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Is Priming in Fragment Completion Based on a "Traceless" Memory System?

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Four experiments investigated the relation between successive tests of primed fragment completion with the use of the same or different fragments on successive tests. The results were contrasted with successive tests of fragment cued recall using identical study/test stimuli and differing from the fragment completion task only in terms of instructions. Performance on successive tests of primed fragment completion was dependent if the same fragments were represented on both tests. There was no reliable dependence when different fragments were used on the two fragment completion tests. In contrast, when fragment cued recall instructions were given, successive tests with both same and different fragments yielded clear dependence. The results are interpreted as evidence that performance in the fragment completion task does not depend upon a specific cognitive unit or memory trace, whereas in episodic cued recall it does. This suggestion is elaborated in terms of an integration of the transfer-appropriate procedural approach with the idea of a traceless memory system that supports priming in tasks such as fragment completion.

In a word-fragment completion task, subjects are shown words from which certain letters are deleted (e.g., -AR-VA--), and they are asked to identify the unique word that fits the fragment, in this case AARDVARK. Performance in this task is facilitated by a prior presentation of the word (Tulving, Schacter, & Stark, 1982). Such facilitation has been referred to as *repetition priming* or, simply, *priming.* Its magnitude is measured in terms of the difference between the proportions of fragments completed for studied and nonstudied, or *primed* and *unprimed*, words.

An interesting feature of repetition priming in the fragment completion task is revealed by experiments using the method of successive tests. In these experiments the same items are tested on two or more successive tests for each subject, and success or failure in one test is correlated with success or failure for the same subject and item in another test. Experiments have shown that under the conditions of successive tests, primed fragment completion is stochastically independent of yes/no recognition of study words (Hayman & Tulving, 1989; Light, Singh, & Capps, 1986; Tulving et al., 1982): The probability of successful fragment completion in the second test is usually indistinguishable for studied words identified as "old" in a preceding recognition test and for those identified as "new."

Because the typical finding in memory experiments involving successive tests of studied items is one of dependence (e.g., Ogilvie, Tulving, Paskowitz, & Jones, 1980; Postman, Jenkins, & Postman, 1948; Rabinowitz, Mandler, & Patterson, 1977; Tulving & Watkins, 1975; Wallace, 1978; Watkins & Todres, 1978), Tulving et al. (1982) suggested that the observation of stochastic independence between recognition and primed fragment completion might have reflected retrieval of information from two different memory systems. Similar findings of stochastic independence between what Richardson-Klavehn and Bjork (1988) have called *indirect* and *direct* measures of memory have been reported by others (e.g., Chandler, 1983; Eich, 1984; Hayman & Tulving, 1989; Mitchell & Brown, 1988; Jacoby & Witherspoon, 1982; Light et al., 1986). These findings of stochastic independence complement findings of functional independence between indirect and direct measures of memory (e.g., Cohen & Squire, 1980; Graf & Mandler, 1984; Graf, Mandler, & Haden, 1982; Graf, Squire, & Mandler, 1984; Jacoby & Dallas, 1981; Schacter & Graf, 1986; Tulving et al., 1982).

Recent evidence indicates that the Tulving et al. (1982) interpretation of stochastic independence may have been incorrect. In two experiments Witherspoon and Moscovitch (1989) found that primed responses observed in one type of indirect test of memory (tachistoscopic word identification; cf. Jacoby & Dallas, 1981) did not predict primed responses in a different type of indirect memory test (fragment completion; cf. Tulving et al., 1982). They observed stochastic independence between different indirect tests of memory. To the extent that different types of indirect memory test tap one and the same memory system, separate from episodic memory, one would expect to find a positive correlation between them under the method of successive tests. Because Witherspoon and Moscovitch (1989) found independence, rather than dependence, and because they were reluctant to assume that the finding reflected the existence of separate systems for individual tasks, they questioned the hypothesis that a separate system subserves priming effects.

The present experiments were in part designed to replicate the observation of stochastic independence between succes-

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sive indirect tests of memory reported by Witherspoon and Moscovitch (1989). More specifically, we were concerned with three related problems: (a) Under what conditions—if any—would successive tests of primed performance be dependent? (b) What changes in these initial conditions would be needed to yield independence between successive tests of priming? And (c) assuming the first and second conditions were met, to what extent would the pattern of dependence and independence observed with primed performance be a function of the measure of memory used (i.e., implicit as opposed to explicit measure of memory)? We investigated these problems by using word fragments with a single solution, similar to those employed by Tulving et al. (1982), in a variety of experimental conditions.

To assess the extent to which successive tests of priming can and will exhibit dependence, both the test stimulus and the task were held constant on successive tests. The same fragment was presented on two successive fragment completion tests (*same* fragment condition). To examine changes in these conditions which lead toward independence, the task was held constant on successive tests while the stimulus was changed. Two different fragments of the same word were presented on successive fragment completion tests (*different* fragment condition). Thus, when the same fragments were tested on successive tests, a fragment such as A- -D- -RK would be shown on both the first and second test of fragment completion. When different fragments were tested on successive tests, then if the fragment A- -D- -RK was shown on the first test, the fragment -AR-VA- - would be shown on the second test, and vice versa. The extent to which the effects observed in the fragment completion task were specific to priming as a measure of retention, and not to general properties of fragments as stimuli, was examined by changing the task from one of successive tests of fragment completion to one of successive tests of fragment-cued recall. Fragment-cued recall employed the same stimuli as those used in fragment completion. However, subjects were instructed to use the fragment as an aid for recalling study words. Because the only difference between the two tests of memory was in the instructions given at the time of test, any differences in the pattern of dependence observed between successive tests would necessarily reflect differences attributable to the measure of retention.

A single task (fragment completion) was employed to examine the relation between successive tests of memory in order to increase the sensitivity of measurement for three reasons. First, the use of a single task excludes differences in observed priming due to gross task differences. For example, in the word identification task, the stimulus must be rapidly encoded, and responses are strongly influenced by word frequency (Jacoby & Dallas, 1981); in contrast, in the fragment-completion task, encoding is more leisurely, and responses are relatively insensitive to word frequency (Broadbent & Broadbent, 1975). These differences between task demands may also result in differences in the character of repetition priming. Second, testing the same word fragment on successive tests provides an estimate of the overall reliability of primed performance, which may prove to be more robust than that observed with other indirect measures such as the lexical decision task (e.g., Scarborough, Cortese, & Scarborough, 1977) and the word identification task (e.g., Jacoby & Dallas, 1981), in which a momentary lapse of attention during test can strongly affect the outcome for individual items. Finally, and most important, the use of different fragments for the same word on successive tests provides a measure of dependence between tests of priming in which the task is nominally the same but the characteristics of the stimulus eliciting the response are different. Moreover, appropriate choice of the letters present in a fragment makes it possible to construct two fragments for the same word whose relatedness varies systematically. Similarity will be high when the two different fragments share many letters in common and low when they have few letters in common. This systematic control of similarity is not available in other indirect tests of memory such as tachistoscopic identification, stem completion, instance generation, naming speed, and lexical decision.

The method of successive tests and attendant contingency analysis entail certain problems of interpretation (see Hintzman, 1980; Shimamura, 1985). One way of restricting errors of interpretation is the "method of triangulation" described by Hayman and Tulving (1989). Another method, a variant of the reduction method described by Tulving and Watkins (1975), is used in the present series of experiments. It minimizes some of the problems encountered with successive tests by eliminating first-test response effects on the second-test responses while preserving the essence of the successive-tests method, namely the feasibility of measuring the contingency relation between the two tests.

General Method

Because one basic paradigm was used throughout the series of experiments, the method is described in detail at this point. Variations in the general method will be indicated as each experiment is described.

Critical items were selected from a pool constructed by Chandler (1983) and consisted of 128 words with two different fragments for each word (e.g., AARDVARK, A- -D- -RK, -AR-VA- -). The words were 6- to 8-letter low-frequency words (mean Thorndike-Lorge frequency was 20 occurrences/million). Two sets of word fragments were created by first forming a *base* fragment and then a *complementary* fragment. The base fragments were formed by replacing 3–5 letters with dashes to indicate the missing letters, with the constraints that each fragment had only one possible word as its solution and had an average probability of being completed when unprimed between 10% and 20%. The complementary fragments were created by using similar constraints by first replacing each letter in the base fragment with a dash and each dash in the base fragment with the appropriate letter. To meet the constraints, additional letters were sometimes deleted to form the complementary fragment. Because of the difficulty of creating fragments with only one legitimate solution, half (64) of the base-complement pairs had one letter in common. A further set of 128 six- and seven-letter low-frequency words were used as buffer words in the study list. Buffer words were seen during the presentation of the study list, but neither seen nor tested thereafter.

Each experiment included a study phase and two successive test phases. During the test phases, fragments for studied and nonstudied words were intermixed and presented for completion. Each test of retention employed an equal number of base and complement fragments, with only one type of fragment for each word used in a given test.

The study phase was typically introduced to subjects as a study list for an unspecified test of retention. Subjects were informed that they would be asked questions about some of the study words and that they would not be asked for free recall. Each study word was presented for several seconds, and subjects were told to look at each word as it was presented, to think about the word and its meaning, and when the next word was presented, to shift attention to it and to process it in the same way. Each study list began with a small set of primacy buffers and ended with a larger set of recency buffers. A large number of recency buffers was included to lower the overall performance on the target words and to minimize the utility of episodic tactics, such as implicitly recalling study words, during the test phases.

