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Priming Effects in Word-Fragment Completion Are Independent of Recognition Memory

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Subjects saw a list of 96 words. They were tested 1 hr. later and 7 days later for (a) recognition of words encountered in the study list, and (b) their ability to complete graphemic word fragments such as A__A__IN with appropriate words, some of which had appeared in the study list. Performance on the fragment-completion task was primed (facilitated) by the appearance of the target words in the earlier list, but the observed priming effects were independent of recognition memory in two ways: (a) Although recognition accuracy was greatly diminished over the 7-day retention interval, priming effects were unchanged. (b) Priming effects were as large for the words identified as "new" in the immediately preceding recognition test as they were for the words identified as "old." Priming effects in word-fragment completion may be mediated by a cognitive system other than episodic and semantic memory.

An important problem in memory research concerns the construction of a useful taxonomy of memory systems. How many memory systems are there, and how are they related to one another? We do not yet know, because the question is new and relevant evidence is meager. The distinction between episodic and semantic memories as two functionally different, albeit closely interacting, systems (Tulving, in press) can be regarded as a part of the developing taxonomy; acquisition, retention, and utilization of cognitive skills (e.g., Cohen & Squire, 1980; Kolers, 1975) and other forms of procedural knowledge (e.g., Anderson, 1981) probably have to be regarded as yet another part. But even if we accept the broad division of memory into procedural and propositional forms and the division of propositional forms into episodic and semantic forms, there are phenomena that do not seem to fit readily into such a taxonomy. Free-floating mental contents, or free fragments (Schacter & Tulving, in press), abstracted from clinical observations of amnesic patients, represent one such phenomenon. Priming effects may represent another.

Priming refers to facilitative effects of an encounter with a stimulus on subsequent processing of the same stimulus (direct priming) or a related stimulus (indirect priming). Although some studies of priming appeared during the heyday of verbal learning (Cramer, 1968), only recently has a sustained experimental and theoretical effort to understand priming effects been mounted. Among a number of observations concerning direct priming, reported from different laboratories (e.g., Flexser & Tulving, in press; Humphreys & Bowyer, 1980; Jacoby & Dallas, 1981; Morton, 1979; Scarborough, Gerard, & Cortese, 1979), a particularly intriguing and theoretically pregnant finding is that under certain conditions priming effects in semantic memory tasks are independent of episodic memory (Jacoby & Witherspoon, in press; Scarborough et al., 1979). In this article we describe an experiment that provides more evidence on such independence.

In the present experiment, subjects saw a long list of target words and were then given a conventional yes/no episodic recognition test and a word-fragment comple-

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tion test. In the latter, subjects were provided with graphemic word fragments, such as A_ _A_ _IN, and instructed to complete the fragment as a meaningful word by inserting the missing letters. Both previously studied target words and comparable words not seen in the experiment served as test items. Subjects made a yes/no recognition judgment about each test item and also attempted to complete the graphemic fragment of each item. One set of tests was given 1 hr. after the study of the list; another set was given after a retention interval of 7 days.

Word-fragment completion tasks have been used previously by Warrington and Weiskrantz (1970, 1974) as well as by others (Mortensen, 1980; Squire, Wetzel, & Slater, 1978; Woods & Piercy, 1974) in studies of amnesia; they have also been used in laboratory studies of normal memory (Horowitz, White, & Atwood, 1968; Tulving, 1976).

The purposes of the experiment described here were to (a) study the time course of retention of priming effects in word-fragment completion over 7 days, (b) compare this time course with that exhibited by yes/no recognition, and (c) examine the relation between recognition and priming effects in word completion at the level of individual test items. The results were expected to shed additional light on the relation between semantic priming and episodic recognition and to provide evidence on the replicability of findings of dissociation between recognition and word-fragment completion reported by others with both amnesic patients and normal subjects (Jacoby & Witherspoon, in press; Squire et al., 1978; Warrington & Weiskrantz, 1970, 1974; Woods & Piercy, 1974).

