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# On the differential nature of implicit and explicit memory

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In this article, we report two experiments that provide further evidence concerning the differential nature of implicit and explicit memory. In Experiment 1, subjects first undertook a sentence-verification task. While carrying out this task, half of the subjects were also required to carry out a secondary processing task involving tone monitoring. Twenty-four hours later, the subjects' memory for target items in the sentence-verification task was tested explicitly by means of a recognition task and implicitly by examining the extent to which the items primed fragment completion. Recognition performance was significantly impaired by the imposition of secondary processing demands during the original learning phase. In contrast, fragment completion was completely unaffected by this additional processing, even though substantial priming was observed. In Experiment 2, we examined whether priming in fragment completion is influenced by the nature of repetition during initial learning. Subjects studied a list of target items that were each repeated twice. Half the items were repeated immediately (lag 0) and half were repeated after six intervening items (lag 6). Memory for the items was assessed by recognition and by priming in fragment completion. Recognition was affected by lag, with lag 6 items being recognized better than lag 0 items. However, although significant priming was obtained, the extent of this priming was uninfluenced by lag. These data indicate two additional dimensions along which implicit and explicit memory differ and, furthermore, they support recent conceptualizations of processing differences underlying these two forms of memory.

In recent years, there has been growing interest in the distinction between implicit and explicit memory processes (see Schacter, 1987, for a review). Explicit memory refers to any test procedure that requires subjects to reflect consciously on a previous learning episode. Standard free-recall, cued-recall, and recognition tests can all, therefore, be tests of explicit memory. Implicit memory tasks, in contrast, assess subjects' memory for a learning episode without any necessity for conscious recollection of that episode. A common test of implicit memory is the *fragment-completion* task. Subjects are initially exposed to a set of target stimuli, usually low-frequency words (e.g., TOBOGGAN). Following an interval, the subjects are then given a set of single-solution word fragments to solve (e.g., T_ _O_G_ _?). The variable of interest is the extent to which correct fragment solutions involving words in the target set exceed the completion rate for targets that have not been preexposed. When the target rate exceeds the control rate, *priming* is said to have occurred, and it is logically inferred that some representation of the prior learning episode has influenced the subjects' performance even though this was not explicitly required by the test procedure.

Since the discovery of priming effects in fragment completion, other priming phenomena have also been reported. These include enhanced stem completion (e.g., see Greene, 1986), object classification (Schacter, Cooper, & Delaney, 1990), and savings in picture completion (Parkin & Russo, 1990; Parkin & Streete, 1988). In parallel with these developments have been attempts to elucidate the different characteristics of implicit and explicit memory tasks. Studies have identified a number of factors known to affect explicit memory that have no effect on implicit memory. These include the level of processing of target items during learning (Graf & Mandler, 1984), the age of subjects (Light & Singh, 1987; Light, Singh, & Capps, 1986), and the extent to which to-be-remembered items form interitem associations (Graf & Schacter, 1989). In addition, amnesic patients have been shown to perform well on a range of implicit memory tasks despite very poor explicit memory (see Mayes, 1988; Parkin, 1987; Schacter, 1987, for reviews). There are also a number of variables that affect implicit memory more extensively than explicit memory. Both inter- and intramodality shifts between learning and test greatly reduce the amount of priming observed (i.e., see Gardiner, Dawson, & Sutton, 1989; Jacoby & Hayman, 1987; Roediger & Blaxton, 1987). In addition, Graf and Schacter (1989) have found that "unitization," the representation of previously separate items as a single unit, reduces the amount of priming observed.

In two recent articles, Hayman and Tulving (1989a, 1989b) have suggested that priming effects are mediated by a "traceless quasimemory" (QM) system whose properties are very different from the episodic system as-

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sumed to underlie explicit memory. Within the QM system learning occurs not by the establishment of traces representing the original stimulus, as would be required for conscious recollection, but by changes in the various procedures that operate on the stimulus when it is perceptually present. These changes in the QM system do not, therefore, record that a particular stimulus has been presented; rather, they increase the probability or speed of responding to a particular stimulus. Such a theory thus accounts for the fact that priming phenomena are exhibited only when some component of the original stimulus is present—for example, a stem, a fragment, an incomplete picture—and that priming is disrupted by changes in the surface feature of the stimulus between learning and testing. Furthermore, given that the QM system is inextricably linked with perceptual processing, the theory is consistent with the early development of implicit memory (Parkin & Streete, 1988).

Because of its traceless quality, Hayman and Tulving (1989a, 1989b) have argued that modifications of the QM system responsible for priming effects are not content-addressable and thus are not open to introspection. This description of QM is directed toward the state of the system once it has learned. However, it is reasonable to assume that the system should have the same nonintrospective qualities while learning is taking place.

