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Classifying Implicit Memory Tests: Category Association and Anagram Solution

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In three experiments we investigated the nature of two implicit memory tests, free associating to category names and solving anagrams, by manipulating several variables during study. Additional implicit and explicit tests were included for comparison (word fragment completion and free recall). Primed category association responded like free recall by showing an advantage from generating words relative to reading them out of context, a levels of processing effect, and no effect of study modality (visual or auditory). The results of these variables on anagram solution were less clear cut, but tended to resemble the effects of primed word fragment completion (a modality effect, only a slight levels of processing effect, and little priming from pictures). Dissociations were obtained between explicit and implicit tests (e.g., free recall and primed fragment completion), but more importantly between implicit tests (e.g., primed fragment completion and category association). Because implicit tests can be dissociated, no single system underlies their performance; we emphasize instead their processing requirements to explain dissociations among tests.

Implicit memory tests are defined as tests that do not require conscious recollection of a prior study episode for their successful completion (Schacter, 1987); nevertheless, they show a benefit in performance from the previously studied episode. Although the conscious status of a subject during a test is arguable, the implicit nature of these tests is operationalized through instructions at testing (Gardiner, Dawson, & Sutton, 1989; Schacter, Bowers, & Booker, 1989). For example, on an implicit word fragment completion test, subjects are instructed to complete a word fragment such as d _ n _ e _ with the first response that comes to mind. Implicit memory is revealed to the extent subjects are more likely to complete the fragment with the word "donkey" after having studying the item than if they had not studied the item. Some examples of tasks considered implicit memory tests are completing word fragments, such as d _ n _ e _ (e.g., Tulving, Schacter, & Stark, 1982), completing word stems, such as don _____ (e.g., Graf, Squire, & Mandler, 1984), identifying briefly presented words (e.g., Jacoby & Dallas, 1981), or making word/nonword decisions to targets (e.g., Kirsner, Milech, & Standen, 1983). Explicit memory tests are presumed to require conscious recollection of a prior episode (Schacter, 1987). In explicit measures of memory, test instructions refer to a particular spatial or temporal context in a subject's personal history. Examples of these tests are the standard measures such as free recall, recognition, and cued recall.

The distinction between explicit and implicit memory tests is interesting because the two classes of tests exhibit different patterns of results as a function of certain

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independent and subject variables. For instance, compared to normals, amnesic patients show impaired performance on explicit memory tests, but their performance on implicit memory tests is equivalent to that of normals (e.g., Graf & Mandler, 1984). Also, study variables such as levels of processing that influence explicit memory tests in one way frequently do not affect implicit memory tests in the same way (e.g., Jacoby & Dallas, 1981).

These functional dissociations between explicit and implicit memory tests have led some researchers to conclude that they are tapping two different memory systems: one that is impaired in amnesia and another that is preserved in amnesia. Squire's (1986, 1987) theory is an exemplar of this view. He argues that dissociations between explicit and implicit memory tests are evidence for two different memory systems: the declarative and the procedural systems. The declarative system is responsible for conscious access to facts and past experiences and is necessary for performance on explicit memory tests. The procedural system records the processing operations of the system as they are modified by events, but not their explicit description. Procedural memory is revealed by performance on implicit tests. Similarly, Tulving (1985, 1987) discusses dissociations between explicit and implicit tests as evidence for multiple memory systems. According to him, explicit tests tap the episodic memory system, and implicit tests tap either the semantic or procedural memory systems.

An alternate view of these dissociations is based on the assumption that memory is revealed to the extent that processing operations at study and test overlap (the principle of transfer appropriate processing, Morris, Bransford, & Franks, 1977). By this view, dissociations between explicit and implicit memory tests occur because they typically require different modes or types of processing at test (Jacoby, 1988; Kolers & Roediger, 1984; Roediger, Weldon, & Challis, 1989b). Roediger et al. (1989b) proposed a transfer appropriate processing account of these dissociations based on four assumptions: (a) Memory tests benefit to the extent that operations required at test recapitulate operations required at study; (b) implicit and explicit memory tests typically require different retrieval operations, and consequently benefit from different types of processing during learning; (c) most implicit tests rely heavily on the match of perceptual features between learning and test episodes, or *data-driven processing;* and (d) most explicit tests require the encoded meaning of concepts for successful recollection, or *conceptually-driven processing.*

