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Probing memory with conceptual cues at multiple retention intervals: A comparison of forgetting rates on implicit and explicit tests

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The time courses for implicit and explicit conceptual tests of memory were compared in two experiments. In Experiment 1, participants encoded target words by judging the apparent pleasantness of their meaning. Immediately thereafter or 48 h later, retrieval cues were presented to different groups of participants for either an implicit or an explicit free-association task. Whereas explicit test performance showed a decline over the 48-h delay, implicit test performance was statistically unaltered. In Experiment 2, memory was tested at five retention intervals, lasting up to 3 weeks. The forgetting functions of both implicit and explicit tests conformed to a logarithmic function. Despite the large conceptual priming effect, which resulted from relational encoding instructions, implicit memory performance still declined at a much slower rate than did performance on the cued-recall test. We argue that because nominal conceptual cues were held constant across the implicit and the explicit conditions, the observed dissociation in performance supports a memory systems approach.

On standard, explicit tests, memory is probed by instructing participants to refer to a prior learning episode and to consciously recollect previously studied items. Implicit memory tests, in contrast, make no reference to a prior learning episode and, instead, index memory by noting the changes in performance that result from earlier learning (Schacter, 1987). The purpose of this paper is to examine the claim that performance on one subclass of implicit tests—conceptual tests—might reflect the operation of a memory system distinct from the episodic memory system.

Conceptual tests are tests that provide a retrieval cue that is related to previously studied words by meaning, rather than by perceptual form. The demonstration of mnemonic effects on implicit conceptual tests is referred to as the *conceptual priming effect*. This effect is defined as the more frequent occurrence of responses for studied than for unstudied words on implicit conceptual tests of memory, where no reference is made to the study episode (e.g., Blaxton, 1989; Srinivas & Roediger, 1990; Weldon & Coyote, 1996). For example, if participants see a list of words during study and are later asked to free associate to a conceptually related cue (e.g., *leash*), the more frequent generation of studied words (e.g., *dog*) than of unstudied words would exemplify a conceptual priming effect. Conceptual cues can also be used to probe memory explicitly if participants are consciously referred to the study episode, when asked to associate to a target word from the first phase of the experiment.

Tulving and Schacter (1990; Schacter & Tulving, 1994) have suggested that when memory is tested with explicit instructions, an episodic memory system is primarily probed, whereas a semantic memory system is probably probed with implicit conceptual tasks. The postulation of such separate memory systems requires that a set of conditions be met. Recently, sets of a priori criteria that need to be satisfied if the existence of such separate memory systems is to be postulated have been suggested by three theoretical frameworks (i.e., Dosher & Rosedale, 1991; Nadel, 1994; Schacter & Tulving, 1994). The only criterion common to all three frameworks is the requirement that the postulated systems should display different properties of forgetting.

The criterion of a differential pattern of forgetting has sometimes been used to suggest differences between implicit and explicit tests that provide cues that are perceptually (rather than conceptually) similar to target words. Thus, several studies have reported a relatively slow decline in implicit memory performance on perceptual tests. However, these studies have either diverged from the retrieval intentionality criterion (Schacter, Bowers, & Booker, 1989) by confounding different nominal cues with the implicit and explicit retrieval instructions (e.g., Graf & Mandler, 1984; Mitchell & Brown, 1988; Moscovitch & Bentin, 1993) or have provided no measure at all of explicit memory performance (e.g., Roediger & Blaxton, 1987; Roediger, Weldon, Stadler, & Riegler, 1992; Sloman, Hayman, Ohta, Law, & Tulving, 1988; for a recent noteworthy exception, see McBride & Dosher, 1997). Therefore, even if forgetting occurs on these implicit memory tests, it is not clear that the rate of forgetting is different from that observed on explicit tests.

