found no evidence for associative effects on lexical decision performance. Thus, although it appears that implicit retention of new associations can occur, the phenomenon remains to be explored and established more conclusively.

The present study was designed to examine further the implicit retention of newly acquired associations. The general strategy was to present unrelated and related word pairs and then test priming and explicit remembering of the response word from each pair. Explicit remembering was examined with a traditional cued-recall test in which the stimulus member of each list pair was presented and subjects were instructed to remember the response word. Priming was assessed with a word completion test in which the first three letters of the response words were presented and subjects were required to complete them with the first words that came in mind. To assess whether newly acquired associations about the specific pairing of words in the study list affect implicit retention, we compared completion of word fragments that appeared on the test either together with the paired words from the study list (same context) or together with other words (different context).[1] On the view that the presentation of a word activates its preexisting represen-

tation, we expected an increase in completion performance even in the different-context condition. The critical question is, however, whether completion performance in the same-context condition exceeds performance in the different-context condition. To the extent that information about the pairing of words in the study list contributes to priming, test fragments should be completed with words from the study list more often in the same-context condition than in a different-context condition. By an activation interpretation, this outcome is expected for related word pairs, because there is a previously established association between the two words that can be activated as a result of presenting the pair in the study list. However, this outcome is not expected for unrelated word pairs, because there is no preexisting representation that can be activated.

Experiment 1

This experiment examined whether either newly acquired associations or preexisting associations affect completion test performance. We presented subjects with unrelated word pairs and with related word pairs, under study conditions that required either elaborating each list pair or comparing the number of vowels in each pair of words. In the related pairs, the target words are linked by an old and familiar association (e.g., BUTTONED–SHIRT). In the unrelated pairs, the target words have no preexisting relation, and hence must be linked by a new association that is established for the first time during the study trial (e.g., WINDOW–SHIRT). Subjects studied word pairs either under elaborative or non-elaborative task conditions in order to examine the effects of different study tasks on the implicit retention of new and old associ-

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[1] It is important to distinguish between the *local* context provided by a paired word on the completion test and the *global* context that is provided by the entire study list, the experimenter, the experimental room, and so forth (see Schacter, in press-a, for discussion). Although it is well known that amnesic patients have a severe deficit in memory for global context (e.g., Kinsbourne & Wood, 1975; Rozin, 1976; Schacter, Harbluk, & McLachlan, 1984; Winocur & Kinsbourne, 1978), when we use the terms *context* or *context effect* in the present article, we refer exclusively to the *local* context provided by a paired word on the completion test.

ations. Previous studies that tested memory for single words showed that similar task manipulations had no differential effect on the magnitude of priming (e.g., Graf et al., 1982; Graf & Mandler, 1984; Jacoby & Dallas, 1981).

Method

Design. The main experimental conditions were formed by the combination of two between-subjects factors: Type of Study List pairs (related vs. unrelated) and Study Task (elaborate vs. vowel comparison). The design also included completion test context (same vs. different) as a within-subjects factor. In addition, we investigated explicit remembering with a standard cued-recall test.

Subjects. Sixty-four students participated in return for credits in an introductory psychology course. They were randomly arranged into four groups of 16 each. These groups were assigned to four conditions that were defined by the orthogonal combination of two types of study tasks (elaborate and vowel comparison) and two types of word pairs (related and unrelated): elaborate/related, elaborate/unrelated, vowel comparison/related, and vowel comparison/unrelated.

Materials. Forty-two moderately related word pairs (e.g., MOLD–BREAD, RIPE–APPLE) were selected from the Shapiro and Palermo (1968) norms according to the following criteria. First, pairs were chosen if the response was given as a primary associate to the stimulus with a probability between .05 and .20; the selected pairs had an average associative probability of .15. Second, the initial three letters—the stem—of each *response* word (e.g., BRE, APP) had to be unique in the set of all words that were included in the pairs, and for each stem a pocket English dictionary had to list at least 10 common words with the same stem (e.g., BREAD, BREAK, BREAK-FAST, BREAST). Third, the response words had to be between 5 and 10 letters in length and of medium frequency; the selected words averaged 6 letters and they had a mean frequency of 48.4 occurrences per million (Kučera & Francis, 1967). The stimulus words were between 3 and 11 letters long (average 6.2) and they had a mean frequency of 45.1 occurrences per million.

Of these 42 related word pairs, a random set of 32 was selected for use as critical pairs in the study list (Set 1), and the remaining 10 pairs were used for practice (5 pairs) and as fillers (5 pairs) at the beginning and end of the study list. A parallel set of unrelated word pairs was also required for the study; these were obtained by re-pairing the words from the related pairs. The construction of the latter pairs was also constrained by the requirement to keep the same words as responses for the related pairs and for the unrelated pairs. Thirty-two unrelated pairs (Set 2) were formed by re-pairing words from Set 1 and were used as critical items in the study list. The remaining unrelated pairs were used for practice and as fillers. Each of the related and unrelated pairs was printed on an index card, in lowercase letters.

Two additional sets of single words were selected for use as distractors on the completion test. One of these sets (Set 3) included eight words that were similar to the stimulus words used for the study list pairs in Sets 1 and

Table 1

Examples of Study List Pairs and Completion Test Items

Study list	Completion test item
Related pairs	Test item with
MOLD–BREAD	related context word
RIPE–APPLE	MOLD–BRE _____
DELICATE–FRAGILE	RIPE–APP _____
COVERING–BLANKET	Test item with
	unrelated context word
Unrelated pairs	KINDLY–STI _____
KINDLY–STICK	JAIL–STR _____
JAIL–STRANGE	Test item with
BALANCE–CHAIR	stimulus distractor
DRYER–BLOCK	context word
	DETAIL–FRA _____
	BELIEF–CHA _____
	Test item with
	no context
	word—target alone
	BLA _____
	BLO _____
	Test item with
	no context
	word—distractor alone
	ABS _____
	FLA _____

2; they had an average of 5.6 letters and a frequency count of 43.6 occurrences per million. The other distractor set (Set 4) included 32 words that were similar to the *response* words from the study list pairs. The initial three letters of each word from Set 4 was unique in the pool of all words required for the experiment, and a pocket dictionary listed at least 10 common words with the same beginning. These response distractors had an average of 5.8 letters and a frequency count of 47 occurrences per million (Kučera & Francis, 1967).

Tests. The cued-recall test form consisted of a single page; it showed a randomly arranged list of the stimulus words from the critical 32 study pairs. The word completion test form also consisted of a single page. This test included 64 items, with each item defined either as a single word fragment (40 items) or as a word fragment printed to the right of a context word (24 items), as illustrated in Table 1. The test fragments always consisted of the initial three letters of a word.