An important corollary to these assumptions is that explicit memory tests can depend on data-driven processing and implicit tests on conceptually-driven processing; there is no necessary correlation between the explicit-implicit distinction on the one hand, and the conceptually-driven data-driven distinction on the other. Also, the proposed distinction between data-driven and conceptually-driven tests is not intended as a dichotomy, but rather as representing end points on a continuum. Tests may involve both types of processes. Indeed, a more useful assumption is to describe two continua, one for each type of processing (Weldon, 1988), to acknowledge that these two modes of processing can be varied orthogonally (i.e., they need not trade off against one another, as implied if only a single continuum is postulated).

Data-driven and conceptually-driven processing are operationally defined by Roediger et al. (1989b) through study manipulations used by Jacoby (1983). Jacoby (1983) had subjects study words in one of three conditions. In the No Context condition subjects read words aloud without context (e.g., XXX-COLD), and the condition was assumed to involve maximal data-driven processing. That is, subjects must process the visual data, the given letters of the word, to read it aloud. In the Generate condition, subjects produced words from semantic clues (e.g., HOT-???), and this condition was assumed to involve maximal conceptually-driven processing, because no "data" were given to guide the bottom-up production of the target word. Instead, production of *cold* involved top-down, associative processes, because subjects had been told to produce opposites in the Generate condition. In the Context condition, subjects read words with the semantic clue (e.g., HOT-COLD); this condition assumed to involve both data-driven and conceptually-driven processing. Given these assumptions, a memory test can be classified as data-driven when better performance occurs in the No Context condition than in the Generate condition; it can be classified as conceptually-driven when performance is better in the Generate condition than in the No Context condition.

Roediger et al. (1989b) also suggested several converging operations in the classification of memory tests as conceptually-driven or data-driven. Briefly, data-driven tests should be more affected by changes in surface information between study and test, such as changes in modality (auditory or visual), symbolic form (pictures or words), or language for bilinguals (say, Spanish and English). On the other hand, they should be relatively immune to manipulations involving conceptual elaboration such as the levels of processing manipulation (Craik & Lockhart, 1972), forming images of words' referents (Paivio, 1986), organizing words into higher order units (Tulving, 1968), and other forms of elaborative processing that have large positive effects on conceptually-driven tasks such as free recall. Conversely, conceptually-driven tests should be little affected by manipulations of surface information (unless these manipulations also engender differences in conceptual processing; e.g., pictures vs. words), but should be strongly affected by manipulations of conceptual elaboration. Roediger et al. (1989b) discussed various explicit and implicit tests in terms of this classification.

The memory systems view and the transfer appropriate processing approach make differential predictions about the presence of functional dissociations among memory tests. The systems view implies that functional dissociations should not generally occur among explicit memory tests or among implicit memory tests, because they are presumably tapping the same memory system. The transfer appropriate processing view predicts dissociations among explicit tests or among implicit tests whenever they require different types of processing. Unfortunately, most of the research in the area has confounded the implicit/explicit nature of the test with the type of processing required by the tests (Roediger & Blaxton, 1987b). Typically, one explicit test (which usually requires conceptually-driven processing) is compared with one implicit test (which usually requires data-driven processing), and when a functional dissociation is found between the tests, different memory systems are postulated. In order to unconfound the two, one has to compare at least two explicit tests with different processing requirements, and two implicit tests with differing processing requirements.

The first such investigation was made by Blaxton (1985, 1989) who compared five memory tests in all—three explicit memory tests and two implicit memory tests. Two of the explicit tests were conceptually-driven tests (free recall and cued recall with semantic cues), and one of them was designed to be data-driven (cued recall with graphemic cues). Of the two implicit tests, one of them was data-driven (word fragment completion), and the other was designed to be conceptually-driven (answering general knowledge questions). Thus, if the word HEMLOCK was presented in the study phase, subjects were asked to recall all the studied words (free recall), to use the cue POISON to remember the studied word (semantic cued recall), to use the word HAMHOCK to remember the studied word (graphemic cued recall), to solve the fragment HE _ _ O _ K (word fragment completion), or to answer the question "What did Socrates drink at his execution?" (general knowledge). Performance on these tasks was compared as a function of whether words were studied in a Generate, Context, or No Context condition, as in Jacoby (1983).