Method

The materials consisted of a pool of 192 words and corresponding graphemic fragments. Most of the words occur with low frequency in English, and most were seven or eight letters in length. Each fragment allowed only one legitimate completion. Some examples of the fragments used are as follows: A_ _A_ _IN, C_ _AR_T, _YS_ _RY, _E_D_L_M, and _H_O_EM. As these examples show, a variety of fragment patterns were used. The words corresponding to these fragments are ASSASSIN, CABARET, EMISSARY, MYSTERY, PENDULUM, and THEOREM. The pool of 192 words is reproduced in the Appendix.

One half of the words in the total pool (96), were shown to the subjects on a single trial in a study list. We refer to these study-list words as "old." The remaining 96 words served as "new" test items in subsequent tests. Each test item, whether old or new, appeared in both the yes/no recognition test and the word-fragment completion test. In addition to the type of test item (old vs. new), two other variables were manipulated in the design: (a) retention interval—1 hr. or 7 days, and (b) order of tests—recognition followed by fragment completion (Rn–FC) or fragment completion followed by recognition (FC–Rn).

Test items were 48 old words and 48 new words in each of the two test sessions, separated by 7 days. In each session, the test items were divided into two subsets of 24 old and 24 new words. For one of the subsets, the tests were given in the Rn–FC order; for the other, the order was FC–Rn. The sequence of tests within a session was the same for all subjects in both test sessions. If we designate the two subsets of test items as A and B, this constant order of tests within a test session was Rn(A)–FC(B)–FC(A)–Rn(B). Thus, the recognition and fragment-completion tests on Subset A were separated by the fragment-completion test on Subset B, and the fragment-completion and recognition tests on Subset B were separated by the fragment-completion test on Subset A. This design makes possible the assessment of both recognition and fragment-completion performance on old test items in the absence of any test-induced priming (recognition data provided by Subset A and fragment-completion data by Subset B), as well as assessment of test-induced priming in both fragment completion (Subset A) and recognition (Subset B).

Thus, the design of the experiment was 2 × 2 × 2, with type of test items, retention interval, and order of recognition and fragment-completion tests as independent variables. All subjects were tested, with different subsets of test words, in all eight conditions. The 192 words served equally often as old or new words in each of the two test sessions and as members of Subset A or Subset B within a session.

Twenty-four people, 13 women and 11 men ranging in age from 17 to 33 yr., served as subjects. Each subject was paid $10 for attending two sessions, one filled with the study of the list of old words and the first retention test, the other given 7 days later, consisting of the second test. Subjects were tested individually. The 96 old words were presented for study on a single trial in two successive sets of 48; each set was preceded and followed by five buffer words not subsequently tested. Each of the two study sets was equally divided between words of Subsets A and B as described previously. The words in the study sets were presented with a slide projector at a presentation rate of 5 sec per word. Before the presentation of the list, subjects were given general instructions to look at each word as it appeared; they were told, "Do the best you can to learn each of the words as they appear, for you will be tested later for your memory of them." The nature of the memory test(s) was not specified before study.

Both recognition and fragment-completion tests were given on test sheets collated into booklets. Each sheet contained either typed copies of old and new test words for the yes/no recognition test or graphemic word fragments of the kind described earlier for the fragment-completion tests, in the order specified earlier. On each

Table 1
Simple and Joint Probabilities of Responses[a] in the Rn–FC (Recognition–Fragment-Completion) Sequence of Tests

Type of item	Retention interval	Simple probabilities		Joint probabilities				Stochastic independence
		Rn	FC	Rn, FC	Rn, $\overline{FC}$	$\overline{Rn}$, FC	$\overline{Rn}$, $\overline{FC}$	Rn × FC
Old	1 hr.	.783	.648	.512	.271	.136	.081	.507
Old	7 days	.576	.651	.385	.191	.266	.158	.375
New	1 hr.	.226	.544	.124	.102	.420	.354	.123
New	7 days	.334	.537	.182	.152	.355	.311	.179