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The present research focuses on forgetting on implicit, conceptual tests. Only three studies have reported the effects of retention interval on memory performance for this class of tests. Using a free-association task, Shimamura and Squire (1984, Experiment 4) found no priming on a conceptual test after a 2-h delay. Their design, however, did not conform to the retrieval intentionality criterion, in that the implicit free-association task was compared with free recall, rather than with cued recall. In addition, the same participants were tested on both the implicit and the explicit tests, using identical materials, making yet more difficult the comparison of forgetting rates across the two tests.

Using a category exemplar generation task, Hamann (1990) failed to obtain conceptual priming when testing participants 90 min after encoding. Explicit conceptual memory was not tested, however, so it is impossible to describe differences between forgetting on implicit and explicit tests. Finally, Rappold and Hashtroudi (1991) also tested memory, using the category exemplar generation task, and were careful to test explicit memory and adhere to the retrieval intentionality criterion. In one condition, they found that performance under explicit, but not implicit, retrieval instructions was attenuated over a 24-h delay. Because this finding is unique, as well as of theoretical importance, we will attempt to establish its generality to the free-association task.

EXPERIMENT 1

Method

Participants. Fourteen students participated in a pilot study for generating baseline data for the experimental stimuli. An additional group of 56 university students, 14 in each of four between-subjects conditions, participated in the actual experiment. All the students participated on a voluntary basis. The mean age of the participants was 27.2 years, ranging from 20 to 33 years. All the participants had between 13 and 17 years of education, spoke fluent Hebrew, and had normal or corrected-to-normal vision.

Design and Materials. Study status (studied, unstudied) was manipulated within subjects. Test type (implicit, explicit) and retention interval (immediate, 48 h) were between-subjects variables.

The participants in the pilot study generated the first word that came to mind to a pool of 312 cues, 3–4 letters long (see, e.g., Bergerbest & Goshen-Gottstein, 1999). For 64 of the cues, 3 or 4 (21.4%–28.6%) participants generated the same target word. These cues were chosen to be conceptual cues in the retrieval phase of the experiment, and the targets generated by the participants were chosen as the to-be-remembered targets. The 64 cue words and the 64 target words were printed in Hebrew, size 48 Chaim font. Hebrew vowel points (see Navon & Shimron, 1984) were appended to all the stimuli to ensure that all the words would be read without phonological or semantic ambiguity. The words were glued onto 8 × 10 cm index cards.

The 64 word pairs were randomly divided into two lists of equal length. Each participant studied one of the lists and was tested on both. Counterbalancing of the materials ensured that each participant would be tested on an equal number of cues corresponding to studied and unstudied targets, and across participants each cue appeared an equal number of times as a cue corresponding to studied and unstudied targets. Study as well as test materials were presented in a different random order for each participant.

Procedure. The participants were tested individually. They were told that they would be participating in a word-judgment task, in which they were to verbally rate, on a scale from 1 to 4, the extent to which presented words had subjectively pleasant or unpleasant meanings. A graphic scale depicting the possible ratings was presented to them throughout the study phase. Each participant was presented with three words for practice and then with the actual experimental study targets. Each target was presented for exactly 5 sec and was immediately followed by presentation of the next target word.

Half the participants were tested immediately after encoding, and the other half exactly 48 h later. In the immediate-test condition, the delay between study and test was approximately 5 min, during which instructions were read and questions were clarified. Care was taken to maximize the similarity between study and test contexts even after the 48-h delay (i.e., the same room, same table, same experimenter wearing the same clothing). For each of the two retention interval groups, half the participants were tested under implicit instructions, and the other half under explicit retrieval instructions.

In the implicit condition, the participants were told that they would be presented with a list of words. For each word, they were to say the first word that came to mind. They were asked to respond to each and every cue word presented in the list and were discouraged from responding more than once with the same word. Next, the cue words were presented. Each word remained available until a verbal response was given. The responses were immediately recorded by the experimenter.

All aspects of the explicit condition were identical to those of the implicit condition, except that the participants were instructed to respond with associated words they had previously encountered in the first phase of the experiment. In an attempt to equate response bias across the implicit and the explicit tests, the participants were asked to produce an association to each and every cue (see, e.g., Mulligan & Hartman, 1996) and were discouraged from responding more than once with the same word.