Blaxton (1989, Experiment 1) found better performance in the Generate condition compared to the No Context condition on the conceptually-driven tasks (regardless of whether they were explicit or implicit), and better performance in the No Context compared to the Generate condition on the data-driven tasks (regardless of whether they were explicit or implicit). These data provide evidence favoring the transfer appropriate processing account over the memory systems account of functional dissociations; they suggest that functional dissociations occur when tests require different modes of processing, regardless of whether the tests are explicit or implicit. They also illustrate the critical need to compare several different memory tests to draw secure conclusions regarding dissociations.

The present experiments were designed as further tests of the transfer appropriate processing account and the memory systems account of functional dissociations among memory tests. They were also meant to test the predictions of the transfer appropriate processing approach with two seldom used implicit tests. Specifically, the aim in these experiments was to classify these tests according to their processing requirements using the converging operations described above.

Two implicit tests were selected for comparison, one appearing to depend on conceptually-driven processing (a category association test), and the other seeming to depend on data-driven processing (an anagram solution test). Briefly, the category association test requires the subject to free associate to a given category name (e.g., Articles of Furniture) for a specified time during the test phase. The measure of interest in this test is whether studying a low associate to the category name (e.g., *stool*) prior to the test will facilitate responding with the associate on the subsequent test relative to a nonstudied baseline. Gardner, Boller, Moreines, and Butters (1973) and Graf, Shimamura, and Squire (1985) have shown preserved priming in amnesics with this test. We thought that category association would likely require conceptually-driven processing, because there is no perceptual match between the studied item and the test cue, and performance on this test is guided by associative processes.

The anagram solution test requires the subject to unscramble letters strings in the test phase to form words (e.g., otosl for "stool"). The advantage or priming accruing from having studied the word on the solution of the anagram relative to a nonstudied baseline is the index of retention on this test. A priori, it was thought that anagram solution would require data-driven processing, since solution of the anagrams seems to depend on the match between the perceptual features at study and at test. Also, Jacoby and Dallas (1981) noted briefly that parallel effects were obtained between anagram solution and perceptual identification, although only the latter results were presented in their article. Performance on these tests was compared to performance on the word fragment completion test, which is an implicit test known to be largely data-driven (Blaxton, 1989; Roediger & Blaxton, 1987a).

Three experiments were conducted to compare performance on the three implicit measures. Experiment 1 was an attempt at classifying the tests using the operational definitions described previously for conceptually-driven and data-driven tests. Thus, in Experiment 1, we observed the effects of generating versus reading a word on test performance for the three implicit tests. Free recall was also included as a conceptually-driven explicit measure. Experiments 2 and 3 were attempts at obtaining converging operations in the classification of these tests. In Experiment 2, the modality in which a studied item was presented (auditory or visual), and the level of processing of the studied item (orientation to its meaning or its appearance) were varied. In Experiment 3, the effect of changing the symbolic form of the studied items (pictures or words) was observed for the word fragment completion and anagram solution tests.

Experiment 1

Method

Subjects

One hundred and fifty-two Purdue University undergraduates participated in the experiment in partial fulfillment of a course requirement.

Design

A 4 (Study Conditions: Generate, Context, No Context, or Nonstudied) × 4 (Test Conditions: Free Recall, Category Association, Word Fragment Completion, and Anagram Solution) mixed factorial design was used in the experiment. Study Conditions were varied within-subjects, while Test Conditions were varied between-subjects. For the free recall and word fragment completion tests, 32 subjects were assigned to each test, whereas 44 subjects received the category association and anagram solution tests.

Materials

The study and test stimuli were 40 category exemplars drawn from two different sets of category norms (Battig & Montague, 1969; Hunt & Hodge, 1971), such that each stimulus word was a category exemplar of a particular category. These stimuli were selected to be medium to low frequency associates of the category names. In order to minimize differences in solving the stimuli on the anagram solution task, words were selected from a narrow range of word length (4–7 letters). The complete set of materials appear in Appendix A.