Data Analysis and the Measurement of Dependence

We will report the main data from our experiments in terms of marginal and conditionalized proportions and in terms of 2 × 2 contingency tables by using the "reduction method." The reduction method, described by Tulving and Watkins (1975) and Watkins and Todres (1978), is designed to minimize possible influences of one test on another, such as test-priming (Shimamura, 1985) and/or "selective reexposure" (H. L. Roediger, personal communication, June 24, 1988). Selective reexposure refers to an experimental complication when all target words are cued on both tests: Completion of a fragment on the first test functions as an additional presentation of the target item, whereas noncompleted fragments leave their corresponding words unchanged from the study phase. When items are retested on the second test, selective reexposure from the first test can produce a positive dependence between success on the first test and success on the second test.

The procedure for the reduction method differs from that of a typical successive-tests design in that it requires testing of two study lists, which for convenience we will designate as the *conditionalized* and the *control* lists. Both lists are encoded under the same study manipulation, and items are counterbalanced across subjects. The lists differ in that the conditionalized list is tested on each of two successive tests, whereas the control list is tested only on the second test. Thus, for the conditionalized list, presentation in the second test is conditional upon response failure in the first test. For the control list, performance in the second test is unaffected by processing in the first test. This procedure eliminates the effects of test priming and of selective reexposure. To assess stochastic dependence, three proportions are derived for each subject: (a) the probability of success on the first test independent of the second test—from the conditionalized list, (b) the probability of success on the second test independent of the first test—from the control list, and (c) the probability of success on the second test conditionalized on failure in the first test—from the conditionalized list. These three measures are sufficient to derive a contingency table expressing the estimated stochastic dependence between responses in the successive tests.

We will report the dependence between successive tests in terms of Yule's Q, which is the same as Goodman and Kruskal's *gamma* in a 2 × 2 contingency table (see Bishop, Fienberg, & Holland, 1975; Hayman & Tulving, 1989; Nelson, 1984). Yule's Q takes on values between +1 and −1, with maximum values representing asymptotic dependence, and with the intermediate value, 0, representing the special case of independence.

In summary, the following experiments were designed to investigate the relation between successive tests of fragment-cued performance by using same or different fragments on successive tests. In addition, the experiments examined the effect of instructions, requiring either fragment completion or fragment-cued episodic recall on successive tests. The dependent variable was the relation between successive tests, indexed by the Q statistic. Experiment 1 provided a straightforward assessment of the relation between successive tests using same and different fragments of primed fragment completion. Experiment 2 replicated Experiment 1 and also examined the same relation in the fragment-cued episodic recall task. Experiments 3 and 4 provided further comparisons of the manipulation of instructions but compared fragment completion and fragment-cued recall with different fragments only.

Experiment 1

The purpose of Experiment 1 was to examine the contingency relation in successive tests by using the same or different fragments on successive tests of fragment completion. Successive tests using the same fragments were expected to show dependence, whereas the results of successive tests with different fragments could not be predicted. Although Witherspoon and Moscovitch (1989) found independence between two different tasks, word identification and fragment completion, it was not known whether the same finding would be obtained with a single task, namely fragment completion, held constant on both tests but using different fragment cues.

Method

Subjects. A total of 48 students at the University of Toronto received $5 for participating in the experiment, approximately 1 hr in duration. Subjects were assigned arbitrarily to one of two groups of 24 subjects.

Materials. A total of 128 target words were assigned randomly to one of four sublists of 32 words. There were 96 buffer words in the study list, 16 primacy and 80 recency buffers.

Design and procedure. The design of the experiment was a 2 × 2 between-within factorial, comparing stimulus relations (same or different fragments) between subjects and successive tests of fragment completion within subjects. The within-subjects design matched that recommended by Watkins and Todres (1978) for minimizing test effects in successive tests of retention. Stimulus presentation and response collection were controlled by an APPLE II/e computer. One hundred and sixty study words—64 target (32 conditionalized and 32 control words) and 96 buffer—were presented individually centered on a cathode-ray tube (CRT) screen at a rate of 4 s/word. Subjects were instructed to look at each word as it was presented and to think of the word's meaning; they were told that later on they would be asked specific questions about some of the study words. Immediately after the study list each subject was given a 3-min interpolated activity, a geography quiz. The geography quiz was a computer program which presented a series of city names and required subjects to enter the country in which the city was to be found. A new city name was presented every 15 s or 1 s after a correct response, whichever came first.

Immediately following the geography quiz, each subject was introduced to the fragment completion task by a series of 12 practice fragments. Each fragment was shown on the screen for 15 s, and the subject was required to type in the correct word completion for the fragment. Subjects were told that although some of the fragments could be completed with a word seen during the study session, many fragments could be completed only by words known in general. They were told that they were to complete as many of the fragments as possible. When subjects indicated that they understood the task, the fragment completion task began.

The first fragment completion test consisted of fragments for 32 studied and 32 nonstudied words. Each fragment was presented for 15 s. If the subject correctly entered a fragment solution, the fragment was removed, and the next fragment was presented. If a subject had not begun to type a solution at the end of 15 s, the fragment was replaced with the next fragment. If a response had been initiated, additional time was allowed for typing. At the end of the first test of fragment completion, the experimenter checked all entries for spelling errors. Spelling errors were defined as letter strings that differed by one or two letters from the correct response. Such errors were scored as correct completions. After this check for spelling errors, the subject was required to resume the geography quiz for an additional 3 min.

The second fragment completion test consisted of fragments for the remaining 32 studied words, 32 nonstudied words, and a variable number of fragments for the studied and nonstudied words that had not been solved in the first test. Thus, the exact number of fragments tested in the second test varied for each subject. Theoretically, a maximum of 128 and minimum of 64 fragments could be tested.

Up until the time of the second fragment completion test, subjects in the two groups were treated identically. On the second test, however, they were presented with two different types of fragment. In the same fragment group, the fragments not solved in the first test were re-presented. In the different fragment group, the fragments not solved in the first test were changed to the complementary fragments for the same words.

The details of the second fragment completion test were the same in all respects as those of the first test.

Response latencies (in milliseconds) were also recorded for both the first and second test sessions. The response latencies measured the time from the first presentation of a fragment to the first key press as subjects entered a solution at the keyboard. Response latencies were analyzed only for correct responses.

Results and Discussion

Table 1 displays the mean proportion of fragments completed for each condition, with the associated mean correct response latencies in milliseconds. The proportion correct in each condition was calculated separately for each subject. The analysis of the first test will not be reported. The critical analysis compared the probability of fragment completion for the two conditions (conditionalized and control) in Test 2 and was conducted separately for studied and nonstudied words. For conditionalized responses, the probability of fragment completion in Test 2 was based upon items failed in Test 1. For control responses, the probability of fragment completion in Test 2 was computed for previously untested items.

Studied words. As expected, conditionalized responses in primed fragment completion were noticeably reduced in the same fragment condition (Ms = .359 and .168 for control and conditionalized, respectively), but much less changed for the different fragments (Ms = .369 and .336). These data were analyzed in a 2 × 2 mixed-factors analysis of variance (ANOVA), with fragment type (same vs. different) as the between-subjects factor and test condition (conditionalized vs. control) as the within-subjects factor. The analysis showed significant main effects of fragment type, and test condition, as well as a significant interaction, $F(1, 46) = 19.92$, $MS_e = 0.008$. Planned comparisons (Fisher's LSD = .06) revealed that conditionalized fragment completion with the same fragments ($M = .168$) was reliably lower than fragment completion in the other three conditions (Ms = .359, .336, and .369), which did not differ significantly from each other.

Nonstudied words. There was an interaction between fragment type and test condition for fragment completion with nonstudied words, $F(1, 46) = 9.98$, $MS_e = 0.007$. As with the studied words, planned comparisons (Fisher's LSD = .05) revealed that conditionalized fragment completion in the same fragment condition ($M = .093$) was lower than fragment completion in the other three conditions (Ms = .183, .191, and .174), which did not differ significantly from each other.

The only notable result for response latencies was that the facilitation of studied relative to nonstudied control words (M = 4,439 vs. 5,570 ms) was not present in the conditionalized same fragment condition (Ms = 6,067 vs. 5,828 ms, for studied and nonstudied, respectively). There were no differences in latency between the control (M = 4,727 vs. 5,547 ms) and conditionalized responses in the different fragment condition (M = 4,183 vs. 5,274 ms). These results rule out any simple interpretation of the proportion correct in terms of a speed–accuracy trade-off.

Measures of dependence. The estimates of dependence are shown in rows 1 and 2 of Table 2. Successive tests of primed fragment completion using the same fragments were highly dependent, [$Q = .88$, $\chi^2(1, N = 768) = 210.4$], whereas successive tests using different fragments were less dependent, [$Q = .19$, $\chi^2(1, N = 768) = 6.4$]. When the "method of triangulation" was used, (Hayman & Tulving, 1989), this differential dependence was reliable [$\chi^2(1, N = 768) = 92.11$].

Table 1
Proportion of Fragments Solved and Response Latency (in Milliseconds) for Same and Different Fragments in Experiment 1

	Studied words				Nonstudied words			
	Test 1		Test 2		Test 1		Test 2	
Test	Ppn	RT	Ppn	RT	Ppn	RT	Ppn	RT
Same fragments in Test 1 and Test 2								
Conditional	.324	4,470	.168	6,067[a]	.198	4,941	.093	5,828[a]
Control			.359	4,439			.183	5,570
Different fragments in Test 1 and Test 2								
Conditional	.353	4,235	.336	4,183[a]	.186	5,458	.191	5,274[a]
Control			.369	4,727			.174	5,547

Note. Ppn = proportion; RT = response time.
[a] Test 2 responses are conditional on failure in Test 1.