In Experiment 1, we examined the possibility that implicit learning lacks any conscious involvement. The basic experimental procedure was derived from that of Tulving, Schacter, and Stark (1982), and it will be useful to describe it in some detail. Subjects were first presented with a series of target items. Later, they were tested for both recognition (Rn) and fragment completion (FC) in a multiple test procedure. In the first phase of the test, they were given an initial recognition test (Rn 1), in which they had to distinguish targets presented on the previous day from new items. Rn 1 was composed of half of the targets from the learning phase plus an equal number of new distractors. Next, the subjects received their initial fragment-completion test (FC 1). In this test, half of the fragments corresponded to the remaining targets (i.e., those not used as targets in Rn 1) and the remaining fragments were more new distractors. After this test, a second fragment-completion test (FC 2) was given in which the fragments corresponded to the targets and the distractors used in Rn 1. Finally, there was a second recognition test (Rn 2), in which the targets and distractors were the items used in FC 1. This arrangement allows recognition to be tested uncontaminated by prior fragment completion (Rn 1), and for fragment completion to be tested without the prior influence of recognition (FC 1). The inclusion of FC 2 and Rn 2 allows an additional set of observations concerning the *stochastic independence* of recognition and fragment-completion processes. Such independence would be demonstrated if the probability of successful recognition and fragment completion of the same items does not differ from the product of the simple probabilities of success on either task alone (Tulving et al., 1982).

In the first phase of Experiment 1, subjects were presented with a series of targets in the form of a sentence-verification task. While carrying out this task, one group of subjects was also required to perform an additional task involving tone monitoring. This group is referred to as the divided attention group; those not required to perform the additional task are referred to as the undivided attention group. Retention was tested 24 h later in the same basic way as that used by Tulving et al. (1982) (i.e., recognition was tested both before and after fragment completion, and vice versa). The tone-monitoring task is an established method of disrupting explicit memory (see Anderson & Craik, 1974; Parkin, 1989; Parkin & Russo, 1990) and can therefore be assumed to affect the degree of conscious involvment in learning. If, as Hayman and Tulving's (1989a, 1989b) account implies, the memory system mediating priming is of a nonintrospective kind, the extent to which priming in fragment completion occurs should be uninfluenced by the divided-attention manipulation.

## EXPERIMENT 1

### Method

**Subjects.** Twenty-four people recruited from the student population of the University of Sussex served as subjects.

**Materials.** One hundred twenty words and their word fragments were chosen from the pool of 192 items used by Tulving et al. (1982). All of the words were low in frequency and between seven and nine letters in length. Each fragment allowed only one legitimate completion (e.g., T__O_G__ = TOBOGGAN; ___JO_AM = MARJORAM). All were singular common nouns. Each item was assigned to one of three word groups—A, B, or C—each comprising 40 items. The A and B groups were used as items in the study phase. Accordingly, a "sensible" sentence was constructed around each of these items and the target item was presented in uppercase (e.g., The boy fell off the TOBOGGAN"; "The chef could not find the MARJORAM"). Group C items were used as the basis for "nonsense" sentences in the study phase (e.g., "The OBELISK worked as a dustman"; "The SAPPHIRE was the author"). Two study booklets were constructed. The first, A′, comprised sensible sentences generated from Group A words plus the nonsense sentences generated from Group C. The other booklet, B′ was composed of the sensible sentences generated from the Group B words plus the Group C nonsense sentences. Two test booklets were also constructed, each containing four sections in the following order: an initial recognition test (Rn 1), an initial fragment-completion test (FC 1), a second fragment-completion test (FC 2), and a second recognition test (Rn 2). To construct the test booklets, each word group (i.e., A and B) was divided into two sets of 20 (i.e., a1, a2, b1, and b2). Two test booklets were constructed (1 and 2). In Booklet 1, Rn 1 targets were the a1 items and the distractors were b1 items; in FC 1, the study items were the a2 words and the unprimed items were the b2 words; FC 2 items were those used in Rn 1 (i.e., a1 and b1), and Rn2 consisted of the items used in FC 1 (i.e., a2 and b2). Booklet 2 was the converse of Booklet 1; thus, Rn 1 was composed of a2 and b2 items, FC 1 was composed of a1 and b1 items, and so on.