Table 1 illustrates the construction of completion test items. Consider first the items that consisted of fragments with context words. Each of these items included a fragment corresponding to a response word from the study list pairs. For 8 items, the context was a related word from Set 1 (e.g., MOLD–BRE___). These items were used to assess completion performance in the same-context condition following study of related word pairs, and they were used to assess performance in a different-context condition following study of unrelated word pairs. For an additional eight items, the context was an unrelated word from Set 2 (e.g., KINDLY–STI_____). These items were used to assess completion performance in the same-context condition following study of unrelated word pairs, and they were used to assess performance in

a different-context condition following study of related word pairs. For the remaining eight items, the context was a stimulus distractor word from Set 3 that never appeared in the study list (e.g., DETAIL–CHA____); these items were used to assess completion performance in a different context. Of the single fragment test items, eight corresponded to response words that were presented in the study list pairs; these items were used to obtain a further index of completion performance in a different context. Finally, 32 single fragment test items corresponded to the words that had been selected as response distractors (Set 4) and they never appeared in the study list. The distractor fragments were included in order to disguise the memory testing aspects of the completion test by merging the target fragments among a longer list of test cues. This disguise is critical because once the memory testing aspects of the completion test become apparent to subjects, the test can be transformed into a cued-recall test. Previous studies have shown that this transformation can be achieved by a simple change in instructions (Graf & Mandler, 1984; Graf, Squire, & Mandler, 1984).

To ensure that each study list response word could be presented in each condition of the completion test (i.e., with a related, unrelated, or distractor context word, or alone), four alternative test forms were required. The use of these forms was counterbalanced within and across experimental conditions.

Procedure. The same general procedure was used for each subject group. It consisted of three parts: instruction and practice, study, and testing. Each subject was tested individually. During instruction and practice, subjects were instructed in a task that required either elaborative processing or vowel comparison, and they practiced these tasks either with related or unrelated pairs. For the elaborative task, subjects used a 5-point scale that had the labels "Easy to Relate" and "Difficult to Relate" at its ends; they had to "construct a sentence" that related "the two words in a meaningful manner," say that sentence to the experimenter, and then record how easy or difficult it had been to produce that sentence. Subjects created a wide range of sentences, some short and simple, "He ate the RIPE APPLE," and some long and complex, "John found a quarter and went to the store to buy a RIPE APPLE with it." For the vowel comparison task, subjects were instructed to decide (Yes/No) whether the two words in each pair had the same number of vowels and to record their decision. Practice continued until each subject followed these instructions. The rate of pair presentation was controlled by subjects' speed on each processing task (approximately 8 vs. 5 seconds per pair for the elaborate vs. vowel comparison task). Previous work has shown that variations in the rate of presentation across this range has no systematic effect on word completion performance (Graf & Mandler, 1984).

Immediately after instruction and practice, each subject was presented with a study list consisting of either related words or unrelated words. This list included 32 pairs either from Set 1 (related) or Set 2 (unrelated), and five filler pairs, three of which were at the list beginning and two at its end. The fillers were added to minimize primacy and recency effects on the subsequent tests. The 32 critical pairs were arranged randomly within the study list. The study list was presented once, self-paced by each subject's speed on the processing tasks described earlier.

During the third part of the experiment, each subject received a sequence of three tests: name completion, word fragment completion, and cued recall. The name completion test was given immediately after study. Its functions were to engage subjects in an unrelated activity before administering the word completion test, and more importantly, to induce an appropriate set for word completion testing. The name completion test presented subjects with the fragmented names of 11 famous people (e.g., G____e____ ____ G____ ____ ____d, L____ ____a ____i____e____ ____i), and 3 min were allowed for completing as many names as possible.

The word fragment completion and cued-recall tests were described in the materials section. The completion test instructions informed subjects that before they would receive a memory test, they had to "complete each word beginning on the [completion test] form with the first word that [came] to mind." Subjects were instructed that they could write any word except proper names, and when a proper name was given an alternative completion was requested. Because some of the completion cues were presented in the context of another word, several of which were from the study list, the instructions emphasized that the task was to complete each cue with the first word that came to mind, that the context word would sometimes help to think of a completion, but that it was unimportant whether or not the completion was related to the context word. Subjects who requested more information about the purpose of this test, particularly the role of the context words, were told that this filler task had been borrowed from a different experiment. We encouraged subjects to finish the completion test as quickly as possible (it required about 3 min). Then the cued-recall test was presented. The cued-recall instructions emphasized explicit remembering. Subjects were reminded of the word pairs that they had studied, they were informed that the test cues were the stimulus words from the pairs that they had seen, and they were instructed to recall the response word that had been paired with each stimulus in the study list. This test required about 5 minutes and it was terminated when a subject had not written anything for about 1 minute.

In summary, each subject studied a 37-item list consisting of either related or unrelated word pairs, under conditions that required either elaborative processing or vowel comparison. The pairs were presented at a pace determined by each subject's speed on the study task. Immediately after study a distractor task was given (the name completion test) for 3 minutes, followed by a word fragment completion test and then a cued-recall test.

Results

The dependent measures were the proportion of study list response words produced on the fragment completion test and the proportion of words remembered on the cued-recall test. In order to assess the completion test effects attributable to different experimental conditions, we also required an estimate of baseline performance on this test. This estimate was obtained from a group of
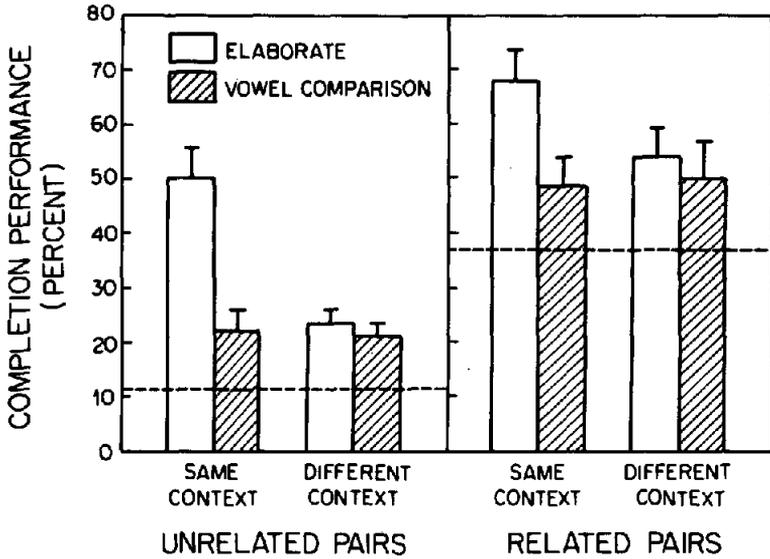
Figure 1. Mean completion performance for related and unrelated word pairs that were presented in a task that required generating a sentence for each pair (elaborate condition) or in a task that required comparing the vowels in each pair (vowel comparison condition). [The completion test showed the initial three letters of the response word from each pair, either with the paired stimulus word from the study list (same context) or with another word or alone (different context). A separate control group was used to obtain an estimate of baseline completion performance on the target response words, shown by the dashed lines. Vertical bars show the standard errors of the means.]

116 subjects who received the same completion test without a presentation of the study list. The performance of this control group showed that for fragments that were tested in the context of a related word, baseline performance was 38.5%, whereas it was lower for fragments that were tested in the context of an unrelated list word (12.2%), an unrelated new word (11.9%), or alone (12.2%). The latter means did not differ significantly, $F <$ 1, and thus we used their overall mean (12.1%) in subsequent analysis ($p < .05$ for this and all other statistical tests). These baseline levels, shown in Figure 1, provide the reference points for assessing the completion test effects produced by learning unrelated and related word pairs under elaborative and vowel comparison study tasks and across different testing conditions.

Effects of context on completion of studied words. The primary goal of the experiment was to compare completion performance on fragments tested in the same context as in the study list (i.e., paired with the same word as in the study list) and on fragments tested in different contexts (i.e., paired with another

word from the study list, paired with a new word, or tested alone). The relevant data are presented in Figure 1. This figure shows that following elaborative processing of either type of word pairs, completion performance on same-context items exceeded performance on different-context items. Following vowel comparison, however, the level of completion performance was similar across same- and different-context test items for both types of study list pairs.