Results and Discussion

The free-association task provides virtually no constraint on possible responses that can be made to a particular cue. Therefore, participants sometimes generate target words to cues that were not originally designated to elicit those words. Still, these responses index memory. Therefore, generation of any of the 64 target words was scored as correct, in both the implicit and the explicit test conditions, as well as in the studied and the unstudied conditions.[1] For any participant, a specific target response was scored as correct only once. The number of studied and unstudied responses were converted into percent scores and are presented in the upper half of Table 1. Because it is difficult to ascribe meaning to main effects and to two-way interactions in the presence of significant three-way interactions, lower level effects will not be reported when higher level interactions are significant (Howell, 1992, p. 391).

Examination of the data revealed that on the immediate test, memory performance, as measured by the difference between studied and unstudied targets, was 53% on the explicit test. This effect was greatly attenuated with the passage of time on the explicit test, with only a 20% conceptual effect after 48 h. Analysis of the explicit test condition found the two-way interaction between study status and retention interval to be significant [$F(1,26) = 30.87$, $p < .0001$].

In contrast, in the implicit test condition, the immediate conceptual priming effect was 12% and was only slightly reduced, to 7%, after a 48-h delay. Indeed, the study sta-

Table 1
Mean Percentages of Responses With Target Words (and Standard Errors) in the Studied and Unstudied Conditions Under Implicit and Explicit Retrieval Instructions for Different Retention Intervals Under Item-Specific or Relational Encoding

		Study Status					
		Studied		Unstudied		Memory‡	
Retrieval Instructions	Test Time	*M*	*SE*	*M*	*SE*	*M*	*SE*
		Item Encoding*					
Implicit	Immediate	32	3.9	20	2.5	12	4.2
	48 h	30	1.7	23	2.2	7	2.4
Explicit	Immediate	66	2.7	13	1.8	53	2.9
	48 h	41	4.0	21	2.4	20	5.1
		Relational Encoding†					
Implicit	Immediate	70.5	4.9	24.4	2.3	46.1	3.8
	24 h	64.8	5.5	22.1	1.6	42.8	6.0
	48 h	57.8	2.7	18.2	1.7	39.6	2.6
	1 week	61.1	4.3	22.1	2.2	39.1	3.8
	3 weeks	60.2	4.7	22.7	1.9	37.5	5.2
Explicit	Immediate	90.0	2.1	1.8	0.6	88.3	2.2
	24 h	62.9	4.1	2.1	3.1	60.7	4.1
	48 h	52.5	3.0	2.7	0.7	49.9	2.8
	1 week	48.0	4.1	2.5	0.9	45.6	4.0
	3 weeks	40.0	2.7	2.7	0.6	37.3	2.7

*Experiment 1: Participants rated the pleasantness of each studied word only once. †Experiment 2: Participants created three different sentences to the presented word and the word immediately preceding it. ‡Memory = studied − unstudied.

tus × retention interval interaction failed to achieve significance in the implicit test condition [$F(1,26) = 1.13$, $p > .2$]. Interestingly, even when only the delayed condition was analyzed, performance was still more accurate for studied than for unstudied targets [$t(13) = 2.74$, $p = .01$]. Most important, and in conformity with the overall pattern of results, the three-way interaction between study status, test type, and retention interval was significant [$F(1,52) = 13.07$, $p < .0005$]. Therefore, whereas memory performance on the explicit test significantly decreased with retention interval, the decrease on the implicit test, if extant, was too small to be detected. Because the participants were always required to respond, even in the explicit test condition, changes in response bias cannot be invoked to account for differential forgetting rates.