[a] For Rn, yes responses in recognition; for FC, successful word productions in fragment completion; $\overline{Rn}$ = nonrecognition; $\overline{FC}$ = noncompletion of the fragment.

recognition-test sheet, the 24 old words of a given subset were mixed with 24 new words, and subjects were instructed to classify each test word as having occurred in the study list or not and to assign a confidence rating to each response. The recognition test was unpaced. The fragment-completion test form contained the fragments of 24 old words of a given subset mixed with the fragments of 24 new words. Subjects were instructed to try to complete each fragment as a meaningful word by replacing the dashes with letters. They were told that some of the words had appeared on the study list and others had not. They were also permitted to scan the test form freely and do the easier fragments first. Subjects were given 20 min. on the fragment completion test for a given set of 48 fragments.

All subjects returned 7 days after the initial study and test session and were tested for the previously untested 48 old and 48 new test items in the same way in which they were tested in the first session.

Results

The basic unit of analysis in this experiment was a subject–item. With two possible responses given by the subject on the recognition test (yes or no), crossed with two possible responses on the fragment completion test (successful or not), each subject–item could be classified into one of four mutually exclusive categories. The proportion of items in each category defined the joint probability of the outcomes on the two tests.

These joint probabilities, together with simple probabilities of yes responses in recognition and word productions in fragment completion, are shown in Table 1 for the Rn–FC sequence and in Table 2 for the FC–Rn sequence. In both tables, response probabilities are shown separately for the 1-hr. and 7-day tests and for the old and new items. These probabilities in a given experimental condition, represented by one row in each table, are based on 571 to 573 subject–items rather than the planned-for 576 because of missing observations.

Consider first the effect of retention interval on recognition and fragment-completion performances. Replicating many pre-

Table 2
Simple and Joint Probabilities of Responses[a] in the FC–Rn (Fragment-Completion–Recognition) Sequence of Tests

Type of item	Retention interval	Simple probabilities		Joint probabilities				Stochastic independence
		Rn	FC	Rn, FC	Rn, $\overline{FC}$	$\overline{Rn}$, FC	$\overline{Rn}$, $\overline{FC}$	Rn × FC
Old	1 hr.	.790	.473	.417	.373	.056	.154	.374
Old	7 days	.641	.457	.357	.284	.100	.259	.293
New	1 hr.	.308	.304	.159	.149	.145	.547	.094
New	7 days	.427	.316	.209	.218	.107	.466	.135

[a] For Rn, yes responses in recognition; for FC, successful word productions in fragment completion; $\overline{Rn}$ = nonrecognition; $\overline{FC}$ = noncompletion of the fragment.

viously reported findings in the literature and confirming commonsense expectations, the proportion of recognition hits (yes responses to old items) decreased over the 7-day interval, and the proportion of false positive responses (yes responses to new items) increased. In sharp contrast to these data, however, the fragment-completion performance remained virtually unchanged over the 7-day interval: The small variations in the p(FC) values for the old test items in Tables 1 and 2 are approximately of the same magnitude as the variations in these data for the new test items. We can thus conclude that recognition and fragment completion are independent in the sense that recognition scores exhibit forgetting over 7 days whereas fragment-completion scores do not.

The dissociation between recognition and fragment completion with respect to the retention interval is graphically depicted in Figure 1. The recognition measure in Figure 1 corresponds to the difference between proportions of hits and proportions of false alarms from the Rn–FC test sequence; fragment completion proportions are those for the old test items from the FC–Rn sequence. These measures were used by Warrington and Weiskrantz (1974) in their comparison of recognition and fragment-completion performance in amnesics and control subjects and were also used by Woods and Piercy (1974) and Squire et al. (1978) in their demonstrations of similar interactions with normal subjects tested shortly after study and 7 days later. The data in Figure 1 replicate the earlier findings of the dissociation between the two measures with respect to the 7-day retention interval: Recognition performance is greatly affected, but fragment-completion performance is not.