Table 2
Measures of Stochastic Association Between Successive Tests of Fragment Completion and Fragment Cued-Recall, Using Either the Same or Different Fragments in the Two Tests

Experiment and task	Test 1	Test 2	0(1:2)	E(1:2)	*Q*	*SD*	χ^2	*N*
			Completion instructions					
Experiment 1								
Same	.324	.359	.245	.117	.88	.02	210.40	768
Different	.353	.369	.151	.131	.19	.08	6.42	768
			Completion instructions					
Experiment 2								
Same	.170	.170	.100	.029	.88	.03	99.7	528
Different	.200	.200	.050	.040	.18	.13	1.9	480
			Recall instructions					
Experiment 2								
Same	.156	.156	.100	.024	.92	.02	105.6	480
Different	.204	.204	.078	.042	.53	.09	24.0	528
			Different fragments					
Experiment 3								
Completion	.330	.327	.131	.108	.23	.08	8.48	768
Recall	.319	.285	.142	.091	.50	.06	43.82	768
			Different fragments					
Experiment 4								
Completion	.316	.299	.099	.094	.05	.08	0.81	768
Recall	.255	.272	.101	.070	.38	.08	20.23	768

Note. 0(1:2) = the joint probability of responding on Test 1 and 2, estimated by the reduction method; E(1:2) = the expected joint probability of responding on Test 1 and 2, given independence; *Q* = Yule's Q, a measure of association with a (1, −1) range; *SD* = the standard deviation of Yule's *Q*; χ^2 = log odds-ratio chi-square statistic, testing independence.

The novel finding is that the dependence observed with successive tests of primed fragment completion was greatly influenced by the form of the fragment on the two tests. It suggests that the major limiting factor in fragment completion performance resides in the letter-specific interpretation of a fragment, and not in a common and context-free factor, such as the availability of the response word.

Homogenization. Although the estimated dependence with different fragments was small, it was marginally significant at $p < .05$. However, this estimate of dependence includes dependence due to general item covariance, as well as dependence due to the common study presentation (see Flexser, 1981; Hintzman, 1980). Associations at the level of subject and item regularities can be of interest by themselves, but they can also be misleading if they are confused with the experimental manipulation. For this reason, we adjusted the estimates of stochastic dependence by removing correlations due to subjects and items as described by Flexser (1981; note 4, p. 335).

Removing item covariance by using Flexser's homogenization procedure had a small, but noticeable, effect on estimates of dependence for both types of fragments. The corrected estimate of dependence between study words was statistically significant for same fragments [$Q = .65$, $\chi^2(1, N = 768) = 89.2$], but not for different fragments, [$Q = .07$, $\chi^2(1, N = 768) = 0.8$]. The difference between these two Q values remained highly significant [($\chi^2(1, N = 768) = 39.10$]. Thus, failure in primed fragment completion appeared to predict failure in a following fragment completion test when the same fragment was used, but not when the fragment was changed.

Experiment 2

Experiment 2 was a classroom replication of Experiment 1, with the addition of a between-subjects manipulation of response instructions. Some subjects were asked to complete the fragment with any word that came to mind—standard fragment completion instructions. Other subjects were asked to complete the fragment only with study words—fragment-cued recall instructions. This manipulation—similar to that used by Graf and Mandler (1984), Graf and Schacter (1985), and Hayman and Tulving (1989)—was expected to change the task from one of successive indirect tests of memory (fragment completion) to one of successive direct tests of memory (fragment-cued recall). The purpose of this manipulation was to determine whether there was something special about the different fragments such that they inevitably resulted in independence between successive tests of memory. It was hypothesized that successive direct tests of memory using different fragments as cues for recall would lead to dependence, whereas successive indirect tests of memory using the identical different fragments as cues would reveal independence, as in Experiment 1.

Because the present experiment was a classroom demonstration, the design differed from that of Experiment 1 (and that of Experiments 3 and 4) in that it did not present and test a "control" condition during the second test. Instead, dependence in successive tests was estimated by comparing the conditionalized responses in Test 2 with the initial responses in Test 1. Thus, there was no measure of the effects of practice or fatigue in fragment completion during tests of the conditionalized responses. Nonetheless, we will report the results. There are several reasons for this. First, Experiment 2 compares experimental manipulations tested separately in the other experiments and thus provides a link between experiments. Second, the data provide a clear replication of the pattern of results observed in Experiment 1. Finally, the effect of manipulating the instructions given with the fragment cues anticipates the results of Experiments 3 and 4 and provides an additional replication of this result.

Method

Subjects. A total of 84 students enrolled in a second-year psychology course at the University of Toronto were divided into four groups—two of 22 and two of 20 subjects.

Materials. Two lists (A and B) of 24 target words were constructed by selecting 48 words and their associated fragments from the pool of target words. The words selected were those for which completions to the two alternate fragments were of intermediate difficulty (neither too easy nor too difficult to solve). An additional 64 words were selected randomly from the pool of buffer words.

Design and procedure. At the beginning of a 3-hr class, students were divided into two groups (students whose surnames began with the letters *A–K* were assigned to one group, and the remaining students were assigned to the second group). Students in one group left the classroom while students in the other group viewed the study words. The two groups were presented 88-word study lists (16 primacy buffers, 24 target words, and 48 recency buffers) at the rate of 4 s/word. One group studied List A, and the second group studied List B; the alternate set of words (B or A) served as nonstudied words during test. Following the two study sessions, there was a 2-hr interval before testing during which students were given classroom instruction in cognitive psychology.

The test session was administered simultaneously to all students and consisted of students reading and following the instructions in one of eight types of test booklets. Selection of a test booklet determined which of the four experimental conditions a student was assigned to (recall or completion instructions crossed with same or different fragments) and which of the two counterbalancings of test fragments was employed for each item (base or complement fragment in the first test). The test booklets were arranged in two ordered stacks (each group of eight booklets contained one of each of the eight types) and were distributed from the front to back of the classroom. Because the test booklets were distributed pseudo-randomly, an unequal number of subjects were sampled for the four test conditions. There were 20 students in the recall-same and completion-different fragment groups, and 22 students in the recall-different and completion-same fragment groups.

Each test booklet was composed of five pages: one instruction sheet and four test pages. Each test page contained 24 fragments: 12 from List A and 12 from List B. The designation of studied and nonstudied words depended upon the study condition in which a subject had participated. The first two and the last two test pages contained fragments for all 24 target words, as well as for 24 nonstudied words. Subjects in the same fragment condition were tested with the same fragments on the first two and last two pages. Subjects in the different fragment condition were tested with different fragments on the last two pages than had been present on the first two pages. For half the subjects the ordering of the first two and the last two pages was reversed so that the base and complement fragments for each item were tested equally often in the first and second set of fragments.

The subjects were given a total of 4 min per sheet to complete as many of the 24 fragments as possible by filling in the missing letters.

Results and Discussion

The mean proportions of words correctly elicited by the fragments are displayed in Table 3, for the two within-subjects conditions (Test 1 and Test 2 crossed with studied and nonstudied words) and for each of the four test groups (recall or completion instructions crossed with same or different fragment). The proportions were calculated separately for each subject in each condition, and the proportions reported in the second test are conditional upon a response failure in the first set of fragments.

Completion instructions. The first point of interest in Table 3 involves the comparison between the proportion correct in the first (unconditionalized) and second (conditionalized) tests for the fragment completion task. As in Experiment 1, fragment completion performance using the same fragment was noticeably decreased when performance was conditionalized upon prior failure. This was true for both studied (*M*s = .170 and .085 for Tests 1 and 2, respectively) and nonstudied (*M*s = .066 and .025) words. However, when different fragments were used on successive tests, there was essentially no difference between the first and second test performance, (*M*s = .200 and .193 for studied, and *M*s = .073 and .071 for nonstudied words). In summary, failure to complete a fragment with the target word on the first test predicted a similar failure to complete the same fragment on the second test, whereas failure to complete a fragment with the target word on the first test did not predict a similar failure on the second test when two different fragments for the same word were used.

Recall instructions. With one major exception, a similar pattern of results was observed when subjects were given cued recall instructions. Successive direct tests using the same fragment cue resulted in decreased performance in the second test, for both studied (Tests 1 and 2, *M*s = .156 and .072) and nonstudied (*M*s = .035 and .024) words. However, successive direct tests using the different fragment cue resulted in a slight decrease in performance for studied words (*M*s = .204 and .169) but not for nonstudied words (*M*s = .029 and .032).

Table 3
Proportion of Fragments Solved on Successive Tests Using the Same or Different Fragments for Recall and Completion Instructions in Experiment 2

Task	Studied		Nonstudied	
	T1	CND	T1	CND
Completion instructions				
Fragment—same	.170	.085	.066	.025
Fragment—different	.200	.193	.073	.071
Recall instructions				
Fragment—same	.156	.072	.035	.024
Fragment—different	.204	.169	.029	.032

Note. T1 = proportion completed on Test 1; CND = proportion completed on Test 2 conditional on failure in Test 1.

This pattern is consistent with the hypothesis that instructions to use the fragments as cues for recall would lead to dependence for studied words as a result of the task requirement to consult a common episodic trace.

The manipulation of response instructions appeared to have a limited effect. Overall, the proportion of correct responses was decreased when recall instructions were given, with this reduction being most apparent for responses for nonstudied words.

The mean subject proportions were analyzed separately for studied and nonstudied items with three-factor ANOVAS with two between-subjects factors (completion or recall instructions, and same or different fragments), one within-subject factor (first and second test, where performance on the second test was conditionalized on failure in the first test), and unequal group *N*s.