This summary of the findings is supported by a $2 \times 2 \times 2$ analysis of variance (ANOVA) that treated materials (related and unrelated pairs) and study task (elaborate and vowel comparison) as between-subjects factors and test context (same and different) as a within-subjects factors. For this analysis, the original test scores were adjusted by subtracting the appropriate baseline scores, thereby eliminating effects attributable to the different baseline scores for unrelated and related pairs. The analysis showed significant main effects for study task, $F(1, 60) = 17.5$, $MS_e = 17.8$, and for test context, $F(1, 60) = 16.6$, $MS_e = 15.5$. More importantly, however, there was a sig-

Table 2
Cued Recall Performance (Means and Standard Errors) as a Function of Study Task and Study List in Experiment 1

Study task	Study list	Recall of target words (%)		Recall test intrusions (no. of words)
		M	SE	
Elaborate	Related pairs	66.8	5.5	1.56
	Unrelated pairs	35.4	4.5	3.06
Vowel comparison	Related pairs	8.8	2.9	1.31
	Unrelated pairs	.2	.2	1.63

nificant interaction between study task and test context, $F(1, 60) = 12.9$, $MS_e = 15.5$, with no other effects approaching significance. This interaction indicates that for both unrelated and related study list pairs, completion performance was higher on same-context items than on different-context items after the elaborative study task, but not after the vowel comparison task.

An additional analysis showed that on the different-context test items, performance was systematically affected only by whether or not the context word was related to the target word. On the one hand, for items with unrelated context words, overall completion performance was 23.3 and 20.0% for the elaborative and vowel comparison task, respectively. Both of these means were significantly higher than the appropriate baseline level of 12.1%, $t(31) = 6.5$ and 5.1, respectively. On the other hand, for items with related context words, overall completion performance was 53.9 and 50.0% for the elaborative and vowel comparison task, respectively. Both of these means also exceeded the appropriate baseline level of 38.5%, $t(15) = 2.7$ and 2.1, respectively.

Cued recall. Table 2 shows the overall levels of cued-recall performance in each experimental condition. An analysis of these data showed significant main effects for materials (related, unrelated), $F(1, 60) = 27.6$, $MS_e = 23.8$, and for study task (elaborate, vowel comparison), $F(1, 60) = 149.5$, $MS_e = 23.8$, as well as a significant interaction between these factors, $F(1, 60) = 9.0$, $MS_e = 23.8$. Overall recall was lower under vowel comparison than elaborative task conditions and with unrelated than related word pairs.

The interaction effect is probably an artifact that stems from the near-zero level of recall under vowel comparison task conditions. The table also shows the number of incorrect words or intrusions that appeared on the recall test; these intrusions were infrequent in all experimental conditions.

Discussion

Experiment 1 yielded three main findings. First, following an elaborative study task, there was a higher level of completion performance when the study context was reinstated at testing than when study and test contexts were different, for both unrelated and related study list word pairs. In contrast, following the vowel comparison task, there was no same-different effect on either type of word pairs. Second, across all types of different-context test items, there were similar and significant increases above baseline completion performance under both elaborative and vowel comparison task conditions. This finding replicates and extends the results from previous studies that reported that priming of single words is not affected by similar study task manipulations (Graf & Mandler, 1984; Graf et al., 1982; Graf, Squire, & Mandler, 1984; Jacoby & Dallas, 1981). Third, there was a higher level of recall for related pairs than for unrelated pairs as well as a higher level of recall under elaborative than vowel comparison task conditions. Overall, the pattern of findings suggests that implicit memory for new associations, as indexed by completion test performance, is affected by manipulations of test context. The similarity in the results for unrelated and

related word pairs indicates that the same–different completion test effect does not depend on preexisting associations between words, because the normatively unrelated word pairs were associated for the first time during study list presentation.

The finding of a higher level of completion performance on same-context test items versus different-context test items under elaborative study conditions, but not under vowel comparison conditions, contrasts with the results from previous studies that found comparable levels of priming across similar task manipulations. This invariance of completion performance across task manipulations (e.g., Graf & Mandler, 1984; Graf et al., 1982; Jacoby & Dallas, 1981) was used to argue that implicit memory is mediated by automatic processes. In contrast, explicit recall and recognition were assumed to be mediated by strategic or controlled processes because of their dependence on study task manipulations. On this view, the observation that the same–different effect depends on elaborative processing suggests that the completion test used here measures explicit rather than implicit memory. That is, because performance is affected by study task manipulations that are assumed to operate independently of the automatic processes that mediate implicit memory, the completion test used here was influenced by explicit remembering. Thus, the same–different context effect may not provide evidence of implicit memory for newly acquired associations.

One way to test this hypothesis is by examining the relation between performance on the word completion test and performance on the cued-recall test. Previous studies have shown that the likelihood of producing a word on a completion task does not predict its recognition; performance on a completion task can be statistically independent of performance on a test of explicit remembering (see Tulving et al., 1982). This statistical independence was used to argue that performance across these tests was mediated by different underlying memory processes.

In order to determine whether the same–different effects observed with the elaborative study tasks can be attributed to processes that are also required for cued recall, we examined the relation between completion

and recall performance for words that had been tested in the same-context condition of the completion task. A finding of statistical independence would be difficult to reconcile with the view that the same processes are required for completion and cued recall, because common processes should have similar effects across tests and thus introduce performance dependence. However, the analysis revealed signs of dependence: overall cued-recall performance was generally higher for words that had been produced on the completion test than for words that had not been given as completions (82.7 vs. 58.7% for related pairs and 51.8 vs. 25.2% for unrelated pairs). A chi-square test confirmed this observation by showing a significant amount of dependence between completion and cued-recall test performance for related study list pairs, $\chi^2(1) = 32.1$, and for unrelated study list pairs, $\chi^2(1) = 24.6$.

One possible interpretation of this dependence is that both completion and cued recall are mediated by explicit remembering. However, this dependence does not permit an unambiguous interpretation because it can also occur for a variety of other reasons. For example, dependence can result because words that are produced on the completion test receive an additional exposure between study and cued-recall testing and are thus better recalled than words that were not produced on the completion test (a similar observation was made by Tulving et al., 1982). The present results are consistent with this view. We found that after the elaborative study task, recall of words that had been given as completions in the same-context condition was higher (80.7%) than recall of words that had been given as completions in the different-context condition (56.4%). In contrast, there was no comparable difference in recall for words that had *not* been given on the completion test: recall of words from the same-context condition was 32.1% and recall of words from the different-context condition was somewhat higher, 44.5%. These findings indicate that completion testing had a large influence on recall performance, and this influence may be sufficient to account for the observed dependence between completion and cued-recall performance.

In summary, the same–different effect

found in Experiment 1 demonstrates that completion test performance is affected by newly acquired associations. The interpretation of this finding must remain ambiguous, however, because completion test performance may not provide a pure index of implicit memory. Thus, the same–different effects found here may be attributed either to the implicit or explicit memory for new associations.