We next consider evidence pertaining to priming. Priming occurred in both yes/no recognition and word-fragment completion. One result obtained was that proportions of yes responses in the recognition task were generally higher when the recognition test followed the fragment-completion test (Table 2) than when the recognition test was given first (Table 1). This probably reflects the additional opportunity to study the successfully completed words and thus is neither surprising nor of much theoretical interest. We do not discuss this priming effect in this article.

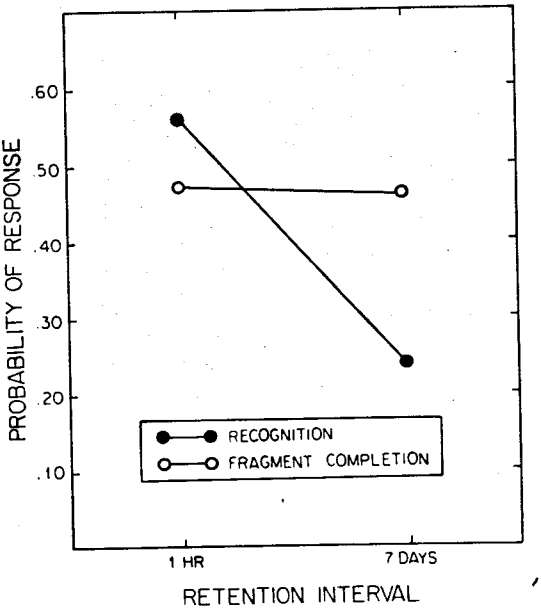

Figure 1. Time course of retention of priming effects in word-fragment completion and recognition over an interval from 1 hr to 7 days.

More important, sizable priming effects were observed in the fragment-completion task. The baseline measure of fragment completion is provided by the fragment-completion performance on new items in the FC–Rn test sequence (Table 2). It was approximately the same (.31) in both the 1-hr. and 7-day retention tests. The remaining data in Tables 1 and 2 provide evidence of three kinds of priming effects: (a) *Study priming* can be estimated from the performance on old items in the FC–Rn test sequence (approximately the same at .46 in the 1-hr. and 7-day tests). (b) *Test priming* can be estimated from the performance on new items in the Rn–FC test sequence (average of .54 in the two tests). (c) *Combined study and test priming* data are yielded by old items in the Rn–FC test sequence (average of .65). The three kinds of priming effects are graphically depicted and compared with the baseline fragment-completion performance in Figure 2.

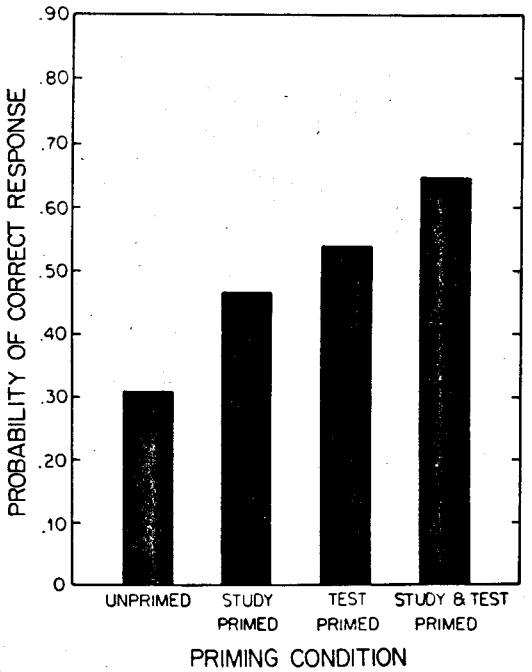

Figure 2. Word-fragment completion performance for unprimed and three kinds of primed words.

Study and test priming conditions were confounded with the retention interval in this experiment: In the former condition the retention interval was at least 1 hr.; in the latter it was a few minutes. Since we do not yet know anything about the time course of retention of primed fragment-completion performance over the interval of 0 sec to 1 hr., it is quite possible that the observed differences between study and test priming reflected the differences in retention intervals.

The data of principal interest from the present experiment concern the relation between recognition and fragment completion at the level of individual items, as revealed by the contingencies of recognition and fragment-completion probabilities. The picture that emerged from this analysis was different for the two test sequences.