For studied words the only significant result was the interaction between fragment type and test, $F(1, 80) = 7.17$, $MS_e = 0.006$. As expected, the mean for conditionalized second-test same fragments ($M = .079$) was significantly lower than the other three means: conditionalized second-test different fragment ($M = .181$), first-test same ($M = .163$), and first-test different ($M = .202$), which did not differ significantly from each other (Fisher's LSD = .05). Thus, as in Experiment 1, success or failure in one test of primed fragment completion predicted performance when the same fragment was used on the second test, but not when the fragment was changed.

There were two significant effects for nonstudied words. The interaction between fragment type and test was significant, $F(1, 80) = 4.00$, $MS_e = 0.002$. This was similar to the previous interaction with studied words. Responses for nonstudied, conditionalized second-test same fragments ($M = .025$) were significantly lower than in the three other conditions: conditionalized second-test different ($M = .052$), first-test same ($M = .051$), and first-test different ($M = .051$), which were not significantly different from each other (Fisher's LSD = .02). There was also a significant main effect of instructions, $F(1, 80) = 11.67$, $MS_e = 0.003$, where fewer nonstudied words were produced under recall instructions ($M = .030$) than under completion instructions ($M = .059$). This result was not unexpected because it reflects the appropriate suppression of extralist intrusions in the recall groups.

Estimates of dependence. The data gathered in Experiment 2 were not directly compatible with the method for estimating dependence described previously. However, if it is assumed that the overall response probability is approximately equivalent for the first and second tests, then a rough estimate of the dependence between successive tests can be calculated.

Estimates of the dependence between successive tests using same and different fragments are presented separately in Table 2 for fragment completion (rows 3, 4) and fragment-cued recall (rows 5, 6). The pattern of these estimates corresponds closely to the previous between-subjects analysis of proportions, with successive tests using the same fragment being highly dependent (*Q*s of .88 and .92 for completion and recall instructions, respectively) and successive tests using different fragments showing less dependence ($Q = .18$ and .53, for completion and recall instructions, respectively). All *Q*s were significantly greater than zero, with the exception of successive tests of fragment completion using different fragments [$\chi^2(1, N = 480) = 1.86$]. More important, the observed estimate of dependence with different fragments was significantly greater with cued recall instructions than with fragment completion instructions [$\chi^2(1, N = 480) = 4.9$].

In summary, the present results for successive tests of fragment completion clearly replicated those of Experiment 1. Successive tests of primed fragment completion are strongly dependent only when the same fragments are tested on successive tests and are essentially independent when different fragments of the same word are tested on successive tests.

Common effect. For the present purposes, a finding of dependence is of interest only to the extent that this dependence can be attributed to a common effect of the study trial on successive indirect tests of memory. One condition where dependence was both expected and observed was successive tests with the same fragments. However, there is a problem in directly attributing the dependence observed for studied words to similar effects of *direct priming* because dependence was also observed for the nonstudied words. That is, the conditionalized proportions were lower than the control proportions for both studied and nonstudied words. We can conclude that the dependence observed with the same fragments is attributable to a common effect of the study presentation only if the reduction observed in the conditionalized proportions is greater for studied than for nonstudied words. One method of examining this is to compare a priming score (studied minus nonstudied items) for the conditionalized and the control conditions. If the priming score is lower for the conditionalized than for the control fragment completion, then it is clear that the effect of the study presentation has been reduced in the conditionalized observations.

We had opportunities to make such comparisons in Experiments 1 and 2. In Experiment 1, a highly reliable difference was observed between the conditionalized ($M = .075$) and the control ($M = .176$) priming scores [$t(23) = 2.95$, $p < .005$], although in Experiment 2 only a marginal difference was observed between the conditionalized ($M = .060$) and the control ($M = .104$) priming scores [$t(21) = 1.60$, $p < .07$]. These combined data suggest that facilitation from the study presentation is reduced when primed fragment-completion performance is conditionalized on prior fragment completion failure. In conclusion, the dependence observed between successive tests of primed fragment completion using the same fragment can in part be attributed to a factor or factors common to the study presentation. We will return to this issue in the General Discussion.

The effect of manipulating response instructions with different fragments was less clear. There was no significant effect when responses were analyzed by subject. However, the contingency analysis revealed that successive tests using different fragments were dependent only when subjects received fragment-cued recall instructions. In light of the stability shown by the nearly identical estimates of stochastic dependence in Experiments 1 and 2, for fragment completion with both same and different fragments, it seemed likely that the dependence observed with cued recall and different fragments was the true state of affairs and that failure to observe dependence in the analysis by subject reflected floor effects. For this reason Experiments 3 and 4 were conducted to provide additional and, perhaps more convincing, data comparing fragment completion and fragment-cued recall with different fragments.

Experiment 3

Experiment 3 replicated the manipulation of instructions with the different fragment conditions found in Experiment 2. Unlike Experiment 2, the present experiment tested both conditionalized and control items on the second test. The purposes of this experiment were (a) to assess whether successive tests using the different fragments accompanied by instructions to recall studied words resulted in dependent responses and (b) to replicate the independence observed between successive tests of primed fragment completion with different fragments in Experiments 1 and 2.

Method

Subjects. A total of 48 introductory psychology students at the University of Toronto served in a 1-hr session for course credit and were assigned randomly to one of two groups of 24 subjects.

Materials and design. The same materials and overall design used in Experiment 1 were employed with two differences: (a) Only the different fragment condition was tested, and (b) one group was given fragment-completion instructions, and the other group was given fragment-cued recall instructions.

Procedure. At the beginning of the test session, subjects in the recall group were informed that they would be shown a series of word fragments and that they were to use these as aids in recalling words from the study list. In addition, they were told that some of the fragments would not lead to a studied word, and in this case they were not to respond at all. Subjects in the completion group were given the same set of instructions used in Experiment 1. They were told to complete the fragments with any English word and were explicitly instructed to solve as many of the nonstudied fragments as possible. Both groups responded by naming the response word verbally. If the word was a correct solution to the fragment, the experimenter pressed a key indicating a correct response, and the next fragment was presented. In all other respects, the procedure was identical to that used in Experiment 1.

Results and Discussion

The mean proportion of responses and response latencies for the two groups (completion and recall instruction) for the three test conditions (first test, second test, and second test conditionalized upon failure in the first test) and for studied and nonstudied words are presented in Table 4. As may be seen, the proportion correct was higher and response latency was shorter for studied than for nonstudied words, indicating a strong facilitation due to the study presentation. Because of the size of these differences in proportion correct, the effect of study presentation was not analyzed further. The proportion correct was analyzed separately for studied and nonstudied responses. The response latency was analyzed but will not be reported.

Studied words. A two-way ANOVA revealed a main effect of instruction, $F(1, 46) = 5.29$, $MS_e = .017$, where completion performance ($M = .309$) was higher than recall performance ($M = .248$), and a main effect of test, $F(1, 46) = 10.43$, $MS_e = 0.007$, where conditionalized responses ($M = .251$) were lower than control responses ($M = .306$). Although the interaction between these factors was not significant, $F(1, 46) = 1.43$, $MS_e = 0.007$), an examination of the cell means suggested that both effects were mainly attributable to the decreased responses in conditionalized recall. This suggestion was tested by conducting separate related measures t tests for the two instruction conditions.

As expected, there was no significant difference between conditionalized and control responses in the completion group, $t(23) = 1.45$, $p > .05$, one-tailed; but, as predicted on the basis of Experiment 2, conditionalized responses were significantly lower than control responses in the recall group, $t(23) = 2.92$, $p < .01$, one-tailed. Thus, the results replicate the previous results for successive tests of primed fragment completion in finding that successive tests using different fragments are essentially independent. In addition, the results show that successive tests of fragment-cued recall using the identical different fragments as cues for recall of the studied word are highly dependent.

A two-factor ANOVA for studied words, with one between (completion vs. recall instructions) and one within (first vs. second) factor, found no reliable effect of, or interaction with, instructions, $F(1, 46) < 1$, and no difference between tests, $F(1, 46) = 1.14$, $MS_e = 0.007$. Thus, it may be concluded that the effect of instructions in the earlier comparison was indeed due to decreased responses for conditionalized recall.

Nonstudied words. A similar two-factor ANOVA for nonstudied words revealed a main effect of instructions, $F(1, 46) = 6.28$, $MS_e = 0.007$, where subjects given recall instructions appropriately produced fewer nonstudied words ($M = .099$) than subjects given completion instructions ($M = .138$).

Measures of dependence. The relevant data are presented in rows 7 and 8 of Table 2. There was a small but significant dependence in successive tests of fragment completion [$Q = .23$, $\chi^2(1, N = 768) = 8.48$], as well as a larger and significant dependence in successive tests of fragment-cued recall [$Q = .50$, $\chi^2(1, N = 768) = 43.82$)]. However, as predicted, the estimated dependence between successive tests of fragment-cued recall was reliably greater than that estimated between successive tests of fragment completion [$\chi^2(1, N = 768) = 7.61$].

As in Experiment 1, much of the dependence observed in the successive tests of fragment completion appeared to be attributable to item effects because dependence after the Flexser (1981) adjustment for item correlations was not significant [$Q = .06$, $\chi^2(1, N = 768) = 0.45$]. Correction for item effects in the successive tests of fragment-cued recall had little effect on the estimate of dependence ($Q = .46$, $\chi^2(1, N = 768) = 35.19$]. These estimates of association corrected for item effects were significantly different from each other [$\chi^2(1, N = 768) = 14.68$]. In conclusion, the data in Experiment 3 replicated those of Experiment 2: Successive tests of primed fragment completion using different fragments were essentially independent (when item effects are excluded), whereas

Table 4
Proportion of Fragments Solved and Response Latency (in Milliseconds) for Fragment Completion and Fragment Cued-Recall Instructions in Experiment 3

	Studied words				Nonstudied words			
	Test 1		Test 2		Test 1		Test 2	
Test	Ppn	RT	Ppn	RT	Ppn	RT	Ppn	RT
Completion instructions in Test 1 and Test 2								
Conditional	.330	3,149	.291	3,810[a]	.156	4,274	.140	4,644[a]
Control			.326	3,655			.135	4,664
Recall instructions in Test 1 and Test 2								
Conditional	.319	3,795	.210	4,303[a]	.117	4,338	.109	5,453[a]
Control			.285	4,055			.088	4,648

Note. Ppn = proportion; RT = response time.
[a] Test 2 responses are conditional on failure in Test 1.

successive tests of fragment-cued recall using the same set of different fragments were robustly dependent.