Experiment 2

The main goal of Experiment 2 was to examine further whether an implicit or explicit form of memory is responsible for the same–different effect observed on completion test performance in Experiment 1. For this purpose, we compared cued recall and completion test performances of amnesic patients and of two groups of control subjects. In view of the amnesic patients' deficit on tests that require explicit remembering and their intact performance on tests that depend on implicit memory, their performance on the word completion test provides a critical test of whether the same–different effect is attributable to explicit remembering. If amnesic patients and control subjects show a comparable performance superiority on the completion test in the same-context condition over the different-context condition, there would be strong support for the view that the same–different effect is mediated by implicit memory for newly acquired associations. However, if amnesics showed a similar level of completion performance on same- and different-context items, it would suggest that the same–different effect found in Experiment 1 was mediated by explicit remembering.

Experiment 2 followed the strategy used in Experiment 1, with three important changes. First, all materials were presented with an elaborative study task because the same–different effect was observed only under elaborative study conditions in Experiment 1. Second, the type of study material (related and normatively unrelated word pairs) was included as a within-subjects factor. Third, a simplified word completion test was used, with fewer items for assessing performance in the different-context condition, because Experiment 1 showed that alternative types of different-context items provide similar information about completion performance. Each subject saw both related and unrelated word pairs and then received a word completion test followed by a cued-recall test. On the assumption that anterograde amnesia impairs only explicit remembering, and that the same–different effect is attributable to implicit memory, we expected the same pattern of completion performance in each subject group, together with different levels of cued-recall performance.

Method

Subjects. Three groups of subjects participated in the experiment. The first group consisted of 12 amnesic patients (8 men, 4 women) with diverse neurological disorders that are commonly associated with memory impairments. These patients became amnesic as a result of closed head injuries (6 patients), ruptured anterior communicating artery aneurysms (3 patients), encephalitis (1 patient), and tumor of the third ventricle (1 patient). No firm neurological diagnosis was available for one patient. Eleven patients lived at home with their families and one lived in a chronic care facility in the Toronto area. Their average age was 42.3 years (range 20–67), and they had an average of 14.0 years of formal education (range 10–22). Their average full scale IQ on the Wechlser Adult Intelligence Scale–Revised (WAIS-R) was 93.3 (range 82–117) and their average Wechsler Memory Scale (WMS) score was 80.8 (range 61–110). In normal subjects the WMS score is equivalent to IQ. None of the patients were aphasic, anomic, apraxic, or agnosic, and none had difficulty in following task instructions. Every patient had difficulties on standard tests of explicit remembering, such as recall and recognition of recently presented words. None of them could recall part of a short paragraph after a 30 min delay, and each showed a severe deficit in paired-associate learning, recalling an average of .08, .17, and .42 responses from six unrelated word pairs after one, two, and three study trials, respectively.

The performance of the amnesic patients was compared with two control groups. The first control group included 5 men and 7 women that were matched to the amnesic patients in terms of age, IQ, and formal education. These subjects lived with their families and volunteered for the study. Seven of them were chosen because they had experienced neurological traumas similar to those of the amnesic patients (mild head injuries for 5 subjects, ruptured anterior communicating artery aneurysms for 2 subjects), but they had no measurable memory deficits. The remaining 5 subjects had not experienced any neurological dysfunction, and were chosen because their ages and IQs were similar to those of the amnesic patients. The group had an average age of 47.2 years (range 22–81) and 12.3 years of formal education (range 8–17). Their average full scale WAIS-R IQ was 99.3 (range 88–120). This matched group did not differ significantly from the amnesics in terms of age, $t(22) < 1$, years of education, $t(22) = 1.3$, or full scale WAIS-R IQ, $t(22) = 1.4$. The experiment also included a control

group of 24 college students who participated in return for credits in an introductory psychology course. The latter group was included to provide a replication of Experiment 1.

Design. The design included the three groups as a between-subjects factor, and materials (related vs. unrelated word pairs) and test type (completion vs. cued recall) as within-subjects factors.

Materials. Most of the materials from Experiment 1 were used, including 30 word pairs each from the related and unrelated sets (Sets 1 and 2), 30 of the response distractor words from Set 4, and a random selection of 15 related and unrelated practice–filler pairs. In addition, 40 words were required to serve as stimulus distractors for the completion test used in Experiment 2. This set of stimulus distractors consisted of words that were similar to the stimulus words used in the study lists, as described in Experiment 1.

Tests. The cued-recall test form consisted of 2 pages, each of which showed the 15 stimulus words from one half of the study list pairs in a random arrangement. The same test form was used to assess recall for both related and unrelated word pairs, because the words from the related pairs had simply been re-paired in order to construct the unrelated pairs.

The completion test was a simplified version of that used in Experiment 1 because the results from that experiment showed that alternative types of different context items provide similar measures of performance. A different test form was used to assess completion for related and unrelated pairs. Each test was constructed to obtain three measures of completion performance on target words from the study list and one measure of baseline completion performance on new words. The three measures of performance on target words were obtained by presenting test fragments in three types of contexts. Each completion test consisted of 2 pages, and each page showed a random arrangement of 30 test items (i.e., a fragment with a context word). Five items consisted of a fragment with a paired word from the study list (same-context items), 5 items consisted of a fragment with a presented word that had not been paired with the target in the study list (broken item), 5 items consisted of a fragment with a stimulus distractor word from Set 3 (new–old item), and 15 items consisted of a response distractor fragment from Set 4 with a stimulus distractor word from Set 3 (new–new item). For each page of the completion test, three different forms were required in order to present each study list target word in each test context.

Procedure. The general procedure was similar to that of Experiment 1. Each subject was first instructed in the elaborative study task used in Experiment 1. This task required subjects to generate a sentence for each study list word pair and to evaluate on a 5-point scale how difficult it had been to generate that sentence. Subjects practiced this task on five word pairs. The rate of pair presentation was self-paced by each subject's speed on the study task.

Immediately after instruction and practice, each subject received two study–test trials, with a short pause (about 3 min) separating the two trials. Each trial included a study list presentation and a sequence of three tests: name completion, word completion, and cued recall. The study

list consisted of either 15 related word pairs or 15 unrelated word pairs, and 5 filler pairs—three at the list beginning and two at its end. For one half of the subjects in each group, the first list included the related pairs and the second list included the unrelated pairs; the reverse order was used for the remaining subjects. The first and second list had none of the same words, for any subject. The name completion test, which was described in Experiment 1, was given immediately after the study list; its functions were to engage subjects in an unrelated activity for 3 min before administering the word completion test, and more importantly, to induce an appropriate test set for word completion. The word completion and cued-recall tests were described in the materials section; they were administered as in Experiment 1.

Results

The dependent measures were the proportions of test fragments that were completed with study list response words in the same-context condition and in the different-context condition by each subject group. The completion test also yielded a measure of baseline performance because it included some test items corresponding to response distractor words that were never presented in the study list. All subject groups showed similar levels of completion performance on these baseline items (amnesic patients = 14%, matched controls = 11.7%, and student controls = 13.6%). An additional estimate of baseline completion performance was obtained from a group of 48 college students who received the completion test without having seen the study lists. They completed 11.9% of the distractor items. More importantly, as in Experiment 1, the results from the control group showed that for target word fragments that were tested in the context of a related word, baseline performance averaged 25.8%, whereas it was lower for fragments that were presented in the context of an unrelated list word (12.9%) or an unrelated new word (13.5%). Because the latter two means did not differ significantly ($t = .4$), their overall mean (13.2%) was used as an estimate of baseline performance on test items with unrelated context words. Figure 2 shows the baseline level for related items and for unrelated items; these levels provide reference points for assessing the completion test effects produced by learning unrelated or related word pairs.