**Procedure.** The subjects were tested individually in two sessions separated by 24 h. In the first phase, the subjects were presented with the study booklet and given instructions for the sentence-verification task. They were told to read each of the sentences and decide whether or not the sentences made sense. The subjects were encouraged not to rush. In the study phase, half of the subjects were randomly assigned to the A′ study condition and the remaining 12 subjects were assigned to the B′ study condition. Half of the subjects in the A′ group and half in the B′ group were also required to perform an additional task while carrying out the sentence-verification task (divided attention groups). They were required to listen to a tape recording on which a sequence of single tones occurred at intervals ranging randomly between 3 and 7 sec. The tones were of high, medium, or low frequency. The subjects were told to monitor the tape and, on hearing a tone, to indicate whether it was high, medium, or low. A practice session on this task was given before the experiment proper commenced. In the test phase, the subjects were presented with a test booklet. There were 40 items per page in the booklets. As described above, the test booklet consisted of an initial recognition test followed by two fragment-completion tests and a second recognition test, one page for each test. In the recognition tests, the subjects were asked to identify any words that they remembered seeing in the previous day's study phase. In the fragment-completion tests, the subjects were told that they would be shown a series of incomplete words and that they should try to complete them. They were told that if they failed initially on a fragment they could try again later, but only if they were still on the same page of fragments. The fragment-completion instructions made no reference to the fact that the items had been exposed in either the study or the test phase. Within both the undivided- and the divided-attention conditions, half of the subjects who studied A′ were tested with Booklet 1 and the remainder with Booklet 2. The same arrangement was used for subjects who studied B′.

## Results

**Recognition**. Recognition responses for each subject in both the divided- and the undivided-attention conditions were classified into four types: correct rejections on Rn 1, correct rejections on Rn 2, hits on Rn 1, and hits on Rn 2. These data are summarized in Figure 1. The data were analyzed in a 2 × 2 × 2 ANOVA with group (undivided vs. divided attention), test position (Rn 1 vs. Rn 2), and response type (correct rejection vs. hit) as fixed factors. This analysis demonstrated that subjects in the undivided-attention condition performed better overall [$F(1,22) = 4.387$, $MS_e = 12.65$, $p < .05$] than the subjects in the divided-attention condition. There was also a main effect of response type, indicating a higher level of correct rejections than hits [$F(1,22) = 10.793$, $MS_e = 2.71$, $p < .01$]. The interaction between test position and response type just missed conventional significance [$F(1,22) = 4.001$, $MS_e = 4.813$, $p < .058$]. Figure 1 shows that this interaction was due to greater correct rejections relative to hits in Rn 1 than in Rn 2.

**Fragment completion**. Correct fragment-completion responses were classified as follows: unstudied items on FC 1, studied items on FC 1, FC 2 fragments consisting of distractors on Rn 1, and FC 2 fragments that were targets on Rn 1. Following the convention of Tulving et al. (1982), these four response categories will be designated as unprimed, study primed, test primed, and study-test

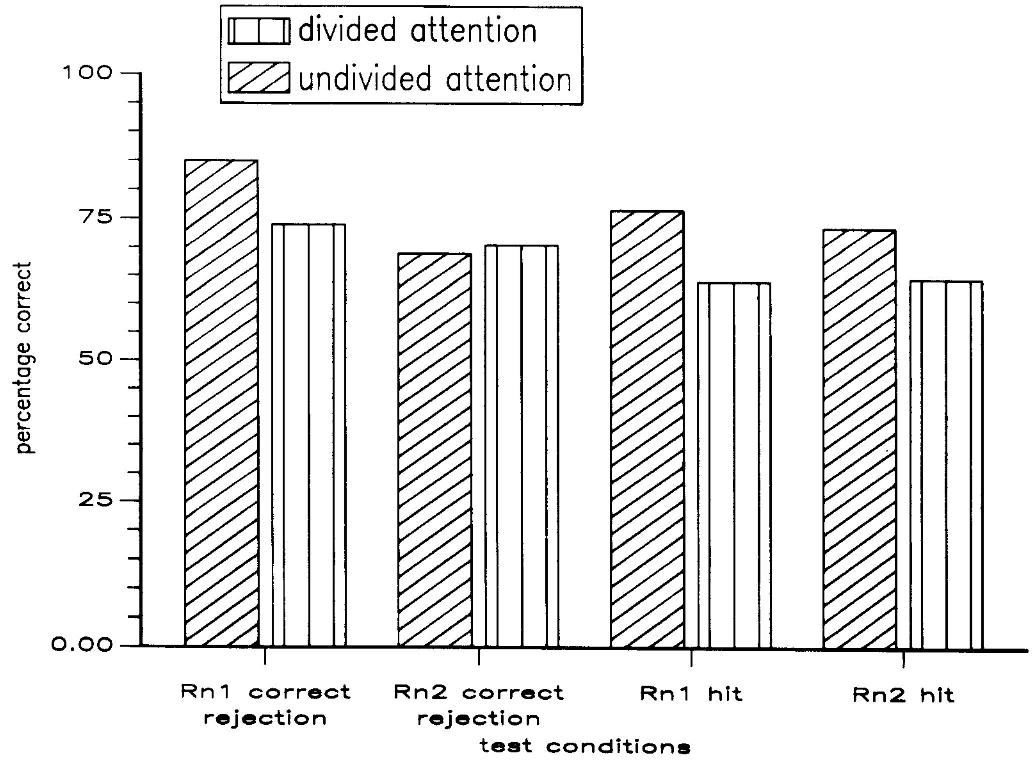

Figure 1. Correct recognition responses in Experiment 1. Rn 1 = first recognition test, Rn 2 = second recognition test.