Experiment 4

Although dependence was found by using different fragments in successive tests of fragment-cued recall in Experiments 2 and 3, the dependence observed was much smaller than the dependence reported by Watkins and Todres (1978) between successive tests of cued recall and recognition. One possible explanation of the smaller dependence in the present experiments is simply that subjects are not sufficiently motivated to follow the cued-recall instructions. That is, although subjects given cued-recall instructions sometimes follow the instructions to respond only with words they remember from the study list, at other times they may respond as if the task were one of fragment completion, naming any word that will complete the fragment. This is especially plausible in Experiment 3, where the number of intrusions in cued recall averaged about 10%.

In Experiment 4 we attempted to increase the dependence observed for successive tests of fragment-cued recall with different fragments. The primary difference between Experiments 3 and 4 was the provision of a brief practice trial at the beginning of the experiment and the use of stronger and more frequent cued-recall instructions.

The second purpose in conducting Experiment 4 was to examine the suggestion from the analysis of Experiments 1 and 3 that dependence between successive tests of fragment completion was primarily attributable to item effects. To this end, the words from Experiments 1 and 3, which showed common floor or ceiling effects on the two sets of fragments when analyzed across subjects, were replaced by a set of new words and their associated fragments.

Method

Subjects. Forty-eight introductory psychology students at the University of Toronto served in a 1-hr session for course credit and were assigned randomly to one of two groups of 24 subjects.

Materials and design. Essentially the same materials and design were used as those employed in Experiments 1 and 3. The only difference in materials was the replacement of 16 critical words and their associated fragments. The replaced words were 8 with the lowest and 8 with the highest probabilities of fragment completion. The new words and associated fragments were chosen to satisfy the same constraints described earlier. The replaced words and fragments were used as additional practice items. The 8 difficult fragments were modified by replacing the first blank with the corresponding letter. The only difference in design was that the second test session employed all 128 target items. Thus, unlike Experiments 1 and 3, where fragments in the second test session corresponding to successful responses in the first session were removed from the test sequence, some responses in the second test session had been given previously in the first test session.

Procedure. There were only two differences in procedure from Experiment 3. After the initial instructions were given to subjects, they were given a short practice session. This consisted of a 12-item study list for the recall subjects, followed by 12 fragment cues—corresponding to 8 studied and 4 nonstudied words. If the corresponding word was not given in 12 s, the word was shown to the subject. When nonstudied words were encountered in this procedure, the recall subjects were reminded that these were not studied words and that they were not to name such words. After the practice fragments, these subjects were told that after a longer study list, they would be given a similar test of fragment-cued recall. The completion subjects were not given the initial practice study list but were given the 12 practice fragments. They were told that they would be given a similar task after completing several intervening tasks.

Results and Discussion

Table 5 presents the mean proportion of fragment-cued responses and the mean response latencies. These data replicate the patterns of independence and dependence found in Experiment 3.

The analysis of the first test responses and response latencies will not be reported here, except to note that there was a significant effect of the study presentation in both analyses.

Studied words. Fragment-cued responses for the second test were analyzed in a 2 × 2 mixed-factors ANOVA, with instructions (completion, recall) as the between-subjects factor and test (conditionalized, control) as the within-subjects factor. The main effect of instructions, $F(1, 46) = 1.85$, $MS_e = 0.027$, and of test, $F(1, 46) = 2.04$, $MS_e = 0.007$, were not significant, nor was the interaction between instructions and test, $F(1, 46) = 1.15$, $MS_e = 0.007$. However, planned, one-tailed, t tests conducted separately for the two subject groups

Table 5
Proportion of Fragments Solved and Response Latency (in Milliseconds) for Fragment Completion and Fragment Cued-Recall Instructions in Experiment 4

	Studied words				Nonstudied words			
	Test 1		Test 2		Test 1		Test 2	
Test	Ppn	RT	Ppn	RT	Ppn	RT	Ppn	RT
Completion instructions in Test 1 and Test 2								
Conditional	.316	3,487	.293	3,919[a]	.164	4,476	.163	5,014[a]
Control			.299	3,765			.140	4,860
Recall instructions in Test 1 and Test 2								
Conditional	.255	3,634	.229	4,317[a]	.062	4,904	.072	4,758[a]
Control			.272	4,121			.083	4,776

Note. Ppn = proportion; RT = response time.
[a] Test 2 responses are conditional on failure in Test 1.

revealed a significant effect of test in the recall group, $t(23) = 2.33$, $p < .03$, but not in the completion group, $t(23) = 0.21$, $p > .10$. As predicted, fragment-cued recall in the second test was reliably decreased when recall was conditionalized on cued recall failure in the first test ($M = .229$), when compared with the control condition ($M = .272$), but there was no reliable difference between the conditionalized ($M = .293$) and the control ($M = .299$) measures of fragment completion.

Nonstudied words. These data were also analyzed in a 2 × 2 mixed-factors ANOVA, with instructions as the between-subjects and test as the within-subjects factors. As in Experiment 3, there was a significant main effect of instructions, $F(1, 46) = 7.42$, $MS_e = 0.017$. As predicted, the number of nonstudied words produced under cued recall instructions was appropriately reduced ($M = .078$) when compared with fragment-completion instructions ($M = .152$). Neither the effect of test ($F < 1$) nor the interaction of instructions and test, $F(1, 46) = 1.77$, MS_e 0.004, was significant.

Measures of dependence. The relevant data are presented in rows 9 and 10 of Table 2. Successive tests of fragment completion using different fragments were not significantly related [$Q = .05$, $\chi^2(1, N = 768) = .81$]. However, when the identical different fragments were presented for fragment-cued recall, responses were dependent [$Q = .38$, $\chi^2(1, N = 768) = 20.23$]. As in Experiments 2 and 3, the two estimates of stochastic dependence were significantly different, $\chi^2(1, N = 768) = 8.35$. This same pattern of results was found after using the Flexser (1981) adjustment for item correlations—*Q*s of −.03 for completion and .38 for recall instructions, with a significant difference between the two estimates of association, $\chi^2(1, N = 768) = 11.95$.

There was no evidence that the greater emphasis on instructions in the present experiment on the recall nature of fragment-cued recall had any influence on the dependence observed. Although there were fewer intrusions observed in cued recall in the present experiment relative to Experiment 3, the overall dependence observed in the present experiment was lower than that observed in Experiment 3. In short, the intermediate level of dependence observed in fragment-cued recall does not appear to be attributable to subject motivation. This issue will be discussed in more detail in the General Discussion.

Successive tests of different fragment completion in Experiments 1 and 3 appeared to show a small but significant dependence, which was attributed to item correlations. No such dependence was observed in the present experiment. This difference may be a result of sampling error or, alternatively, it may be a result of the change in materials. That is, the substitution of new materials for words whose fragments were rarely solved or were nearly always solved may have reduced the contribution from item correlations.

In summary, the results of Experiment 4 replicated those of Experiments 2 and 3, where it was found that primed-fragment completion responses were essentially unrelated when different fragments were employed on successive tests and that instructions to use the identical different fragments as cues for recall of the studied words resulted in dependent responses. Moreover, the results of Experiment 4 suggest that the smaller dependence observed between successive tests of fragment-cued recall than between recall and recognition (e.g., Watkins & Todres, 1978) was not attributable to low motivation on the part of subjects to follow recall instructions. Although there were fewer extralist intrusions in Experiment 4 than in Experiment 3, dependence was numerically higher in Experiment 3.

Additional analysis. Although between-subjects comparisons of successive tests of fragment completion with different fragments were not found to be statistically different in any single experimental comparison, in all four experiments the conditionalized proportions were found to be slightly lower than the control proportions ($M_s = .336$ vs. .369 in Experiment 1, .193 vs. .200 in Experiment 2, .291 vs. .326 in Experiment 3, and .293 vs. .299 in Experiment 4). To evaluate the statistical significance of this trend toward dependence, we conducted a fixed-effects ANOVA with conditionalized and control proportions for studied words as the within-subjects factor for 72 subjects (24 subjects from each of Experiments 1, 3, and 4). This analysis revealed no significant differences between test conditions, $F(2, 69) = 2.61$, $MS_e = .008$, $p > .10$. Thus, although we cannot reject the null hypothesis of no difference, neither can we accept it. It seems likely that responses on successive tests of primed fragment completion with different fragments are slightly related—the mean conditionalized (.31) and mean control (.33) proportions averaged over the three experiments differed by about .02. More important, it can be said that if there is a dependence between successive tests of different fragments, it is weak and unreliable in typical experiment sample sizes (subject $N \leqq 72$).