Effects of context on completion of studied words. The primary goal of the experiment
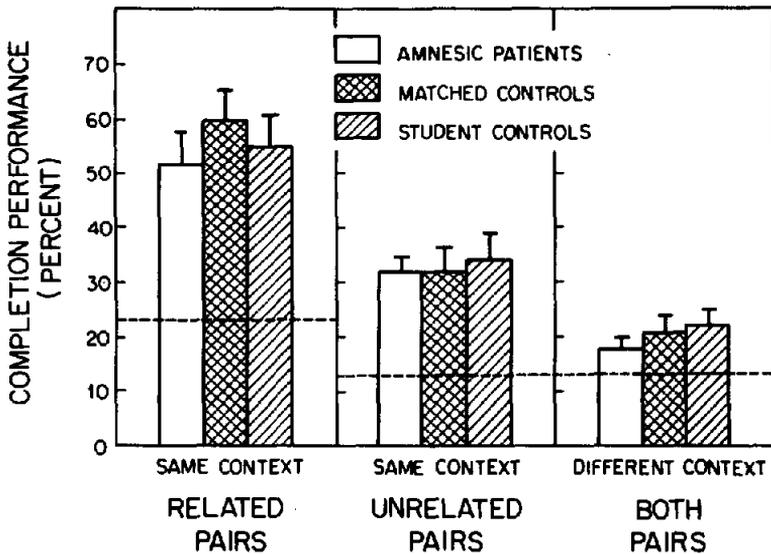
Figure 2. Mean word completion performance for related and unrelated pairs, studied under elaborating task conditions by three different subject groups: amnesic patients, matched controls, and student controls. [The completion test presented the initial three letters of the response word from each study list pair, either with the paired stimulus word from the study list (same context) or with an another word (different context). A separate control group was used to obtain an estimate of baseline completion performance on the target response words, shown by the dashed lines. Vertical bars show the standard errors of the means.]

was to compare completion performance of amnesic patients and control subjects on fragments tested in the same context as in the study list (i.e., paired with the same word as in the study list) and on fragments tested in different contexts. The relevant data are presented in Figure 2. The figure shows that for both types of word pairs and for all subject groups, completion performance was higher in the same-context condition than in the different-context condition. For the same-context condition, performance on items with unrelated context words averaged 31.7, 31.7, and 34.2% for amnesic patients, matched controls, and student controls, respectively ($F = .1$), and performance on items with related context words averaged 51.7, 60.0, and 55.0% for amnesic patients, matched controls, and student controls, respectively ($F = .3$). This summary of the findings was supported by an ANOVA that revealed a significant main effect for type of completion test context (same related, same unrelated, different), $F(2, 90) = 13.8$, $MS_e = 1.0$, with no other effects approaching significance. For this analysis the original test scores were adjusted by subtracting the appropriate base-

line scores, thereby eliminating effects attributable to the different baseline scores for unrelated and related pairs. Across subject groups, the overall increase in completion performance was higher in the same-context condition (24.5%) than in the different-context condition (7.0%).

An additional analysis showed that in the different-context condition, performance was similar across the three subject groups, averaging 17.9% (17.5 and 18.3% for the related and unrelated list, respectively) for the amnesic patients, 20.4% (20.0 and 20.8% for the related and unrelated list, respectively) for the matched control group, and 21.9% (21.7 and 22.1% for the related and unrelated list, respectively) for the student controls. These means did not differ significantly from each other, $F = .7$. However, they reveal a significant increase over baseline completion performance; the smallest increase was shown by the amnesic patients (10 out of 12 showed an increase) but even this level of performance was above baseline, $t(11) = 2.27$.

Cued recall. Table 3 shows the level of cued-recall performance in each experimental condition, as well as the number of incorrect

Table 3
Cued-Recall Performance (Means and Standard Errors) as a Function of Study List and Subject Group in Experiment 2

Study list	Subject group		
	Amnesic patients	Matched controls	Student controls
Related pairs			
Target words (%)			
M	33.3	72.8	92.2
SE	6.6	5.3	2.1
Intrusions (no. of words)	5.0	1.6	.3
Unrelated pairs			
Target words (%)			
M	2.2	35.0	63.9
SE	1.3	7.7	4.7
Intrusions (no. of words)	7.4	3.0	1.0

words or intrusions that appeared on the recall test. An analysis of the recall data showed a significant main effect for group, $F(2, 45) = 53.7$, $MS_e = 11.1$, attributable to a high level of recall in the student control group (78.1%), a medium level of recall in the matched group (53.9%), and a low level of recall in the amnesic group (17.8%). The analysis also showed a main effect for study list, $F(1, 45) = 104.0$, $MS_e = 4.9$, with higher recall of words from the related (66.1%) than the unrelated (33.7%) pairs. No other effects reached significance.

Discussion

Experiment 2 yielded three new facts. First, for amnesic patients, matched controls, and student controls, there was a higher level of completion performance when the study context was reinstated at testing (same context) than when study and test contexts were different, for both unrelated and related word pairs. Second, the level of completion performance on same-context test items did not differ among the three subject groups. Third, there was a higher level of recall for both control groups than for the amnesic group. The control groups' data replicate the findings

from Experiment 1. The amnesic group's data provide critical evidence in support of the view that the same–different effect on the word completion test is mediated by implicit memory for newly acquired associations. In spite of their severely impaired recall, the amnesic patients showed entirely normal levels of completion test performance after studying unrelated and related word pairs. This pattern of results suggests that amnesic patients can have normal implicit memory for newly acquired associations, just as they can show normal priming for items with preexisting representations, such as words (e.g., Diamond & Rozin, 1984; Graf, Squire, & Mandler, 1984; Warrington & Weiskrantz, 1970, 1974). Thus, the present findings support the view that implicit and explicit memory for new associations are mediated by different underlying processes.

It is necessary, however, to consider also a more parsimonious account of the present results, one that does not require the assumption of two qualitatively different forms of memory. The present results might also be interpreted in terms of differences in test difficulty; it could be that word completion is an *easier* test than cued recall because the cues provided on the completion test, particularly in the same-context condition (e.g., MOLD–BRE___), provide more information than do the cues provided on the recall test (e.g., MOLD–_____). Thus, amnesic patients may show normal performance on the *easy* test and a deficit on the *difficult* test. Accordingly, there may be no need to assume that an implicit form of memory mediates the retention of newly acquired associations in amnesic patients; it may be that the explicit form of memory is recruited whenever a retention test becomes sufficiently easy.

Three aspects of the results from the present experiment, however, argue against a test difficulty explanation of the amnesic patients' performance on the word completion test. First, on the argument that word completion is an easier test than cued recall, it would be expected that all subject groups would show a higher level of performance in the same-context condition of the completion test than on the cued-recall test. However, this outcome was not observed. The relevant data are presented in Figure 2 and in Table 3, which

illustrate that (a) the student controls showed a higher level of cued-recall performance than word completion performance in the same-context condition, (b) the matched controls showed similar levels of cued recall and word completion performance, and (c) only the amnesic patients performed more poorly on the recall test than on the completion test. This pattern of findings highlights the substantial between-group differences on the recall test, and the absence of such differences on the completion test, thus arguing against a simple quantitative difference interpretation for the completion and recall test results.