In the Generate condition, sentence frames were used to guide the generation of 40 target words. In each case, a sentence context was prepared so that the target word could be completed by the subject at the end of the sentence (for e.g., "Heroin is related to c ________"). The sentence contexts were selected so that they specified only the critical word. No mention was made of the category to which the target word belonged. These materials were normed with 105 subjects in order to ensure that subjects generated the correct words 95% of the time. Four sets of 10 items each were then created by randomly assigning the items to each set. These sets were rotated through the four study conditions to create four study lists that completely counterbalanced conditions and materials across subjects. Thus, the same item (e.g., *thunder*) was presented in the three studied conditions as follows: (a) Generate: Lightning is associated with t ________. (b) Context: Lightning is associated with *thunder*. (c) No context: *thunder*. The fourth set of nonstudied words was used as a baseline measure for the implicit tests.

Test materials were prepared as follows for implicit memory tests. Word fragments were prepared by haphazardly deleting certain letters of the word; for instance, "thunder" was presented as t h _ _ _ e r. Most word fragments had one solution, but a few had more than one. All word fragments were presented in lowercase to encourage a perceptual match between the study and test conditions. These fragments were normed with 35 subjects so that the baseline rate of performance on the fragments was about 30%. Similarly, anagrams were prepared by haphazardly scrambling the letters of the word stimuli presented in the study phase. Thus, for instance, "thunder" was presented as "tderhun." Again, the anagrams usually had one solution, but some had more than one. Anagrams were presented in lowercase letters and they were also normed with 30 subjects so that baseline rates averaged about 30%. For the category association test, category names used at test were identical to the names used in the norms from which the critical words were drawn (Battig & Montague, 1969; Hunt & Hodge, 1971).

A set of 20 filler items and nine practice items were also constructed. These were transformed appropriately for each test (i.e., fragments, anagrams, or category names were presented).

Procedure

Subjects were tested individually. In the study phase, they were given a booklet that contained a mixed list of items from different conditions. They were instructed to read the critical target item, which was underlined, out loud in each of the three conditions. Depending on the study condition, subjects either completed the sentence with the target word (Generate condition), or read the underlined word in a sentence (Context condition) or read the word in isolation (No Context condition). In rare cases when subjects failed to generate a target item correctly, the experimenter said the correct response.

Subjects were instructed to pay attention to the words that they read aloud. They were told that they might be given a memory test later, but the nature of the memory test was left unspecified. A signal recorded on tape was used to pace the subjects through the study task at 12 s/item. A cover sheet was also used to ensure that subjects spent an equal amount of time on each item.

Following the study phase, subjects were given two filler tasks. For the first 5 min, subjects wrote down the names of all U.S. presidents they could remember, and for the next 5 min, subjects wrote down the names of U.S. state capitals.

In the test phase, subjects received either a free recall test, a category association test, a word fragment completion test, or an anagram solution test, depending on the group to which they had been assigned. In all four test conditions, the variable of interest was the proportion of items correctly recalled, produced, completed, or solved, respectively, as a function of study condition. Each test procedure will be described briefly.

In the free recall test, subjects were asked to recall the studied words on a blank sheet of paper for 7 min. For all the implicit memory tests, the cover story used was that the experimenter was interested in developing some materials for a future study. In the category association test, subjects were told that they would be presented with category names, and they had to name all the things belonging to that category within the given time limit. (This was similar to the presidents and capitals tasks). The category names were presented on an IBM computer screen for a period of 30 s. Subjects' responses were recorded on a tape recorder. The experimenter also discreetly recorded the critical words that the subject produced.

In the word fragment completion test, subjects were asked to complete fragments of words that were presented on an IBM computer. Each word fragment was displayed on the screen for 30 s or until the subject responded. Subjects completed the fragments verbally. Voice keys were not used to record the latencies to complete word fragments (or anagrams), because subjects tended to verbalize while solving anagrams or word fragments. Experimenters were trained to hit a key as soon as the subject responded, and latencies for responses were recorded in ms on the computer. The solution words given by the subjects were also recorded on the computer by the experimenter. Nine practice trials were given before starting the actual test. Following the practice session, 60 word fragments were presented to the subjects and the ratio of studied words to nonstudied words was 1:1. The procedure used for the anagram solution test was the same as the procedure used for the word fragment completion test, except that subjects saw anagrams on the IBM computer screen and tried to solve them verbally. The latencies to respond for each item, as well as the solution words given by the subjects, were recorded on the computer by the experimenter.