An examination of Table 1 revealed an unexpected finding that in the explicit test condition, the participants responded *less* frequently with unstudied target words when tested immediately (13%) than when tested after a 48-h delay [21%; $F(1,26) = 7.31$, $p < .0125$]. This finding was likely influenced by the inclusion-like instructions (Jacoby, 1991), wherein participants were required to produce a studied word and, if that failed, were still required to produce a word. We suggest that on the immediate test, generating target words to unstudied cues was doubtless hindered by episodic memory of the study because the study list did not contain associations to the cues of unstudied targets. On the delayed explicit test, the participants probably relied less on episodic memory and reverted to a free-association strategy that was less obstructed by conscious recollective processes. Therefore, the participants were free to generate the same targets that were generated, with high probability, in the pilot study to these very same cues. According to this suggestion, our anomalous finding was the result of the inclusion-like instructions and should not appear under a standard test of cued recall. This prediction will be tested in Experiment 2, together with the suggestion that forgetting does, in fact, occur on the implicit test but could simple not be detected.

EXPERIMENT 2

The data for Experiment 1 demonstrate that whereas implicit memory performance did not deteriorate significantly over time, explicit memory performance did decline over time. However, it may be that implicit memory performance did decline over time but that this decline in performance was difficult to detect owing to the initial low level of performance on this test, compounded by the low power of the between-subjects design. One goal of Experiment 2 was, therefore, to elevate the magnitude of the conceptual priming effect, so that a decline in performance, if extant, would be detected.

To elevate the magnitude of the conceptual priming effect, three changes were introduced. First, presentation of study stimuli was self-paced, rather than participant independent. Second, younger, high school students participated in this experiment. Third and most important, the encoding task was changed to a relational task, which involved processing of the context in which the item occurred. The task was modeled after that of McDermott and Roediger (1996, Experiment 3), who asked participants to create, for each word that was presented, a sentence that contained the current word and the previously presented word.

In their study, McDermott and Roediger (1996) established that relational processing leads to an increase in conceptual priming, as opposed to item-specific processing (e.g., thinking about specific aspects of an item). To highlight relational processing, we asked the participants to create not one, but three sentences containing the current word and the previously presented word. Presumably, this task would facilitate memory performance not only beyond the item-specific rating used in Experiment 1, but also beyond the conceptual priming effects observed by McDermott and Roediger.

An additional, equally important goal of this experiment was to obtain estimates of the forgetting rates of the implicit and explicit tests by measuring performance at multiple retention intervals. Theoretical arguments are restricted to describing the pattern of two-way interactions, when performance is limited to only two retention intervals. Because such patterns are qualitative, rather than quantitative, little can be learned about the rate of forgetting for the specific tests that are examined. Indeed, the conclusion from Experiment 1, that implicit memory performance does not deteriorate over time, must be confined to the two retention intervals that were chosen and the power of the design. One would certainly not want to argue that conceptual implicit tests are completely immune to forgetting.

By measuring memory performance over multiple retention delays, the nature of forgetting could be plotted as a function of time (e.g., McBride & Dosher, 1997). Estimates could then be derived for the rate of forgetting on the implicit and explicit tests. Most important, the forgetting rates can be compared across the tests, suggesting whether common or distinct mechanisms are mediating performance on the two tests.

Method

Participants. One hundred and sixty students were chosen, 16 for each of the 10 between-subjects conditions. The mean age of the participants was 17.1 years, ranging from 15.8 to 17.4 years. All the participants had between 10 and 12 years of education, spoke fluent Hebrew, and had normal or corrected-to-normal vision.

Design and Procedure. The participants were randomly assigned to the 10 between-subjects conditions that were created by crossing the five retention intervals by the two retrieval conditions (implicit, explicit). Testing of the between-subjects groups was conducted at time intervals of 5 min, 24 h, 48 h, 1 week, and 3 weeks. As in Experiment 1, care was taken to maximize the similarity between study and test contexts at all the retention intervals. The five implicit retrieval groups received retrieval instructions that were identical to those in Experiment 1.