Second, it also follows from the test difficulty argument that a word that was given on cued recall—the *hard* test—should also have been given on completion—the *easy* test, and consequently, the probability of failing to complete a word that was given on the recall test $[P(\bar{c}|R)]$ should be very low. To evaluate this possibility, we computed $P(\bar{c}|R)$ for words that had been tested for completion in the same-context condition. Contrary to the test difficulty argument, a high proportion of the recalled words had not been given on the word completion test. Specifically, $P(\bar{c}|R)$ was 44.1 and 62.1% for related and unrelated pairs, respectively, for student controls; 32.0 and 52.5% for related and unrelated pairs, respectively, for matched controls; and 31.0% for related pairs for amnesic patients (recall of unrelated pairs was too low for a meaningful contingency analysis).

Third, the test difficulty argument would predict statistical dependence between completion and recall performance for words that had been tested in the same-context condition of the completion test. However, there were signs of dependence only in the data for the age matched control group ($\chi^2(1) = 3.8$ and 8.0 for unrelated and related word pairs); the data from the amnesic patients and the student control group showed no evidence of dependence (all $\chi^2(1) < 2.5$). In view of the fact that strong dependence between word completion and cued recall was observed in Experiment 1, it is not entirely clear why we found independence in some conditions of the present experiment. There are a number of procedural differences between Experiment 1 and 2 that could explain this pattern of findings, such as length of study list and the composition of the word completion test.

Taken together, the foregoing findings are not consistent with a test difficulty interpretation of the results from Experiment 2. Instead, they provide additional evidence for the view that word completion performance and cued-recall performance reveal qualitatively different forms of memory. The present results also emphasize that the sensitivity to a particular form of memory is not determined solely by the nominal amount of information that is provided on the test. Instead, it appears that a test's sensitivity to a particular form of memory is heavily influenced by the instructions that are used to induce a testing set for the implicit expression of memory or for explicit remembering (cf. Graf & Mandler, 1984).

On the argument that instructions are critical for defining the nature of a test, it follows that if the completion test used here were given with instructions for explicit remembering, a different pattern of results would emerge. Specifically, if both the completion test and the recall test were given with explicit remembering instructions, $P(\bar{c}|R)$ should be very low, because the two tests would then measure the same form of memory. To assess this possibility, a group of 6 students studied the list of unrelated pairs that was used in Experiment 2 and was then given the word completion test followed by the cued-recall test. In contrast to the previous experiments, however, these subjects were given instructions that emphasized that the cues on both tests were related to the words from the studied pairs and that the task was to use these cues as aids for recalling the words from the study list. Consistent with expectations, the results showed that for pairs tested with same-context items on the completion test, $P(\bar{c}|R)$ was only 14% in contrast to 62.1% when completion instructions were used in Experiment 2. This finding reveals the critical nature of instruction in defining what is tapped by a test, and it strengthens the view that word completion and cued recall are sensitive to qualitatively different forms of memory.

General Discussion

The present study complements previous research on direct priming and explicit re-

membering in three ways. First, the results show that word completion performance is affected by newly acquired associations between pairs of unrelated words. This demonstration extends the findings on priming of new associations shown previously with lexical decision, word identification, and listening and reading tests (e.g., Carroll & Kirsner, 1982; Franks et al., 1982; McKoon & Ratcliff, 1979; Moscovitch, 1984). Second, the results show that implicit memory for new associations can occur independently of the level of explicit remembering. It was found that amnesic patients and control subjects showed similar levels of performance in all conditions of the word completion test despite the amnesics' severe deficit on the cued-recall test. This pattern of results indicates that implicit and explicit forms of memory can be dissociated for newly acquired associations as well as for preexisting associations. Third, this study identified a critical factor in implicit memory for new associations by showing that it depends on elaborative processing of to-be-remembered materials.

The present finding that implicit memory for new associations requires elaborative processing, differs from previous demonstrations that showed that implicit memory for items with preexisting representations, is independent of semantic–non-semantic task manipulations (e.g., Graf et al., 1982; Graf & Mandler, 1984; Graf, Squire, & Mandler, 1984; Jacoby & Dallas, 1981). These contrasting results raise questions about the representations that mediate implicit memory for new associations. One possibility is that implicit memory occurs independently of the specific study task requirements with single words because they have highly integrated representations that are completely activated even when only some of their components are processed deliberately (cf. Horowitz & Prytulak, 1969; Rumelhart & Ortony, 1978). In contrast, there is no preexisting unitized representation for a pair of unrelated words. Thus, the relation between these words must first be constructed by engaging in elaborative processing during the study trial, and only then can it support the redintegration of the pair subsequently.

The demonstration in Experiment 1, that the same–different effect depended on elabo-

rative processing for both related and unrelated pairs may seem inconsistent with this interpretation, because a pair of related words (e.g., RIPE–APPLE) is linked by a preexisting association, and thus even the nonelaborative vowel comparison task should have produced a same–different effect on the completion test. However, these moderately related pairs may not be represented in an integrated or unitized manner, and hence they still require elaborative processing in order to affect performance on a test for implicit retention. It is possible that highly related pairs (e.g., TABLE–CHAIR), that are represented as integrated units (cf. Hayes-Roth, 1977), would have produced a same–different effect on the word completion test even under nonelaborative task conditions.

Although our findings indicate that priming entails more than activation of preexisting representations, implicit memory for a pair of newly related words may still depend critically on the preexisting representations of the component words. Some degree of dependence on preexisting representations is suggested by the finding that in the present experiments, a same–different effect for unrelated word pairs was observed when the completion test cues consisted of the stimulus word and part of the response word from each list pair (e.g., BALANCE–BRE___). However, when the test presented only the stimulus word from each pair, and no part of the response word (e.g., BALANCE___), there was no evidence of a priming effect. This latter finding was observed in a pilot study with 4 amnesic patients. These patients were required to generate sentences for randomly paired words as in the present study, and then they were given a completion test for the target words. In contrast to the completion test used here, however, the test used in the pilot study presented only the stimulus word from each pair and required subjects to respond with the first word that came to mind. The subjects never produced the response words, even after four study–test trials.

A recent study by Schacter (in press-a) provides a more systematic demonstration of the fact that priming of new associations is observed only when the test cue consists of parts of both words from an unrelated pair. Schacter presented amnesic patients and con-

trol subjects with unitized phrases that represented linguistic idioms (e.g., SOUR GRAPES, SMALL POTATOES) and nonunitized phrases that were formed by re-pairing the components of the idioms (e.g., SMALL GRAPES, SOUR POTATOES), and then gave a completion test followed by a free-recall test and a cued-recall test. The critical data come from the completion test, which showed the initial word from each phrase as a cue (e.g., SOUR____, SMALL____) and required subjects to write the first response word that came to mind. Schacter found that on this completion test, subjects produced 26.3% of the correct response words for the unitized phrases (27% for amnesics and 26% for controls), but they produced virtually none of the response words for the nonunitized phrases (0% for amnesics and 1% for controls). The absence of a priming effect on the nonunitized or unrelated items stands in contrast with results from the present study, which differed from Schacter's study primarily in terms of the cues that were provided on the test. When the completion test reinstated part or all of each preexisting component of an unrelated word pair, as in the present experiments, there was evidence of implicit memory for new associations; but when the test provided only one preexisting component of a pair of unrelated words, as in Schacter's study, there was no evidence for implicit memory. Schacter's results show, however, that for a pair of words that forms a well-integrated, preexisting unit (e.g., SOUR GRAPES), one word from the pair is sufficient for cuing the entire unit on a completion test. This pattern of results reveals a distinction between the preexisting representation for a pair of related words (e.g., a linguistic idiom) that can be redintegrated when one of its components is provided as a cue and the newly established representation for a pair of previously unrelated words whose redintegration requires that the completion test cue provides access to each of its preexisting components.