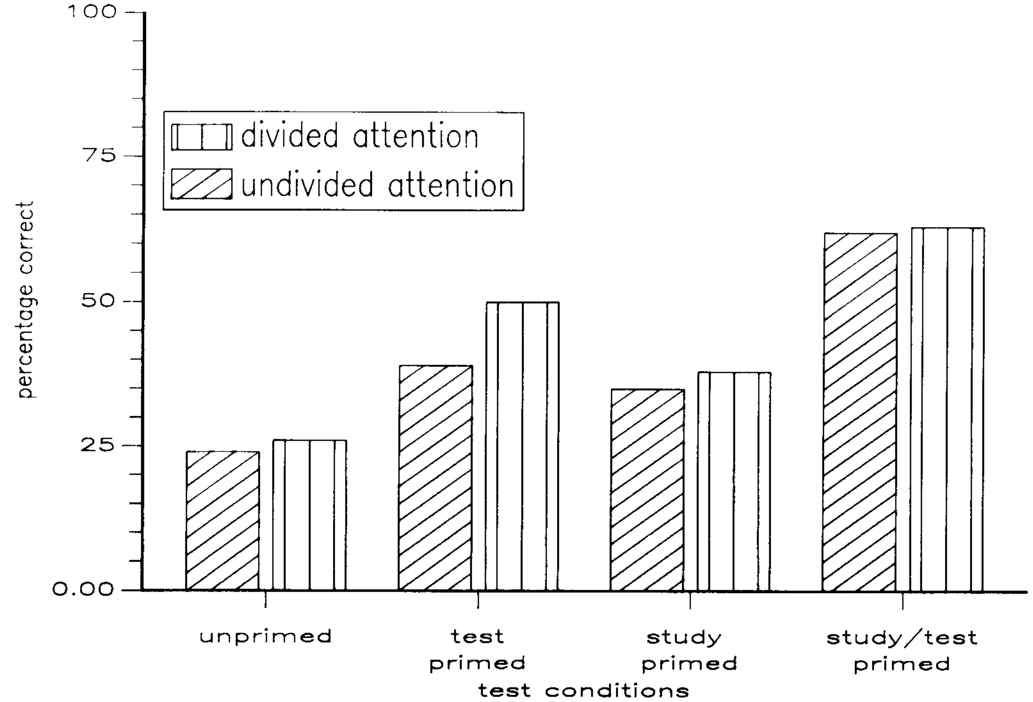

**Figure 2. Correct fragment completions in Experiment 1. Unprimed = fragments of unstudied words in Fragment Completion Test 1 (FC 1), test primed = unstudied fragments that were distractors in Recognition Test 1 and targets on FC 2, study primed = fragments of targets tested in FC 1, study/test primed = fragments of targets tested in FC 2.**

primed, respectively. The data are summarized in Figure 2.

The fragment-completion data were analyzed in a 2 × 2 × 2 ANOVA with group (divided vs. undivided attention), test position (unprimed and study primed vs. study-test primed and test primed), and response type (study and study-test primed vs. unprimed and test primed) as fixed factors. This analysis demonstrated a main effect of response type [$F(1,22) = 52.767$, $MS_e = 9.21$, $p < .001$], indicating that fragment completion was greater for studied items than for nonstudied items—in other words, a priming effect. The analysis also showed that fragment completion was higher for FC 2 fragments than for FC 1 fragments [$F(1,22) = 28.7$, $MS_e = 7.31$, $p < .001$].[1] The main effect of group did not approach significance ($F < 1$).

## Discussion

Experiment 1 confirms the earlier findings of Tulving et al. (1982) by showing that prior exposure to target items in a study phase can facilitate fragment completion. The major feature of interest, however, is the manner in which the fragment-completion and recognition aspects of performance were affected by divided attention during learning. Figure 1 illustrates that, overall, recognition performance by subjects in the divided-attention condition was significantly lower than that of subjects in the undivided-attention condition. The only exception to this finding was the correct rejection data from Rn 2. This finding most likely reflects a degree of confusion among some subjects about what was required on Rn 2 (i.e., subjects may have misinterpreted the instructions and made incorrect "yes" responses to items that were solutions to baseline items).