In view of the fact that conditionalized proportions with nonstudied words were slightly higher on successive tests with different fragments,[1] whereas with studied words they were lower, it is possible that conditionalized responses to different fragments were not entirely independent of the prior processing episode. One explanation of such an effect is that on rare occasions subjects failed to produce as a response a word elicited by the first fragment. That is, some fragments were covertly but not overtly solved. The effect of this covert response would be to test-prime the response (e.g., Shimamura, 1985; Tulving et al., 1982) and to increase the probability of solving the following different fragment. Such positive test priming would tend to offset decreases in the conditionalized score. In order to control these possible positive effects in evaluating dependence between successive tests of primed fragment completion, priming scores (studied minus nonstudied) were computed and analyzed for the conditionalized and control condition for each subject in Experiments 1, 3, and 4. A fixed-effects ANOVA revealed a slight, but significant, difference between priming scores, $F(2, 69) = 3.98$, $MS_e = 0.014$, where the priming score for the conditionalized ($M = .14$) was smaller than that for the control ($M = .18$) condition. This result suggests a positive relation between priming levels in successive tests of fragment completion with different fragments. This conclusion does not seriously affect the interpretation of dependence between successive tests of primed fragment completion with different fragments. The difference in priming scores was small and not reliable in any one experiment; $ts(23)$ were .80, 1.24, and 1.42 for Experiments 1, 3, and 4, respectively. Moreover, the effects observed with nonstudied words do not necessarily transfer to the studied words. For example, if the mechanism of covert but not overt responding were present, it is conceivable that primed words—as a result of being primed—would be less likely to be covertly but not overtly produced. In summary, there appears to be a small, but often insignificant, common component in the facilitation of a prior presentation in fragment completion when different fragments are used as cues.

Instructions to use the different fragments as cues for recall of the studied words produced stochastic dependence in Experiments 2, 3, and 4. Moreover, in each experiment the stochastic dependence observed with cued-recall instructions was found to be statistically greater than the smaller dependence observed with fragment-completion instructions in all three experiments.

The analysis of proportions was generally consistent with the stochastic analysis. Although the difference between the first test and conditionalized proportions was not statistically significant in Experiment 2, $t(21) = 1.24$, $p < .10$, one-tailed, the difference between control and conditionalized proportions was significant in Experiment 3, $t(23) = 2.92$, $p < .01$, one-tailed, and Experiment 4, $t(23) = 2.33$, $p < .025$, one-tailed. None of the analyses comparing conditionalized and control proportions revealed a significant interaction between the completion and recall instructions in the production of studied words. Given the above differences in cued recall and the fact that neither the four individual comparisons nor a comparison involving completion instructions with different fragments collapsed across three experiments revealed a significant difference between conditionalized and control proportions, the overall pattern of these results is consistent with a difference in dependence attributable to instructions.

General Discussion

The experiments reported in this article yielded three findings.

1. Performance measures on two successive tests are *highly dependent*, or strongly correlated, if the fragment cues used on the second test are the *same* as those used on the first and if the tests are those of *fragment completion*. *Q*-values ranged from .88 to .92 with primed fragment completion. This finding confirms that the measures used are reliable and extends similar results reported by Witherspoon and Moscovitch (1989).

2. Performance measures on two successive tests are *moderately dependent* if the fragment cues used on the second test are *different* from those used on the first and if the tests are those of *cued recall*. *Q*-values were .53, .50, and .38 for Experiments 2, 3, and 4, respectively. Successive tests of episodic memory with different cues typically yield such moderate levels of dependence, both in standard experiments in which the same items are targets on both tests (e.g., Watkins & Tulving, 1975) and under the reduction method (e.g., Tulving & Watkins, 1975). The present results extend the generality of such dependence to fragment cues.

3. Performance measures on two successive tests are *largely independent* if the fragment cues used on the second test are *different* from those used on the first and if the tests are those of *fragment completion*. *Q*-values in the four experiments ranged from .23 to .05 without the Flexser (1981) homogenization correction and from .07 to −.03 with it. This finding complements and qualifies similar findings by Witherspoon and Moscovitch (1989), who reported stochastic independence between successive tests of primed performance with different tasks, namely fragment completion and word identification.

Before we discuss these results, a few preliminary observations are in order. First, successive tests with changed fragments yield facts about memory not revealed by other methods. The interesting juxtaposition of our second and third finding could not be achieved by any other method. Second, changing cues from the first to the second test is possible with the fragment-completion task but not with other tasks that have been used to study priming, such as tachistoscopic identification, lexical decision, or word naming. Third, the findings reported here were obtained by using a version of the reduction method that eliminates the potentially "contami-

[1] A fixed-effects ANOVA carried out on the nonstudied conditionalized and control proportions of Experiments 1, 3, and 4 did not produce a significant effect of test conditions, $F(2, 69) = 1.98$, $MS_e = 0.004$. For nonstudied words, the conditionalized ($M = .16$) was slightly higher than the control ($M = .15$) proportion.

nating" effects of test priming (Shimamura, 1985) or the effects of selective reexposure. These facts speak to the issue of contingency analyses (cf. Hayman & Tulving, 1989, footnote 2, p. 229), underscore the usefulness of the fragment-completion task, and vitiate some possible but uninteresting and irrelevant criticisms concerning the use of such analyses.

We discuss our findings under the following subheadings: (a) stochastic independence and multiple memory systems, (b) independent retrieval of episodic information, (c) priming as an expression of the "traceless" QM (quasi-memory) system, (d) relation to other theoretical ideas, and (e) conclusions.

Stochastic Independence and Multiple Memory Systems

Observations of stochastic independence between recognition and fragment completion have been interpreted as reflecting the operations of different memory systems, episodic and QM (Hayman & Tulving, 1989; Tulving, 1985; Tulving et al., 1982). Now we have some new facts: Stochastic independence can be obtained between successive tests of priming, not only with different tasks, as shown by Witherspoon and Moscovitch (1989), but also with *identical* tasks, as shown in our experiments. Witherspoon and Moscovitch (1989) argue that if two implicit-memory tasks are mediated by a common system, some dependence between them should be found in the kinds of contingency analyses they performed. Because it was not, they suggest that it is necessary to reevaluate the data and logic that relate priming effects to the theory of multiple memory systems. We agree that reevaluation of the original hypothesis is called for by the new facts. However, as we will see, such a reevaluation does not produce any change in the theoretical status quo.

The empirical facts concerning successive fragment-completion tests with different cues suggest the following simple explanation of why Tulving et al. (1982), as well as others after them, observed stochastic independence between recognition and primed fragment completion. The lack of correlation reflected nothing more nor less than the lack of psychometric reliability of one of the measures. If one measure of primed fragment completion shows zero correlation with another measure of primed fragment completion, it means that the measures have zero reliability. If so, we cannot possibly expect either measure of primed fragment completion to correlate with any other measure. The modest correlations between, say, recognition and primed fragment completion that sometimes have been reported (e.g., Neely & Durgunoğlu, 1985) may be attributable to (theoretically uninteresting) subject or item correlations.

We do not like this explanation because it overlooks an important fact: Fragment-completion measures are unreliable *if and only if* different cues are used for one and the same target word; they are quite reliable if the same cues are used. This fact means that the explanation of independence in terms of unreliability of measures must be rejected and a more promising explanation sought elsewhere.

We prefer to interpret our findings within the model of the relation between recognition and recall described by Flexser and Tulving (1978, 1982). Although proposed as an explanation of the phenomenon of recognition failure of recallable words, the model is sufficiently general to permit other applications. In the present instance, it serves the useful triple function of (a) providing a general framework for findings from a variety of memory experiments in which successive tests are used, (b) relating implicit memory results in such experiments to explicit memory results, and (c) suggesting that priming effects and episodic memory performances are mediated by different systems.

Thus, although at first blush the new findings seem to have dealt a blow to the idea that priming effects are mediated by a system different from that responsible for episodic recognition, further thought suggests that the contrary can be said to have happened. Our reasons for believing in this hypothesis are somewhat more specific now, and hence stronger, than they were before: Interpreted within the Flexser-Tulving model, our data suggest that the QM system, unlike the episodic system, operates without focal memory traces. We spell out our reasoning in what follows.

Independent Retrieval of Episodic Information

The moderate dependence with different fragments in successive cued-recall tests parallels similar findings in recognition-failure experiments (Tulving, 1983) which frequently show a moderate correlation *between recognition and cued recall* (Nilsson, Law, & Tulving, 1988, p. 267). The *special model* proposed by Flexser and Tulving (1978, 1982) demonstrates that a moderate level of dependence between tests of retention necessarily occurs under conditions where independent retrieval cues are used to gain access to one and the same memory trace and where the traces of different items vary in their "goodness of encoding." In an episodic-memory situation, such as a typical recognition-failure experiment, these conditions are presumably satisfied, and hence the Flexser-Tulving model fits the data from a large number of experiments that show a moderate level of dependence, or correlation, between recognition and recall (Nilsson et al., 1988). But the same conditions are also satisfied by using successive *cued-recall* tests in our present experiments: The informational "contents" of the cues are independent, or uncorrelated. We suggest, therefore, that the moderate level of dependence between successive cued-recall tests involving different fragment cues reflects the same properties of the general situation that the Flexser-Tulving special model was designed to cover: Independent retrieval cues are used to gain access to a *particular* memory trace resulting from an earlier study episode.

This inference is supported by findings from other experiments involving successive cued recall tests with dimensionally orthogonal, or independent, retrieval cues. For instance, Tulving and Watkins (1975) tested cued recall in successive tests by using associates and rhymes of target words as cues. The median Q of their results turns out to be .71. Data from similar experiments were reported by Ogilvie et al. (1980) with a median Q of .75, and by Le Voi, Ayton, Jonckheere, McClelland, and Rawles (1983, Experiments 1 and 2) with median Qs of .54 and .35. Although these estimates of dependence in cued recall with associative and rhyme cues are somewhat higher than the present estimates with word-fragments as cues, they overlap the present values. An even closer parallel is provided by the third experiment reported by Le Voi et al. (1983), in which the first, middle, or final letters of 6- and 9-letter words were used as cues in successive tests of cued recall. With different letter combinations as cues on successive tests, median *Q*s for short and long study-to-test delays turn out to be .35 and .45. These levels of dependence are consistent with the present results where word fragments were used as retrieval cues.