In the explicit retrieval condition, the participants were given standard, cued-recall instructions and were asked to respond to each retrieval cue with associated words they had previously encountered in the first (study) phase of the experiment. They were asked to skip words for which no association could be retrieved from memory. Under these cued-recall instructions, explicit memory performance could justifiably be indexed by the subtraction of incorrect responses corresponding to cues of unstudied words (false alarms) from correct responses corresponding to cues of studied words (hits). In contrast, under the inclusion-like instructions used in Experiment 1, the percentage of correct responses to cues corresponding to unstudied words reflects not only incorrect false alarms, but also correct guessing responses. Therefore, the interpretation of the index obtained by subtracting this measure from the hit rate is not evident (but see Mulligan & Hartman, 1996, who failed to find differences between the two indexes).

By changing retrieval instructions from inclusion to cued recall, we hoped to eliminate the anomalous finding of elevated responses to unstudied words in the delayed-retrieval condition (Experiment 1). In all other respects, the materials, design, and procedure conformed to those of Experiment 1.

Results

The responses were scored as in Experiment 1 and are described in the lower half of Table 1. Mean memory performance at the different retention intervals, measured by the difference between studied and unstudied targets, is graphically depicted in Figure 1. An examination of the results revealed that the attempts to elevate memory performance were successful. Performance increased on the immediate test, to 88% for the explicit test and to 46% for the implicit test. To the best of our knowledge, the 46% conceptual priming effect is the largest ever reported. Presumably, the repeated relational encoding of study materials, as well as the self-paced nature of encoding, improved performance on both the implicit and the explicit tests.

An examination of the results also revealed that the participants' baseline responses in the explicit retrieval condition were considerably lower than those in Experiment 1. Moreover, these responses did not show an increase, comparable with that observed in Experiment 1, when moving from the immediate test (1.8%) to the delayed tests [2.7%; $F(4,75) < 1$]. Doubtless, the discrepancy between these two experiments results from the change in the retrieval instructions, from instructions in Experiment 1 that encouraged guessing (inclusion-like instructions) to instructions in Experiment 2 that discouraged guessing (cued recall). Because in the present experiment, guessing was discouraged, the participants made fewer responses to cues corresponding to unstudied words, and response strategies in the explicit retrieval condition remained invariant, even after long retention intervals.

Most important to our concerns, despite the initial superiority of performance on the explicit test, the drop in explicit memory performance over the 3-week interval was so large that, at 3 weeks, performances on the implicit and the explicit tests were indistinguishable. This finding argues against the possibility that the rates of forgetting on the two tests were simply proportional to initial levels of performance.

We submitted the data to a three-way analysis of variance, with study status (studied, unstudied) as a within-subjects variable and test type (implicit, explicit) and retention interval as between-subjects variables. The three-way interaction was significant [$F(4,150) = 8.77$, $p <$