In contrast to the recognition data, the fragment-completion data show that attentional demands had no effect on performance, even though substantial degrees of priming were achieved. These data are consistent with Hayman and Tulving's (1989a, 1989b) view that the memory processes underlying priming effects are not open to conscious inspection and should not be disrupted by experimental manipulations that reduce the subjects' degree of conscious involvement with the initial learning task.

The present data complement those in a recent study by Parkin and Russo (1990). Using a picture-completion task, they examined how simultaneous processing demands imposed during learning affected both savings performance and explicit recall of the picture sequences. Divided attention during learning substantially impaired recall of the pictures but had no effect on the observed degree of savings in picture completion.

The interpretation of priming effects in terms of memory processes unaffected by the degree of conscious involvement during learning also fits reasonably with other recent data. Jacoby (1983), for example, showed that subjects required to generate target information during the learning phase showed better recognition memory for those items than did subjects who merely read the same items. However, when memory was assessed in terms of priming on a perceptual identification test, subjects who read the targets produced a higher level of priming. Similarly, Roediger and Blaxton (1987) found that reading items during learning produced more priming in fragment-completion than in generate-study conditions. On the assumption that performance of less consciously effortful processing might, in proportional terms, provide greater scope for nonconscious mechanisms, the results of these studies are consistent with the existence of the putative QM system.

## EXPERIMENT 2

Experiment 1 showed that a reduction in conscious processing resources during acquisition reduced explicit memory performance but had no impact on the extent of either study priming or study-test priming in fragment completion. Experiment 2 was designed to extend the generality of this account by examining how explicit and implicit memory are affected by a manipulation whose influence on learning is assumed to influence item-specific memory. Melton (1970) drew attention to a series of learning phenomena that have become known collectively as *spacing effects*. If items are repeated during a learning phase, it is well established that items repeated immediately are not retained as well as those repeated after a delay. This delay is usually filled with other items (e.g., see Madigan, 1969) but can occur even when the spacing involves variations in unfilled time (Rea & Modigliani, 1987). The spacing effect is an extremely robust phenomenon that has been shown over a variety of learning conditions involving many different forms of material. Indeed, the ubiquitous nature of the spacing effect has led one reviewer to note that it is "so general that there doesn't seem any way to get rid of it" (Hintzman, 1974, p. 224), while another set of investigators have concluded that spacing effects are "one on the most omnipresent effects found in the verbal learning laboratory" (Underwood, Kapelak, & Malmi, 1976, p. 391).

Explanations of the spacing effect are still a matter of some contention (e.g., see Greene, 1989). However, one point seems indisputable—the assertion that whatever mechanisms underlie the spacing effect operate at the level of memory traces representing to-be-remembered items. This follows from the observation that the spacing effect is at its most reliable when free recall serves as the dependent measure. Greene found that spacing had no influence on recognition performance when items were viewed under incidental learning conditions but, with free recall, intentionality had no effect.

If the interpretation of priming effects in terms of a traceless QM memory system is correct, it follows that the spacing effect should not be observed. The argument here is that priming effects are not mediated by specific stimulus representations, whereas the spacing effect is. In Experiment 2, we set out to explore this possibility. The procedure was similar to that of Experiment 1, except that targets were presented in isolation rather than in the context of sentence verification. For each subject, half of the targets were repeated immediately (lag 0) and half were repeated after six intervening items (lag 6).

### Method

**Subjects**. The subjects were 16 members of the staff and student population of the University of Sussex. None had taken part in Experiment 1.

**Materials**. The materials were essentially the same as those used in Experiment 1, except that the target items were presented in isolation during the learning phase. The two sets of target items (A and B) were each divided into four lists of 10 items, to which 10 additional filler items from Word Set C were added. Two versions of each of these lists was then produced, one in which target items were repeated immediately (lag 0) and one in which each target was separated by six intervening items (lag 6). For both word sets (A and B), four experimental sequences were then constructed, each comprising two lists of lag 0 items and two lists of lag 6 items. Each list was used only once in each experimental sequence in either its lag 0 or its lag 6 format. Across the experimental sequences, each list appeared twice in the lag 0 format and twice in the lag 6 format. In two of the experimental sequences, the order of conditions was lag 0, lag 6, lag 0, lag 6, and in the other two it was lag 6, lag 0, lag 6, lag 0. The test booklets were the same as those used in Experiment 1. Each booklet was paired twice with each of the eight learning sequences, thus ensuring no confounding between type of item and condition.

**Procedure**. In the first phase of the experiment, the subjects were seated in front of a visual display unit. They were told that a sequence of words would appear and that they should try to remember the words. Each word was presented for 2 sec, with an interstimulus interval of 0.5 sec. Following presentation of the last item, the subjects were seated at a desk and carried out the same test procedure as that used in Experiment 1.