In summary, we conclude that if two different fragments act as independent cues for ecphorizing the trace of a studied target word, then the moderate level of dependence observed in successive cued recall tests is consistent with the findings from other comparable experiments and can be accounted for by the Flexser and Tulving (1978, 1982) model.

But what are we to make of the virtual independence observed with the same set of unrelated fragments in completion tasks?

Priming as an Expression of the "Traceless" QM System

The observation that successive tests of primed and unprimed fragment completion with different fragment cues produce essentially independent outcomes, as well as the Witherspoon and Moscovitch (1989) results, can also be evaluated in terms of the Flexser and Tulving (1978) special model of retrieval independence in successive memory tests. The model predicts, as a minimum, a moderate correlation between successive tests in any situation in which retrieval cues (a) are independent and (b) converge on common memory traces that vary in goodness of encoding. These two conditions of the model were presumably satisfied in our experiments—retrieval cues were independent, and memory traces varied in goodness of encoding.

Why, then, did we not observe moderate dependence? The Flexser-Tulving model suggests that our outcome—no reliable dependence between the two tests—may reflect the fact that one of the necessary conditions for the observation of moderate dependence—independent cues and common traces—was not fulfilled. As the fulfillment of the condition concerning different retrieval cues appears unassailable, the observed lack of moderate dependence must have resulted from the nonfulfillment of the remaining condition, namely the presence of an integrated trace common to both tasks.

This reasoning thus leads us to a remarkable hypothesis about priming in fragment completion: Fragment completion of words, whether primed or unprimed, does not seem to depend on the existence or utilization of representations or memory traces of these words of the kind postulated in all accounts of episodic memory or even semantic memory. These are unitized and *integrated* traces—also sometimes referred to as *abstract traces*—composed of factual or propositional information representing effects of occurrences of stimulus objects and their repetition. Because these traces seem to be absent in the hypothetical QM system that subserves priming effects, QM could be thought of as a "traceless" system.

The hypothesis implies that findings of stochastic independence, not only in Witherspoon and Moscovitch (1989) and our present experiments but also in experiments correlating priming in fragment completion with episodic recognition such as Tulving et al. (1982), reflected the absence of any common memory traces on which the retrieval processes of the QM system that mediates priming effects could operate.

Learning in such a traceless system could be conceptualized in terms of strengthening of particular stimulus–response connections, rather than in terms of retrieval of or access to information that represents a state of the world not perceptually present, as stored information does in episodic and semantic memory. In priming experiments, the stimulus is usually complex (e.g., partial or complete word or picture), and the response takes the form of *naming* the stimulus, identifying it or some of its components, or classifying it. Priming effects in such a system would reflect the enhanced utilization of specific procedures, or "tuning of the circuits," and would not reflect any storage or modification in storage of propositional information concerning stimuli or events.

As thus conceived, the traceless QM system is akin to procedural memory or a subsystem of procedural memory (Cohen, 1984; Cohen & Squire, 1980; Squire, 1982; Zola-Morgan, Squire, & Mishkin, 1982), and priming effects in this system are akin to changes in internal procedures of the sort described by Kolers and his associates (Kolers, 1975, 1979; Kolers & Roediger, 1984; Kolers & Smythe, 1984). Changes in procedural memory (procedural learning) consist in refining, modifying, and optimizing the activity or responding dictated by a perceptually present stimulus and the state of the system. Such changes are reflected in the improvement of skill, in an increase in the probability that a particular response is made to the stimulus, or in a reduction of reaction time. Changes in episodic and semantic memory, on the other hand, consist in modifications of the "declarative" or propositional information that allows the individual to introspectively contemplate the world at large, quite independently of any particular action that may or may not be taken on the basis of such contemplation.

In summary of our discussion to this point, we suggest that the failure of one completion test to predict the outcome of another completion test with different fragment cues reflects the absence of a common trace or common cognitive unit and that the changes in behavior that are known as priming effects can be conceptualized as an adjustment of specific procedures within a traceless QM memory system. Because these adjustments are neither goal directed nor content addressable, priming effects are not open to introspection and do not contribute to judgments about the ecphorized contents of episodic memory.

Relation to Other Theoretical Ideas

There are two kinds of theories explaining priming effects: abstractionist and nonabstractionist (Richardson-Klavehn & Bjork, 1988). They differ in that abstractionist positions—such as the multisystem theory (Morton, 1979), procedural memory (Cohen, 1984; Squire & Cohen, 1984), and activation of preexisting mental representations (Graf & Mandler, 1984)—postulate that priming effects can be localized at a specific, abstract cognitive unit, and therefore different tasks that access the same unit should show similar effects of priming. Nonabstractionist positions (e.g., Jacoby & Dallas, 1981; Kolers, 1975, 1979; Kolers & Roediger, 1984, Roediger & Blaxton, 1987; Roediger, Weldon, & Challis, 1989) treat all forms of learning as instances of encoding/retrieval interactions; dissociation is seen to be the normal state of affairs whenever different tests of retention make different processing demands (e.g., Kolers & Roediger, 1984, p. 435).

Our data and conclusions are at variance with abstractionist theories because independence of priming between different indirect tests of memory is not easily accounted for within these theories. Similar conclusions have been proposed by Jacoby (1983), Jacoby and Hayman (1987), Roediger and Blaxton (1987), and Sloman, Hayman, Ohta, Law, and Tulving (1988) on other grounds.

Our results have particular relevance for Mandler, Graf, and Kraft's (1986) elaboration of the two-process model of recognition (Mandler, 1980), which predicts a positive stochastic relation between tests of recognition and of primed performance because of a common activation component. Although this prediction is not supported by experimental comparisons of recognition and primed fragment completion (e.g., Hayman & Tulving, 1989; Light et al., 1986; Tulving et al., 1982), recognition and word-stem completion (Graf & Schacter, 1985), recognition and homophone spelling (Eich, 1984; Jacoby & Witherspoon, 1982), and recognition and reading of inverted scripts (Kolers, 1975), Mandler et al. (1986) treat this discrepancy between theory and data as a result of the experimental procedure (see also Shimamura, 1985). We suggest that the problem lies not in the data but in the prediction. The use of the reduction method eliminates the procedural problems discussed by Mandler et al. (1986). And if activation produces positive dependence between recognition and priming, then it should produce stronger dependence between successive tests of priming because activation alone is said to mediate priming, whereas both activation and elaboration contribute to recognition responses. Our repeated failure to find significant dependence between successive tests of primed fragment completion with different fragments implies that there are no common effects of activation across tests when independent retrieval cues are employed. To the extent that retrieval cues in recognition and priming tests are independent, there is no basis for predicting stochastic dependence because of a hypothetical common activation component.

Within the transfer-appropriate (nonabstractionist) procedural approach, priming is a function of the degree to which operations acquired during the study presentation offset processing limitations present in the test situation (Jacoby & Hayman, 1987; Roediger et al., 1989). Observation of little or no dependence between successive fragment completion tests would be consistent with this approach, if it were assumed that the different fragments made different processing demands. Such an explanation of transfer assumes that (a) transfer is highly specific to the components of a word (i.e., specific letter patterns) and that (b) transfer among different components is unrelated despite their association in terms of a common response. Gardiner, Dawson, and Sutton (1988, Experiment 2) present evidence of such strong specificity of priming effects in fragment completion. In their experiment, subjects studied (a) single words, (b) words with their to-be-tested fragment, or (c) words with fragments which differed by only one letter from their to-be-tested fragment. In a subsequent fragment completion test, while studied words in all conditions showed significant priming, only the condition in which words were presented with the same fragment at study and test produced transfer greater than that seen in the single word condition. Fragment completion was no greater for one-letter different fragments (e.g., A--A–IN presented at study and A-SA--IN at test) than for single words. Thus, association of the response word (ASSASSIN) with a particular fragment produced significant gains in transfer if and only if the specific letter pattern was repeated.

One difficulty in the transfer-appropriate approach lies in its assumption of a single, "unitary" memory, because with this assumption it has no natural explanation of preserved priming in amnesia (Hayman & Tulving, 1989; Richardson-Klavehn & Bjork, 1988). In experiments comparing amnesics' and control subjects' performance on priming tests and episodic tasks, all conditions that determine the success or failure of such performance are identical for the two groups. Thus, from the perspective of the transfer-appropriate approach, there is no reason to expect that amnesic patients should do well on priming tasks and poorly on episodic tasks. But they do (Schacter, 1987; Shimamura, 1986). We suggest elsewhere (Hayman & Tulving, 1989) that if the functional properties of the QM system are hypothesized to include the basic assumptions of the transfer-appropriate procedural approach, as described by Roediger et al. (1989), then the difficulty disappears, and the amnesia data fall into place. The QM system, a hypothetical brain/cognitive system different from that supporting episodic memory, one that we have surmised to operate without integrated traces, mediates transfer in tasks such as fragment completion, both primed and unprimed. Because the transfer in the QM system does not require access to an integrated trace, whereas recollection based on the episodic system does, one characterization of amnesia would be that it entails the loss of the ability to form or to retrieve information from integrated episodic memory traces.