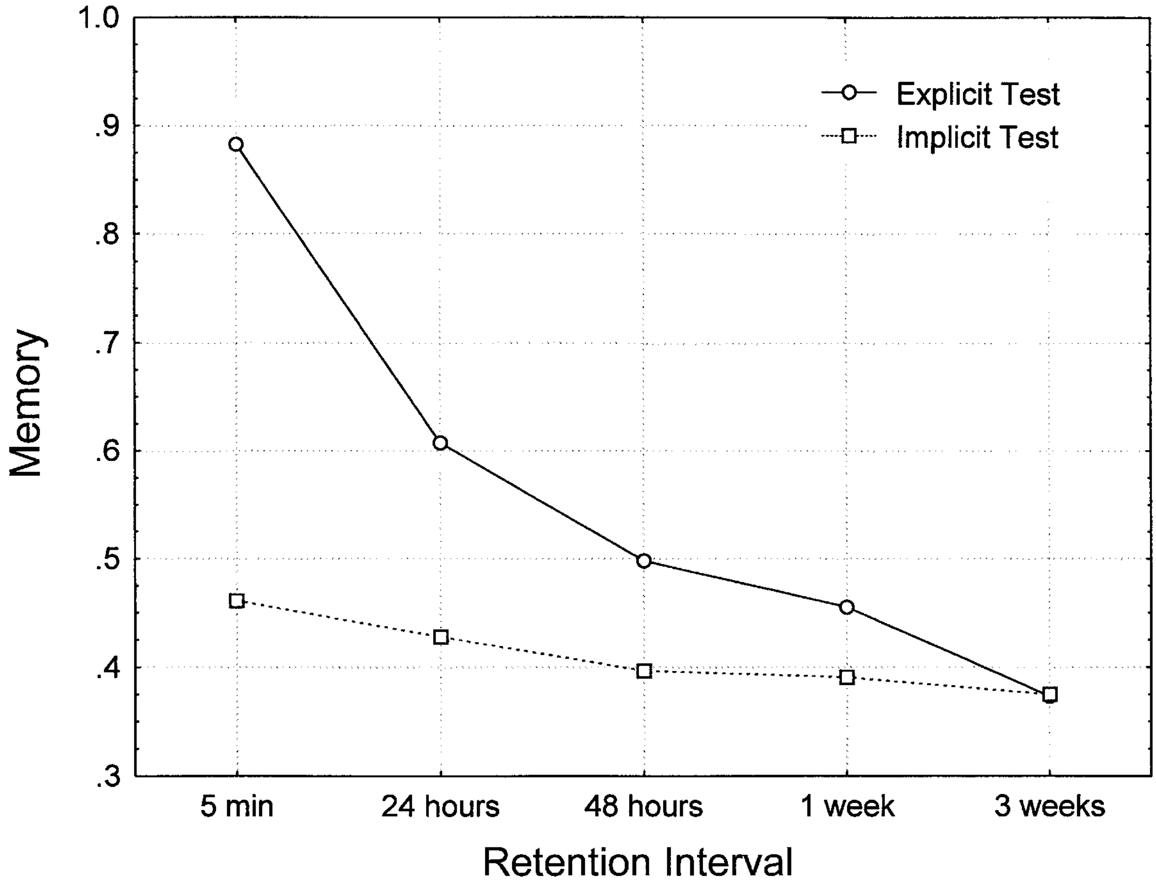

Figure 1. Mean memory performance (studied − unstudied) under relational encoding instructions for the implicit and explicit tests as a function of retention interval in Experiment 2.

.00001]. Further analysis found a two-way interaction between study status and retention interval on the explicit test [$F(4,75) = 36.22$, $p < .000001$], revealing a significant decline of 51% when going from the immediate test to the delayed test 3 weeks later. The large decrease on the explicit tests contrasted with the small, 9% decrease that was observed on the implicit test condition over the same time period. Despite the obvious drop in performance, the decrease on the implicit test condition failed to achieve significance, as measured by the study status × retention interval interaction [$F(4,75) < 1$]. Therefore, whereas memory performance on the explicit test significantly decreased with retention interval, the decrease on the implicit test was too small to be detected. This is despite the high level of memory performance that was initially found on the immediate test.

In order to characterize the functional form and rate of forgetting, the data were fit to descriptive forgetting functions that describe the monotonic loss of information with time (e.g., linear, hyperbolic, power, and logarithmic functions) for both the implicit and the explicit tests. (For a summary of the psychological meaning of these functions, see Rubin & Wenzel, 1996.) To this end, we converted the durations of retention to a common time scale ranging from 5 (immediate test) to 30,240 min (i.e., 3 weeks). The best fit was provided by the logarithmic function, $y = a - b \cdot \ln(\text{time})$, with $R^2 = .98$ for the explicit test, and $R^2 = .91$ for the implicit test. The estimated slopes for these fits, which describe the rate of forgetting on the two tests, were 0.06 for the explicit test [$t(3) = -12.8$, $p < .005$] and 0.01 for the implicit test [$t(3) = -5.5$, $p < .05$]. The intercepts were 0.98 for the explicit test [$t(3) = 28$, $p < .001$] and 0.48 for the implicit test [$t(3) = 35$, $p < .005$].