### Results

**Recognition**. Recognition responses for each subject's data for Rn 1 and Rn 2 were each classified into three types: correct rejection, hit lag 0, and hit lag 6. These data are summarized in Figure 3. Because performance on distractor items could not be interpreted unambiguously (i.e., performance on distractors did not differentiate between dectectability of immediate and spaced targets), separate analyses of the hit and correct rejection data were undertaken. The hit data were analyzed in a two-way ANOVA with learning condition (immediate vs. spaced) and test (Rn 1 vs. Rn 2) as fixed factors. This analysis showed that lag 6 items were recognized better than lag 0 items [$F(1,15) = 4.97$, $MS_e = 1.52$, $p < .05$]. The analysis of correct rejections indicated the percentage was higher in Rn 1 than in Rn 2 [$F(1,15) = 7.41$, $MS_e = 8.8$, $p < .01$].

**Fragment completion**. The fragment-completion data were calculated in the same way as in Experiment 1, except that, for study and study-test items, an additional division was made between lag 0 and lag 6 presentations. These data are summarized in Figure 4.

The first analysis was restricted to the study and study-test items and examined whether lag had any influence on performance. A two-way ANOVA with lag (0 vs. 6) and test position (study vs. study-test) revealed no effects

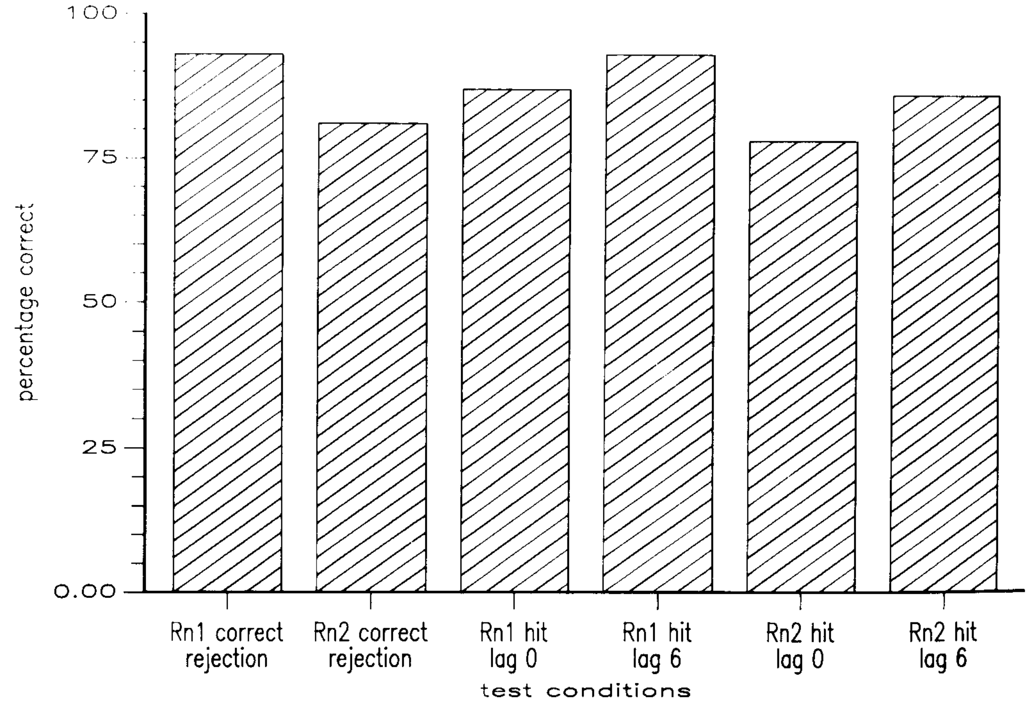

**Figure 3.** Correct recognition responses in Experiment 2. Rn 1 = first recognition test, Rn 2 = second recognition test. Lag 0 = targets repeated immediately, lag 6 = targets repeated after six intervening items.