Nelson and his colleagues (Nelson, Canas, Bajo, & Keelean, 1987; Nelson & McEvoy, 1984) have also compared completion and cued-recall performance with identical fragment cues. They found that the lexical/orthographic constraints on target selection affected performance similarly in both tasks. Comparable results have been reported by Greene (1986) and Hayman and Tulving (1989). In cued recall, the common effects of such variations in materials have been attributed to variations in cue effectiveness (see Tulving, 1976, p. 67; 1983, p. 209). Nelson et al. (1987, p. 548) proposed that fragment completion depends on a lexical search process, whereas fragment cued recall depends on both a lexical and a semantic search process. In this accounting, variables affecting lexical search would have similar effects in the two tasks, and variables affecting semantic search would have an effect only in cued recall. Thus, the differential dependence observed in the present experiments could be described within Nelson et al.'s theory by assuming that retrieval within lexical search was independent for the different fragment cues and that retrieval within semantic search was partially dependent for all retrieval cues. Such a description would be very similar to that of a multiple memory systems account, and if it is assumed that processing from the lexical and semantic searches engages separate memory representations, Nelson et al.'s account of differential dependence would be similar to our explanation. As we have mentioned previously (Hayman & Tulving, 1989), we prefer to interpret our own and other data in terms of multiple memory systems because such an interpretation naturally fits the finding of preserved priming in amnesic patients who cannot remember episodes (Schacter, 1987; Shimamura, 1986).

Conclusions

The major finding reported in this article concerns stochastic independence between successive tests of primed fragment completion with different cues. It represents an extension of Witherspoon and Moscovitch's (1989) finding of independence between two different priming tasks.

The major theoretical idea that emerges from the contemplation of this and other related findings is that the QM system, hypothesized to subserve priming effects, contains no integrated traces of stimuli, events, or facts of the sort postulated in the episodic and semantic memory systems. Such a traceless QM system may be seen as related to or as a subsystem of the procedural memory system. The idea of such a system also fits well with theories that have attempted to explain priming effects in terms of concepts such as transfer-appropriate processing.

References

Bishop, Y. M. M., Fienberg, S. E., & Holland, P. W. (1975). *Discrete multivariate analysis: Theory and practice.* Cambridge, MA: MIT Press.

Broadbent, D. E., & Broadbent, M. H. P. (1975). Some further data concerning the word frequency effect. *Journal of Experimental Psychology: General, 104,* 297–308.

Chandler, C. (1983). *Does retrieval strategy determine the relation between episodic recognition and semantic priming?* Unpublished master's thesis, University of Toronto.

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.

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

Flexser, A. J. (1981). Homogenizing the 2 × 2 contingency table: A method for removing dependencies due to subject and item differences. *Psychological Review, 88,* 327–339.

Flexser, A. J., & Tulving, E. (1978). Retrieval independence in recognition and recall. *Psychological Review, 85,* 153–171.

Flexser, A. J., & Tulving, E. (1982). Priming and recognition failure. *Journal of Verbal Learning and Verbal Behavior, 21,* 237–248.

Gardiner, J. M., Dawson, A. J., & Sutton, E. A. (1988). *Specificity and generality of enhanced priming effects for self-generated study items.* Unpublished manuscript.

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

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

Graf, P., 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.

Greene, R. L., (1986). Word stems as cues in recall and completion tasks. *Quarterly Journal of Experimental Psychology, 38,* 663–673.

Hayman, C. A. G., & Tulving, E. (1989). Contingent dissociation between recognition and fragment completion: The method of triangulation. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 15,* 228–240.

Hintzman, D. L. (1980). Simpson's paradox and the analysis of memory retrieval. *Psychological Review, 87,* 398–410.

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

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., & Hayman, C. A. G. (1987). Specific visual transfer in word identification. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 13,* 456–463.

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

Kolers, P. A. (1975). Specificity of operations in sentence recognition. *Cognitive Psychology, 7,* 289–306.

Kolers, P. A. (1979). A pattern-analyzing basis of recognition. In L. S. Cermak & F. I. M. Craik (Eds.), *Levels of processing in human memory* (pp. 363–384). Hillsdale, NJ: Erlbaum.

Kolers, P. A., & Roediger, H. L. III. (1984). Procedures of mind. *Journal of Verbal Learning and Verbal Behavior, 23,* 425–449.

Kolers, P. A., & Smythe, W. E. (1984). Symbol manipulation: Alternatives to the computational view of the mind. *Journal of Verbal Learning and Verbal Behavior, 23,* 289–314.

Le Voi, M. E., Ayton, P. J., Jonckheere, A. R., McClelland, A. G. R., & Rawles, R. E. (1983). Unidimensional memory traces: On the analysis of multiple cued recall. *Journal of Verbal Learning and Verbal Behavior, 22,* 560–576.

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

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

Mandler, G., Graf, P., & Kraft, D. (1986). Activation and elaboration effects in recognition and word priming. *Quarterly Journal of Experimental Psychology, 38,* 645–662.

Mitchell, D. B., & Brown, A. S. (1988). Persistent repetition priming in picture naming and its dissociation from recognition memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 14,* 213–222.

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, pp. 259–268). New York: Plenum.

Neely, J. H., & Durgunoğlu, A. (1985). Orthographic priming and recall vs. recognition dependencies in word-fragment completion. *Bulletin of the Psychonomic Society, 23,* 293.

Nelson, T. O. (1984). A comparison of current measures of the accuracy of feeling-of-knowing predictions. *Psychological Bulletin, 95,* 109–133.

Nelson, D. L., Canas, J. J., Bajo, M. T., Keelean, P. D. (1987). Comparing word fragment completion and cued recall with letter cues. *Journal of Experimental Psychology: Learning, Memory and Cognition, 13,* 542–552.

Nelson, D. L., & McEvoy, C. L. (1984). Word fragments as retrieval cues: Letter generation or search through nonsemantic memory? *American Journal of Psychology, 97,* 17–36.

Nilsson, L.-G., Law, J., & Tulving, E. (1988). Recognition failure of recallable unique names. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 14,* 266–277.

Ogilvie, J. C., Tulving, E., Paskowitz, S., & Jones, G. V. (1980). Three-dimensional memory traces: A model and its application to forgetting. *Journal of Verbal Learning and Verbal Behavior, 19,* 405–415.

Postman, L., Jenkins, W. O., & Postman, D. L. (1948). An experimental comparison of active recall and recognition. *American Journal of Psychology, 61,* 511–519.

Rabinowitz, J. C., Mandler, G., & Patterson, K. E. (1977). Determinants of recognition and recall: Accessibility and generation. *Journal of Experimental Psychology: General, 106,* 302–329.

Richardson-Klavehn, A., & Bjork, R. A. (1988). Measures of memory. *Annual Review of Psychology, 39,* 475–543.

Roediger, H. L. III., & Blaxton, T. A. (1987). Retrieval modes produce dissociations in memory for surface information. In D. S. Gorfein & R. R. Hoffman (Eds.), *Memory and cognitive processes: The Ebbinghaus centennial conference* (pp. 349–377). Hillsdale, NJ: Erlbaum.

Roediger, H. L. III, Weldon, M. S., & Challis, B. H. (1989). Explaining dissociations between implicit and explicit measures of retention: A processing account. In H. L. Roediger III & F. I. M. Craik (Eds.), *Varieties of memory and consciousness: Essays in honour of Endel Tulving* (pp. 3–41). Hillsdale, NJ: Erlbaum.

Scarborough, D. L., Cortese, C., & Scarborough, H. S. (1977). Frequency and repetition effects in lexical memory. *Journal of Experimental Psychology: Human Perception and Performance, 3,* 1–17.

Schacter, D. L. (1987). Implicit memory: History and current status. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 13,* 501–518.

Schacter, D. L., & Graf, P. (1986). Effects of elaborative processing on implicit and explicit memory for new associations. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 12,* 432–444.

Shimamura, A. P. (1985). Problems with the finding of stochastic independence as evidence for the independence of cognitive processes. *Bulletin of the Psychonomic Society, 23,* 506–508.

Shimamura, A. P. (1986). Priming effects in amnesia: Evidence for a dissociable memory function. *Quarterly Journal of Experimental Psychology, 38,* 619–644.

Sloman, S. A., Hayman, C. A. G., Ohta, N., Law, J., & Tulving, E. (1988). Forgetting in primed fragment completion. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 14,* 223–239.

Squire, L. R. (1982). The neuropsychology of human memory. *Annual Review of Neuroscience, 5,* 241–273.

Squire, L. R., & Cohen, N. J. (1984). Human memory and amnesia. In G. Lynch, J. McGaugh, & N. Weinberger (Eds.), *Neurobiology of learning and memory* (pp. 3–64). New York: Guilford Press.

Tulving, E. (1976). Ecphoric processes in recall and recognition. In J. Brown (Ed.), *Recall and recognition* (pp. 361–371). London, England: Wiley.

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

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

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

Tulving, E., & Watkins, M. J. (1975). Structure of memory traces. *Psychological Review, 82,* 261–275.

Wallace, W. P. (1978). Recognition failure of recallable words and recognizable words. *Journal of Experimental Psychology: Human Learning and Memory, 4,* 441–452.

Watkins, M. J., & Todres, A. K. (1978). On the relation between recall and recognition. *Journal of Verbal Learning and Verbal Behavior, 17,* 621–633.

Watkins, M., & Tulving, E. (1975). Episodic memory: When recognition fails. *Journal of Experimental Psychology: General, 104,* 5–29.

Witherspoon, D., & Moscovitch, M. (1989). Stochastic independence between two implicit memory tests. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 15,* 22–30.

Zola-Morgan, S., Squire, L. R., & Mishkin, M. (1982). The neuroanatomy of amnesia: Amygdala-hippocampus versus temporal stem. *Science, 218,* 1337–1339.

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