The data from the conditions in which the recognition test preceded the fragment-completion test (Rn–FC sequence, Table 1) demonstrate stochastic independence between the two measures: The joint probability of recognition and fragment completion is, for all practical purposes, indistinguishable from the product of simple probabilities of recognition and fragment completion. Within the experiment, this stochastic independence is replicated four times: It occurs for both old and new items, and in both 1-hr. and 7-day tests.

However, the data from the conditions in which the fragment-completion test preceded the recognition test (FC–Rn sequence, Table 2) show a certain degree of positive association: The joint probability of the two measures is generally higher than the product of their simple probabilities. This association is probably attributable to the additional study opportunity of the words successfully completed in the fragment test.

Discussion

Independence between recognition memory and priming effects in word-fragment completion was manifested in this experiment in two ways: (a) Although recognition accuracy showed a sizable decrement from the 1-hr. to the 7-day test, subjects' fragment-completion performance, and hence priming effects in this task, remained virtually unchanged over the 7-day retention interval. (b) The probability of successful fragment completion was practically identical for words that the subject (correctly or incorrectly) thought had occurred in the study list and words the subject thought had not occurred in the list. The latter form of independence was observed under the conditions in which the recognition test preceded the fragment-completion test; it held for both old and new test words, and in both the early and the delayed test.

The observed independence replicates and extends similar findings reported by others (e.g., Jacoby & Witherspoon, in press). It implies that priming effects in word-fragment completion reflect the operation of a system other than episodic memory. Similar suggestions have been made by Woods and Piercy (1974) and by Scarborough et al. (1979). The reasoning here is straightforward: If priming effects in fragment completion are mediated by the episodic memory system, we should have observed some "forgetting" of the information acquired in the study list, analogous with forgetting displayed by the data on episodic recognition, and we should have observed some correlation between priming and episodic recognition of individual test words. But we did not.

Anderson and Ross (1980) interpreted priming effects in a sentence-verification-like task as evidence for transfer of information from episodic to semantic memory and, on that basis, argued against a functional distinction between the two systems. By their reasoning, we too observed transfer of episodic information to a semantic task, but our data do not support Anderson and Ross's conclusion. Our data suggest that whatever it is that is transferred from the episodic study of a word to the subsequent fragment-completion task is not identical or even correlated with whatever it is that makes it possible for the subjects to distinguish between words previously encountered in the experiment and words not encountered. The information that subjects use in completing the fragments of primed words is not the same kind of information on which people rely in remembering events from their past.

The observed independence of the subjects' performance on the two tasks supports suggestions made by others (Mortensen, 1980; Squire et al., 1978; Woods & Piercy, 1974) to the effect that the Warrington–Weiskrantz (1970, 1974) effect—that of sizable differences between amnesics and controls in episodic recognition but of no such differences in fragment completion—does not seem to represent a unique phenomenon of the amnesic syndrome. Rather, it looks as if the relatively intact performance of amnesic patients on the fragment-completion task represents yet another example of skills and knowledge that are unrelated to episodic memory and are preserved in amnesia (Cohen & Squire, 1980; Schacter & Tulving, in press; Warrington & Weiskrantz, in press).

Finally, it is worth noting that although the priming effects of interest in this article were demonstrated in what is clearly a semantic-memory task, it is not clear that they can be regarded as a phenomenon of semantic memory. The matter has been discussed elsewhere (Tulving, in press). For instance, the fact that there was no reduction in the size of the priming effect over a 7-day interval does not encourage the view of priming as a temporary activation of relevant information in the lexical or conceptual network (Collins & Loftus, 1975). And if we do not think of a primed word in these terms, how do we think of it? Other evidence difficult to reconcile with the view of priming as some sort of a modification of the semantic memory system is provided by experiments demonstrating that priming effects are absent, or at least severely attenuated, under conditions in which the stimulus originally appears in a different sensory modality than the one used at test (Jacoby & Dallas, 1981; Morton, 1979), or where it appears in the same modality but in a different format (Morton, 1979; Scarborough et al., 1979; Winnick & Daniel, 1970).