The present results, in conjunction with other studies, have implications for a number of interpretive accounts that have been offered for implicit memory. As discussed earlier, it has been argued that priming is mediated by the automatic activation of preexisting representations (e.g., Diamond & Rozin, 1984; Graf, Squire, & Mandler, 1984; Mandler, 1980; Mortensen, 1980; Morton, 1969, 1979; Rozin, 1976; Warrington & Weiskrantz, 1982; Wickelgren, 1979). This view is difficult to reconcile with the finding of implicit memory for newly acquired associations that have no preexisting representation, and with the fact that this type of memory occurs only under semantic or elaborative study conditions and not under nonsemantic conditions. A related account suggests that direct priming is mediated by decontextualized semantic memory representations that can exist independently of context specific representations in episodic memory (e.g., Kinsbourne & Wood, 1975, 1982; Schacter & Tulving, 1982). This view is not supported by the present finding of a context effect on completion performance that indicates that implicit memory can be mediated by representations established as a result of relating two words on a single study trial. A third alternative view suggests that both implicit and explicit memory for a recent experience are mediated by the same episodic memory representation (Jacoby, 1983; Jacoby & Witherspoon, 1982). By this view, an episode is retrieved with awareness for an explicit test, and the same episode is retrieved without awareness for an implicit test. The implicit memory for new associations observed in the present study is consistent with this view, insofar as it indicates that priming can be affected by new representations that were established during a single study trial. If, however, implicit memory is mediated by the same episodic representation that supports explicit remembering, priming should be observed even when only one word of a studied pair is presented as a cue on an implicit test. However, as discussed previously, this outcome is found only for highly related, unitized pairs and not for newly acquired pairs. Priming of new pairs requires a test cue that includes a component corresponding to the preexisting representation of the target response, whereas explicit remembering of a new pair can occur even when only one part of a new unit is presented as a test cue. A similar problem about underlying representations is raised by the finding that amnesic patients do not show priming for pseudowords which have no preexisting representations

(e.g., Cermak, 1984; Diamond & Rozin, 1984; see Schacter, in press-b, for discussion).

The present results also have implications for the understanding of preserved and impaired memory processes in amnesia. Most accounts of preserved memory processes in amnesia emphasize that amnesic patients can strengthen existing representations, associations, or procedures (e.g., Diamond & Rozin, 1984; Mandler, 1980; Squire & Cohen, 1984; Warrington & Weiskrantz, 1982; Wickelgren, 1979). It has been suggested that this strengthening or tuning occurs gradually as a result of repetition (e.g., Mandler, 1980; Mishkin, Malamut, & Bachevalier, 1984; Squire, Cohen, & Nadel, 1984). The findings from Experiment 2 do not support these arguments because they show that at least some amnesic patients can retain a *new* association between normatively unrelated words that was established on a single study trial. These results confirm previous reports of memory for new associations in amnesic patients (Moscovitch, 1984; Schacter, Harbluk, & McLachlan, 1984; Weiskrantz & Warrington, 1979). Whether this aspect of memory is intact in all types and degrees of amnesia remains to be determined.

The new associations retained by amnesic patients, however, are only sufficient to support implicit memory; they do not support explicit remembering. It could be argued that this finding was observed because amnesic patients are capable of forming relatively *weak* associations (cf. Milner, 1984) that require the presence of both the stimulus and part of the response in order to be expressed, whereas normal subjects form *strong* associations that can be elicited by the stimulus word alone. This argument, however, would have difficulty accommodating the results from the contingency analysis described earlier, which revealed that normals and even amnesic patients often give a correct response on the cued-recall test after having failed to produce the same response on the completion test. It seems implausible to suggest that subjects fail on a test that is sensitive to weak associations, and then succeed on a test that requires stronger associations for successful performance. Instead, it seems preferable to postulate two qualitatively distinct representational consequences of a learning episode,

only one of which occurs normally in amnesic patients.

In conclusion, implicit memory for new associations, independent of explicit remembering, is mediated by a representation that is established as a result of semantic or elaborative processing on a single study trial. The representation that mediates implicit memory for new associations depends on preexisting representations, and its redintegration requires that part of each preexisting unit is presented on the memory test. In contrast, the representation that mediates explicit memory for new associations does not depend on preexisting units in the same way; recall and recognition can occur even when only one part of a completely new unit is given as a test cue. These observations further strengthen the suggestion that there are qualitatively different representational consequences of an experience that mediate implicit and explicit memory for new associations. However, a detailed understanding of the nature of these differences will have to await the results of further research.

References

Baddeley, A. D. (1982). Amnesia: A minimal model and an interpretation. In L. S. Cermak (Ed.), *Human memory and amnesia* (pp. 305–336). Hillsdale, NJ: Erlbaum.

Brooks, D. N., & Baddeley, A. D. (1976). What can amnesic patients learn? *Neuropsychologia, 14,* 111–122.

Bruner, J. S. (1969). Modalities of memory. In G. A. Talland & N. C. Waugh (Eds.), *The pathology of memory* (pp. 253–259). New York: Academic Press.

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

Cermak, L. (1984, June). *Some attempts to improve the memory of amnesic patients.* Paper presented to the International Neuropsychological Symposium, Beaune, France.

Cofer, C. C. (1967). Conditions for the use of verbal associations. *Psychological Bulletin, 68,* 1–12.

Cohen, N. J. (1984). Preserved learning capacity in amnesia: Evidence for multiple memory systems. In L. R. Squire & N. Butters (Eds.), *Neuropsychology of memory* (pp. 83–103). New York: Guilford Press.

Cohen, N. J., & Squire, L. R. (1980). Preserved learning and retention of pattern-analyzing skill in amnesia: Dissociation of "knowing how" and "knowing that." *Science, 210,* 207–209.

Cramer, P. (1966). Mediated priming of associative re-

sponses: The effect of time lapse and interpolated activity. *Journal of Verbal Learning and Verbal Behavior, 5,* 163–166.

Diamond, R., & Rozin, P. (1984). Activation of existing memories in the amnesic syndrome. *Journal of Abnormal Psychology, 93,* 98–105.

Eich, J. E. (1984). Memory for unattended events: Remembering with and without awareness. *Memory & Cognition, 12,* 105–111.

Franks, J. J., Plybon, C. J., & Auble, P. M. (1982). Units of episodic memory in perceptual recognition. *Memory & Cognition, 10,* 62–68.

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

Graf, P., & Mandler, G. (1985). *Direct priming across sensory modalities and word boundaries.* Unpublished manuscript.

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

Graf, P., Shimamura, A. P., & Squire, L. R. (1984). Priming across modalities and priming across category levels: Extending the domain of preserved function in amnesia. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 11,* 385–395.

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

Hayes-Roth, B. (1977). Evolution of cognitive structures and processes. *Psychological Review, 84,* 260–278.

Horowitz, L. M., & Prytulak, L. S. (1969). Redintegrative memory. *Psychological Review, 76,* 519–531.