The absolute magnitude of these slopes is a function of the time scale used (i.e., that of minutes) and is of little, if any, psychological relevance. The relative magnitude of the slopes in the two tests, however, is critical for uncovering possible mechanisms underlying the two tests. At a purely descriptive level, the rate of forgetting, as estimated by the slopes, was six times faster on the explicit tests than on the implicit tests. This difference was significant[2] [$t(6) = 9.97$, $p < .0001$]. Therefore, although the pattern of forgetting on both the implicit and the explicit tests is best described by a logarithmic function, the rate of forgetting is considerably faster under explicit than under implicit retrieval instructions.

GENERAL DISCUSSION

The results of the experiments can be summarized as follows. In Experiment 1, implicit conceptual priming declined with time (nonsignificantly) from 12% on the immediate test to 7% after 48 h. The decline on the explicit test was more accentuated and was significantly reduced from 53% on the immediate test to 20% on the delayed test. Interpretation of these results was problematic because of the better performance that was found, in the explicit test, for unstudied targets after 48 h than on the immediate test. This pattern suggests a shift in response strategy across the retention interval. Interpretation of the results was made even more difficult by the low levels of performance that were found in the implicit test at the immediate retention interval.

In Experiment 2, guessing in the explicit retrieval condition was discouraged in order to eliminate the shift in response strategy. Indeed, unlike performance in Experiment 1, the number of responses to cues corresponding to unstudied words in the explicit condition remained invariant across the retention intervals. Note, however, that although response strategies probably remained invariant in the explicit retrieval condition, changes in response bias across the implicit and explicit tests may have been introduced into the design. Any interpretation of the results should, therefore, be made with caution (see, e.g., Reingold & Toth, 1996). Hence, a complete understanding of the pattern of performance can be obtained only through a combined consideration of the results of both Experiments 1 and 2.

To elevate baseline performance, a relational encoding task was employed in Experiment 2. In addition, memory performance was examined on five, rather than two, retention intervals, so that the forgetting function could be plotted and the rate of forgetting could be estimated. We found that although performance on the explicit test was considerably superior to that on the implicit test upon immediate testing, forgetting on the explicit test occurred at such a rapid rate that, after 3 weeks, memory was equivalent for the explicit and the implicit tests. That after 3 weeks performance was equal in the two tests suggests that the relative rate of forgetting was not simply a function of the higher level of performance that was initially found in the explicit test condition. If forgetting was only a function of initial level of remembering, forgetting in the explicit test should, in principle, have never "caught up" with forgetting on the implicit test. That performance on the two tests was equivalent after 3 weeks suggests, therefore, that the obtained rate of forgetting reflects, at least in part, a genuine difference in the forgetting functions of the two tests.

Performance was found to decline as a function of log (time), with the slope of the forgetting function equal to approximately 0.06 on the explicit test and to 0.01 on the implicit test. Although Experiment 1 did not provide sufficient data to plot a forgetting function, it is interesting to note that over the time period that was tested, the 6:1 ratio of forgetting that was found (a decline of 33% on the explicit test and a decline of 5% on the implicit test) was almost identical to that of Experiment 2. This suggests that the reason that a decline in performance was not observed on the implicit test in Experiment 1 was genuine, rather than artifactual.

Only a single other study (Sloman et al., 1988, Table 2) has measured implicit memory performance over multiple retention intervals lasting more than a few hours. Unlike the present study, however, Sloman et al. used a fragment-completion task, with cues that were perceptually, rather than conceptually, related to studied targets. Upon reanalyzing their data, the best fit to their data was also a logarithmic function, with a forgetting slope (0.02) that was not dissimilar to the one we found on the implicit test (Rubin & Wenzel, 1996, Table 8). Unfortunately, explicit memory was not tested in their study.