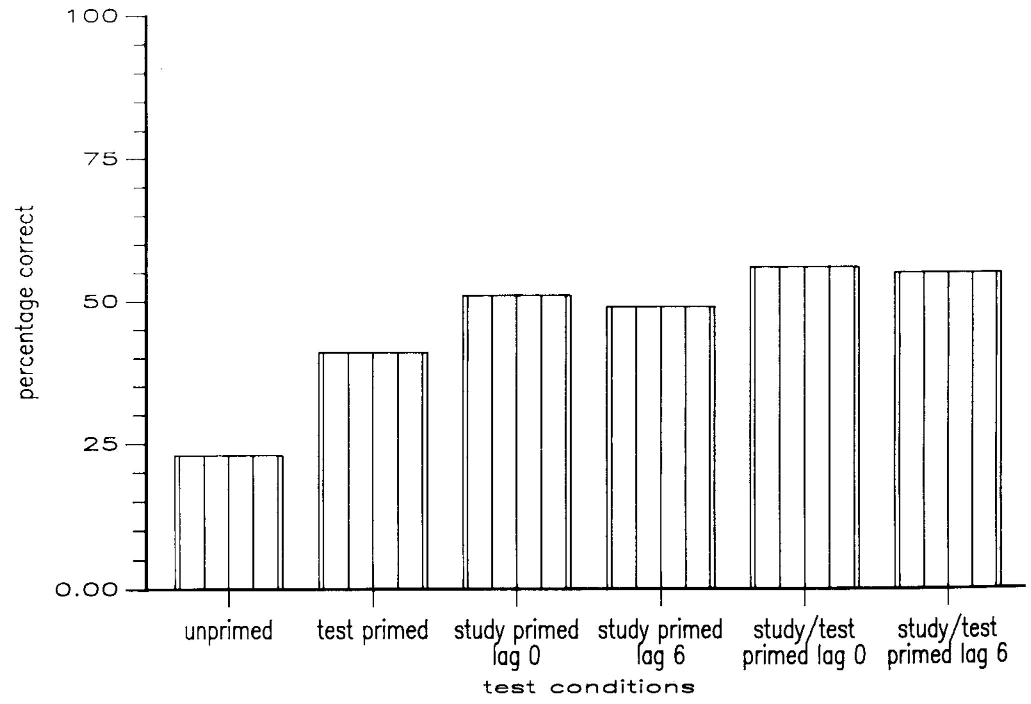

**Figure 4.** Correct fragment completions in Experiment 2. Unprimed = fragments of unstudied words in Fragment Completion Test 1 (FC 1), test primed = unstudied fragments that were distractors on Recognition Test 1 and targets on FC 2, study primed = fragments of targets tested in FC 1, study/test primed = fragments of targets tested in FC 2. Lag 0 = targets repeated immediately, lag 6 = targets repeated after six intervening items.

(all *F*s $< 1$). The critical lag 0 versus lag 6 main effect had a mean standard error of 3.45.

The second analysis examined whether Experiment 2 had produced a priming effect. Since the first analysis had shown no effect of lag, the study and study-test data were collapsed across this variable. A 2 × 2 ANOVA was then performed on these data with test position (study primed and baseline vs. study-test primed and test primed) and response type (study primed and study-test primed vs. baseline and test primed) as fixed factors. The analysis revealed a main effect of response type [$F(1,15) = 31.7$, $MS_e = 8.58$, $p < .001$], indicating that a significant priming effect was obtained in the experiment. The main effect of test position failed to reach conventional significance [$F(1,15) = 3.42$, $MS_e = 24.96$], as did the interaction [$F(1,15) = 2.64$, $MS_e = 7.65$].

### Discussion

Experiment 2 demonstrated that implicit and explicit memory respond differently to manipulations of spacing during initial learning. Implicit memory, as assessed by priming in fragment completion, was uninfluenced by spacing, with completion rates for immediate and spaced items being almost identical. Furthermore, it should be noted that this absence of a difference occurred with completion levels both well above floor and below ceiling. Turning to recognition, there was a significant advantage in correct recognition responses to spaced targets. The small size of this effect can be attributed to the high levels of recognition performance per se, and the fact that recognition may, more generally, be less sensitive to the effects of spacing than is free recall (Greene, 1989).

The results of Experiment 2 therefore provide additional support for the view that priming effects in fragment completion arise from a memory system that does not encode traces of individual items. For this reason, spacing effects, which are due to the differential processing and representation of successive presentations of specific stimuli, were unable to influence the degree of priming observed, even though they affected recognition.

The findings of Experiment 2 should be considered in relation to other studies that have examined the effect of spacing manipulations on implicit memory phenomena. Jacoby and Dallas (1981) reported better subsequent tachistoscopic recognition of spaced items than of massed items. However, in addition to commenting on the rather weak statistical support for this apparent finding (statistical significance was achieved only in one of the two critical comparisons), Perruchet (1989) has drawn attention to methodological issues that undermine interpretation of this result. Perruchet reported four experiments examining the effect of spacing on implicit memory and found a significant effect only in his last study, although a meta-analysis collapsed across all four experiments indicated "a real but probably slight and fluctuating effect upon implicit memory performance" (p. 113). It would seem, therefore, that the failure to find an effect of spacing on fragment-completion priming in Experiment 2 is not unexpected given other available evidence.