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

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

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

Kinsbourne, M., & Wood, F. (1975). Short-term memory and the amnesic syndrome. In D. D. Deutsch & J. A. Deutsch (Eds.), *Short-term memory.* New York: Academic Press.

Kinsbourne, M., & Wood, F. (1982). Theoretical considerations regarding the episodic-semantic memory distinction. In L. S. Cermak (Ed.), *Human memory and amnesia* (pp. 195–217). Hillsdale, NJ: Erlbaum.

Kučera, M., & Francis, W. (1967). *Computational analysis of present-day American English.* Providence, RI: Brown University Press.

Mandler, G. (1980). Recognizing: The judgment of previous occurrence. *Psychological Review, 87,* 252–271.

McKoon, G., & Ratcliff, R. (1979). Priming in episodic and semantic memory. *Journal of Verbal Learning and Verbal Behavior, 18,* 463–480.

Meyer, V., & Yates, A. J. (1955). Intellectual changes following temporal lobectomy for psychomotor epilepsy. *Journal of Neurology, Neurosurgery and Psychiatry, 18,* 44–52.

Milner, P. (1984, June). *Amnesia: Some neurophysiological considerations.* Paper presented at the Canadian Psychological Association meeting, Ottawa, Ontario, Canada.

Mishkin, M., Malamut, B., & Bachevalier, J. (1984). Memories and habits: Two neural systems. In J. L. McGaugh, G. Lynch, & N. M. Weinberger (Eds.), *Neurobiology of learning and memory.* New York: Guilford Press.

Mortensen, E. L. (1980). The effects of partial information in amnesic and normal subjects. *Scandinavian Journal of Psychology 21,* 75–82.

Morton, J. (1969). The interaction of information in word recognition. *Psychological Review, 76,* 165–178.

Morton, J. (1979). Facilitation in word recognition: Experiments causing change in the logogen models. In P. A. Kolers, M. E. Wrolstad, & H. Bouma (Eds.), *Processing of visible language* (Vol. 1). New York: Plenum.

Moscovitch, M. (1982). Multiple dissociations of function in amnesia. In L. S. Cermak (Ed.), *Human memory and amnesia* (pp. 337–370). Hillsdale, NJ: Erlbaum.

Moscovitch, M. (1984). The sufficient conditions for demonstrating preserved memory in amnesia. In L. R. Squire & N. Butters (Eds.), *Neuropsychology of memory* (pp. 104–114). New York: Guilford Press.

O'Keefe, J., & Nadel, L. (1978). *The hippocampus as a cognitive map.* Oxford, England: Clarendon Press.

Roediger III, H., & Blaxton, T. A. (1983). *Priming in word fragment completion: Effects of modality and orthography.* Paper presented at the 24th annual meeting of the Psychonomic Society, San Diego.

Rozin, P. (1976). The psychobiological approach to human memory. In M. R. Rosenzweig & E. L. Bennett (Eds.), *Neural mechanisms of learning and memory* (pp. 3–48). Cambridge, MA: MIT Press.

Rumelhart, D. E., & Ortony, A. (1978). The representation of knowledge in memory. In R. C. Anderson, R. J. Spiro, & W. E. Montague (Eds.), *Schooling and the acquisition of knowledge.* Hillsdale, NJ: Erlbaum.

Scarborough, D. L., Gerard, L., & Cortese, C. (1979). Accessing lexical memory: The transfer of word repetition effects across task and modality. *Memory & Cognition, 7,* 3–12.

Schacter, D. L. (1983). Amnesia observed: Remembering and forgetting in a natural environment. *Journal of Abnormal Psychology, 92,* 236–242.

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

Schacter, D. L. (in press-b). Multiple forms of memory in humans and animals. In N. Weinberger, J. McGaugh, & G. Lynch (Eds.), *Memory systems of the brain.* New York: Guilford Press.

Schacter, D. L., Harbluk, J. A., & McLachlan, D. R. (1984). Retrieval without recollection: An experimental analysis of source amnesia. *Journal of Verbal Learning and Verbal Behavior, 23,* 593–611.

Schacter, D. L., McLachlan, D. R., Moscovitch, M., & Tulving, E. (1984, August). *Tracking of memory disorders over time.* Paper presented to the American Psychological Association, Toronto.

Schacter, D. L., & Moscovitch, M. (1984). Infants, amnesics, and dissociable memory systems. In M. Mos-

covitch (Ed.), *Infant memory* (pp. 173–216). New York: Plenum.

Schacter, D. L., & Tulving, E. (1982). Memory, amnesia, and the episodic/semantic distinction. In R. L. Isaacson & N. E. Spear (Eds.), *The expression of knowledge* (pp. 33–65). New York: Plenum Press.

Scoville, W. B., & Milner, B. (1957). Loss of recent memory after bilateral hippocampal lesions. *Journal of Neurology, Neurosurgery, & Psychiatry, 20,* 11–21.

Shapiro, S. I., & Palermo, D. S. (1968). An atlas of normative free association data. *Psychonomic Monograph Supplement, 2*(12, Whole No. 28), 219–250.

Shimamura, A. P., & Squire, L. R. (1984). Paired-associate learning and priming effects in amnesia: A neuropsychological study. *Journal of Experimental Psychology: General, 113,* 556–570.

Squire, L. R. (1982). Comparisons between forms of amnesia: Some deficits are unique to Korsakoff's syndrome. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 8,* 560–571.

Squire, L. R., & Cohen, N. J. (1984). Human memory and amnesia. In J. McGaugh, G. Lynch, & N. Weinberger (Eds.), *Proceedings of the Conference on the Neurobiology of Learning and Memory.* New York: Guilford Press.

Squire, L. R., Cohen, N. J., & Nadel, L. (1984). The medial temporal region and memory consolidation: A new hypothesis. In H. Weingartner & E. Parker (Eds.), *Memory consolidation.* Hillsdale, NJ: Erlbaum.

Starr, A., & Phillips, L. (1970). Verbal and motor memory in the amnestic syndrome. *Neuropsychologia, 8,* 75–88.

Tulving, E. (1983). *Elements of episodic memory.* Oxford, England: Clarendon Press.

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

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

Warrington, E. K., & Weiskrantz, L. (1970). Amnesia: Consolidation or retrieval? *Nature, 228,* 628–630.

Warrington, E. K., & Weiskrantz, L. (1974). The effect of prior learning on subsequent retention in amnesic patients. *Neuropsychologia, 12,* 419–428.

Warrington, E. K., & Weiskrantz, L. (1982). Amnesia: A disconnection syndrome? *Neuropsychologia, 20,* 233–248.

Weiskrantz, L., & Warrington, E. K. (1979). Conditioning in amnesic patients. *Neuropsychologia, 17,* 187–194.

Wickelgren, W. A. (1979). Chunking and consolidation: A theoretical synthesis of semantic networks, configuring in conditioning, S-R versus cognitive learning, normal forgetting, the amnesic syndrome, and the hippocampal arousal system. *Psychological Review, 86,* 44–60.

Winocur, G., & Kinsbourne, M. (1978). Contextual cueing as an aid to Korsakoff amnesics. *Neuropsychologia, 16,* 671–682.

Winocur, G., & Weiskrantz, L. (1976). An investigation of paired-associate learning in amnesic patients. *Neuropsychologia, 14,* 97–110.