Since the priming effects described in this article clearly are independent of episodic memory, and since there are problems with their interpretation in terms of modifications of semantic memory, we are tempted to think that they reflect the operation of some other, as yet little understood, memory system.

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Appendix

Materials Used in the Experiment

AARDVARK	BLARNEY	CROQUET	HYDRANT	MENTHOL	SANSKRIT
ABATTOIR	BOGEYMAN	CROUPIER	IDEOLOGY	MIGRAINE	SAPPHIRE
ADENOID	BOROUGH	CUPCAKE	IMBIBER	MONOGRAM	SCIMITAR
AFGHANI	BORSCHT	CURATOR	INCISION	MYSTERY	SEQUOIA
AGNOSTIC	BOURBON	CUTLERY	INERTIA	NEONATE	SEXTANT
AIRSPACE	BOYHOOD	CYANIDE	INFERNO	NIRVANA	SHERIFF
ALLEGORY	BRAHMIN	DELIRIUM	INKWELL	NOCTURNE	SILICON
ALMANAC	BRAVADO	DEMOCRAT	INSOMNIA	OBELISK	SORGHUM
ANALOGUE	BRAZIER	DINOSAUR	ISTHMUS	OCTOPUS	SPATULA
ANATOMY	BROCCOLI	DUODENUM	JAMBOREE	OPERETTA	SPITTLE
ANTENNA	BULLOCK	ELECTRON	KATYDID	ORATION	SPROCKET
ANTIDOTE	BUREAU	ELLIPSE	KEROSENE	OUTSIDER	SURGEON
ANTIQUE	CABARET	EMISSARY	KNAPSACK	PARAFFIN	SWAHILI
ANYBODY	CASHMERE	EPITAPH	KUMQUAT	PARANOIA	TAFFETA
APLOMB	CAVALRY	ESPRESSO	LACROSSE	PENDULUM	TEQUILA
APPROVAL	CHASSIS	ESTUARY	LADYBUG	PEROXIDE	THEOREM
APRICOT	CHICORY	EXPONENT	LAGGARD	PETUNIA	THYROID
ARCHDUKE	CHIMNEY	FASCISM	LANOLIN	PHARAOH	TOBOGGAN
ASBESTOS	CHIPMUNK	FILTRATE	LECTERN	PHOENIX	TRICYCLE
ASSASSIN	CHOLERA	FLAMINGO	LEPROSY	PIGMENT	TWILIGHT
ATROCITY	CHUTNEY	FLANNEL	LETTUCE	PIMENTO	UNIVERSE
AVOCADO	CINNAMON	GANGRENE	LEUKEMIA	PLANKTON	URETHRA
BACHELOR	CLARINET	GAZELLE	LEXICON	POLLIWOG	VENDETTA
BANDANNA	CLIMATE	GAZETTE	LINEAGE	QUARTET	VERANDAH
BASILICA	COBBLER	GIZZARD	LITHIUM	RAINBOW	VERMOUTH
BASSOON	COCKATOO	GONDOLA	LOZENGE	REPARTEE	VICARAGE
BAYONET	COCONUT	GRANARY	MADEIRA	RHETORIC	VICEROY
BAZOOKA	CONIFER	HAYLOFT	MARJORAM	RHOMBUS	WARRANTY
BEESWAX	COPYCAT	HEXAGON	MARTINI	RHUBARB	WAVELET
BEGONIA	CORVETTE	HIBISCUS	MASCARA	ROTUNDA	YEOMANRY
BEHAVIOR	COSSACK	HORIZON	MAZURKA	RUFFIAN	YOGHURT
BLADDER	CREVICE	HYACINTH	MEMBRANE	RUTABAGA	ZEPPELIN

Note. The letters missing from the fragments with which subjects were tested are underlined. For example, the target word AARDVARK was tested with the fragment _AR_VA__.

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