In conclusion, the present experiments have identified two more factors that differentiate implicit and explicit memory as exemplified by dissociation on the Tulving et al. (1982) recognition/fragment-completion paradigm. The data illustrate that implicit memory processes appear to be insensitive to divided-attention manipulations and unaffected by spacing manipulations during learning. The findings also strengthen our theoretical grasp of implicit memory phenomena by supporting Hayman and Tulving's (1989a, 1989b) theory that priming effects are mediated by a traceless QM system, a view that overlaps with other recent accounts of implicit memory phenomena, notably Schacter's (in press) proposal that priming effects reflect the memorial properties of "perceptual representation systems" as opposed to a system that encodes unique representations of stimulus events.

## REFERENCES

Anderson, C. M. B., & Craik, F. I. M. (1974). The effect of concurrent task on recall from primary memory. *Journal of Verbal Learning & Verbal Behavior*, **13**, 107-113.

Gardiner, J. M., Dawson, A. J., & Sutton, E. A. (1989). Specificity and generality of enhanced priming effects for self-generated study items. *American Journal of Psychology*, **102**, 295-301.

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

Graf, P., & Schacter, D. L. (1989). Unitization and grouping mediate dissociations in memory for new associations. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **15**, 930-940.

Greene, R. L. (1986). Word stems as cues in recall and completion tasks. *Quarterly Journal of Experimental Psychology*, **38A**, 663-674.

Greene, R. L. (1989). Spacing effects in memory: Evidence for a two-process account. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **15**, 371-377.

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

Hayman, C. A. G., & Tulving, E. (1989b). Is priming in fragment completion based on a "traceless" memory system? *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **15**, 941-956.

Hintzman, D. L. (1974). Theoretical implications of the spacing effect. In R. L. Solso (Ed.), *Theories in cognitive psychology: The Loyola Symposium* (pp. 77-100). Potomac, MD: Erlbaum.

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

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

Jacoby, L. L., & Hayman, C. A. G. (1987). Specificity of visual transfer in word identification. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **13**, 456-463.

Light, L. L., & Singh, A. (1987). Implicit and explicit memory in young and older adults. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **13**, 531-541.

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

Madigan, S. W. (1969). Intraserial repetition and coding processes in free recall. *Journal of Verbal Learning & Verbal Behavior*, **8**, 828-835.

Mayes, A. R. (1988). *Human organic memory disorders*. Cambridge: Cambridge University Press.

Melton, A. W. (1970). The situation with respect to the spacing of repetitions and memory. *Journal of Verbal Learning & Verbal Behavior*, **9**, 596-606.

Parkin, A. J. (1987). *Memory and amnesia*. Oxford: Blackwell.

Parkin, A. J. (1989). The nature and development of implicit memory. In S. Lewandowsky, J. Dunn, & K. Kirsner (Eds.), *Implicit memory: Theoretical issues* (pp. 231-240). New York: Erlbaum.

Parkin, A. J., & Russo, R. (1990). Implicit and explicit memory and the automatic effortful distinction. *European Journal of Cognitive Psychology*, **2**, 71-80..

Parkin, A. J., & Streete, S. (1988). Implicit and explicit memory in young children and adults. *British Journal of Psychology*, **79**, 361-369.

Perruchet, P. (1989). The effect of spaced practice on explicit and implicit memory. *British Journal of Psychology*, **80**, 113-130.

Rea, C. P., & Modigliani, V. (1987). The spacing effect in 4- to 9-year-old children. *Memory & Cognition*, **15**, 436-443.

Roediger, H. L., & Blaxton, T. A. (1987). Retrieval modes produce dissociations in memory for surface information. In D. S. Gorfein & R. S. Hoffman (Eds.), *Memory and learning: The Ebbinghaus centennial conference* (pp. 349-379). Hillsdale, NJ: Erlbaum.

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

Schacter, D. L. (in press). Perceptual representation systems and implicit memory: Toward a resolution of the multiple memory systems debate. In A. Diamond (Ed.), Development and neural bases of higher cognitive function. *Annals of the New York Academy of Sciences*.

Schacter, D. L., Cooper, L. A., & Delaney, S. M. (1990). Implicit memory for unfamiliar objects depends on access to structural descriptions. *Journal of Experimental Psychology: General*, **119**, 5-24.

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, & Cognition*, **8**, 336-342.

Underwood, B. J., Kapelak, S. M., & Malmi, R. A. (1976). The spacing effect: Additions to the theoretical and empirical puzzles. *Memory & Cognition*, **4**, 391-400.

## NOTE

1. This study was not concerned with the issue of stochastic independence and the problems that surround analytical methods used in its demonstration (Hayman & Tulving, 1989a). The data from Experiment 1 were, however, analyzed using the same procedures as those used by Tulving et al. (1982), and results similar to those of Tulving et al. were obtained. These data and analyses are available on request.

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