In fact, upon analyzing 210 data sets, encompassing different types of memory measures, different subject populations, and different time scales, Rubin and Wenzel (1996) found that the logarithmic function provided the best fit to the vast majority of studies. Interestingly, researchers as early as Ebbinghaus (1964) discovered that when forgetting is plotted as a function of time, performance conforms to a logarithmic function. It is noteworthy that Ebbinghaus quantified memory with his "savings" measure, which can also be construed as an implicit measure of memory.

Psychologically, the meaning of the logarithmic function is that the units of time must multiply themselves (e.g., 2 min, 4 min, 8 min) for a constant amount of loss of information to occur. Stated differently, whereas time advances according to a geometric series, forgetting advances in accordance with an arithmetic series. The estimates in our study establish that the constant amount of information that is lost on the explicit test is six times greater than that on the implicit test.

Studies that have investigated the forgetting rates of perceptual tests have been inconclusive, in that they either used different nominal cues for the implicit and the explicit tests (e.g., Graf & Mandler, 1984) or provided no explicit tests at all (e.g., Roediger & Blaxton, 1987). The only outstanding exception to this is a recent study by McBride and Dosher (1997), who applied the retrieval intentionality criterion to study forgetting rates in a fragment-completion task. This study found equivalent forgetting rates for the implicit and the explicit tests, a finding that does not provide support for a memory systems account with regard to perceptual implicit tests.

A different story is beginning to emerge with regard to conceptual tests. Rappold and Hashtroudi (1991) found faster forgetting on an exemplar generation task than on an explicit version of that task These researchers applied the retrieval intentionality criterion and obtained a clean dissociation between retrievals undertaken intentionally and unintentionally. The findings in this paper generalize those findings to a free-association task and suggest that the differential forgetting rates may be a useful way to distinguish performances on implicit and explicit conceptual tests of memory.

We argue that our results are consistent with a memory systems interpretation (Schacter & Tulving, 1994; Tulving & Schacter, 1990), wherein an episodic system supports memory on the explicit task and a semantic system on the implicit task. Our results satisfy the important criterion for concluding that separate memory systems underlie differences in performance, that of different properties of forgetting for postulated memory systems (Dosher & Rosedale, 1991; Nadel, 1994; Schacter & Tulving, 1994). This conclusion receives further support from, at least, four other studies (Culp & Rajaram, 1999; McDermott & Roediger, 1996; Mulligan, 1997; Weldon & Coyote, 1996; see also Goshen-Gottstein & Peres, 1998) that have succeeded in finding dissociative performance between implicit and explicit conceptual tests when applying the retrieval intentionality criterion (Schacter et al., 1989).

These ideas are further strengthened by the stochastic independence that has been obtained between implicit category exemplar generation and explicit recognition (Cabeza & Ohta, 1993). Finally, our interpretation of a systems account can easily accommodate the finding that amnesic patients show intact performance on implicit, but not on explicit, conceptual tests (e.g., Graf, Shimamura, & Squire, 1985; Keane et al., 1997; but see Blaxton, 1992; for reviews on the pattern of priming performance by memory-impaired patients, see Goshen-Gottstein, Moscovitch, & Melo, 2000; Moscovitch, Vriezen, & Goshen-Gottstein, 1993). This finding suggests that different neural mechanisms, which can be differentially damaged by neurological disease, mediate performance on implicit and explicit conceptual tests. We propose that our results document an important difference in the way that information may be processed by these two different underlying mechanisms.

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NOTES

1. Responses that were generated to cues that were *not* originally designated to elicit them turned out to be equally distributed in all conditions. Therefore, even under standard scoring procedures, the identical pattern of results was obtained.

2. To date, statistical comparisons of forgetting rates for different tests of memory are not common. To show a statistical difference between the slopes of the two tests as some function of time [e.g., log(time)], the overall regression equation—with an interaction vector containing the product of the vector that designates the type of test and the vector designating the time function [e.g., log(time)]—must be shown to account for significantly more variance than does the common regression equation (where the product vector is excluded). For a comprehensive treatment of this issue, see Pedhazur (1982, pp. 436–450).

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