Results and Discussion

Because different memory tests typically have different baselines that complicate the interpretation of cross-test comparisons, the results for the four different memory tests (free recall, word fragment completion, anagram solution, and category association) will be discussed in different sections. Performance on different tests is compared in a final section. The overall results of Experiment 1 are summarized in Table 1, which displays the proportion of target words correctly produced as a function of the different study conditions on each of the four tests. Due to missing observations in the response time data for the word fragment completion and the anagram solution tests, the response time results for these tests are not presented here. The data, however, paralleled the results with proportion correct as the dependent measure. The level of significance for all the results reported in this paper was set at .05.

Free recall. Words studied in the Generate condition were free recalled better than words studied in the No Context (12% difference) or Context conditions (23% difference), and words studied in the No Context condition were recalled better than words studied in Context condition (11% difference). A repeated measures ANOVA confirmed these observations, with a significant main effect of study condition, $F(2,62) = 22.89$, $MSe = .02$, and the least significant difference (LSD) for comparisons between means of .07.

The finding of better performance in the Generate condition compared to the No Context condition is consistent with results from previous experiments (e.g., Blaxton, 1989; Smith & Branscombe, 1988). However, unlike other findings (e.g., Jacoby, 1983), the results suggest that subjects were significantly better at recalling words that were studied without context (.32) than they were at recalling words studied in context (.21). A suggestion of this same pattern occurred in Blaxton's (1989) free recall results, but her 3% difference between the Context and No Context conditions was not significant. This anomalous finding is probably due to the nature of the generation materials used in this study. The target words in the Context condition were embedded in sentences, and thus may have been less salient than words in the No Context condition. Alternatively, items studied in the Context condition may suffer input interference from the study of more material. Because other studies using sentences to evoke generation of items did not include a No Context condition (e.g., Kane & Anderson, 1978), comparison of findings across studies is hazardous. Whatever the reason for the inferiority of the Context to No Context condition, the advantage of the Generate over No Context condition appears even more impressive, because the process of generation overcame the inhibition (from input interference or whatever) engendered by items appearing in a sentence context. .

This advantage in free recall confirms, with the present materials, that free recall is a conceptually-driven test. Now we may

TABLE 1
PROPORTION OF RESPONSES CORRECTLY PRODUCED OR SOLVED AS A FUNCTION OF STUDY AND TEST TYPE IN EXPERIMENT 1

	Study condition			
Test type	Generate	Context	No context	Nonstudied
Free recall	0.44	0.21	0.32	—
Category association	0.33	0.25	0.23	0.16
Word fragment completion	0.35	0.41	0.45	0.21
Anagram solution	0.57	0.58	0.62	0.49

ask if category association is also a conceptually-driven test, in which case we should find the same pattern of results with this test (i.e., superior performance in the Generate condition to that in the No Context condition).

Category association. Results showed that words studied in the Generate, Context, and No Context conditions were produced more often on the category association test than were the Nonstudied words (17, 9, and 7%, respectively). As in free recall, words studied in the Generate condition were produced more often than those in the Context (an 8% advantage) and No Context (10%) conditions. However, on this test, the difference between the Context and No Context tests was not significant.

Repeated measures ANOVA revealed a significant main effect of Study condition, $F(3,129) = 8.16$, $MSe = .02$. The LSD for comparisons between means was .07. The advantage of Generate to No Context conditions in the category association test indicates that it is also a conceptually-driven task.

Word fragment completion. Data for the word fragment completion test indicated significant priming effects on the Generate, Context, and No Context conditions (14, 20, and 24%, respectively). Compared to the free recall and category association tests, the pattern on this test was reversed so that subjects were better at solving word fragments when they had read the words without context compared to when they had generated them (a 10% difference). An ANOVA revealed a significant main effect of study condition, $F(3,93) = 9.00$, $MSe = .04$, and LSD for comparisons between means was .10.

The advantage of No Context to Generate conditions suggests that word fragment completion is largely a data-driven test, and this is consistent with earlier findings (e.g., Blaxton, 1989; Smith & Branscombe, 1988). However, the fact that significant priming also occurred in the Generate condition implicates a lexical or semantic component, too (Weldon, 1988).

Anagram solution. The results showed priming effects on the Generate, Context, and No Context conditions (8, 9, and 13%, respectively) with a 5% advantage of No Context to the Generate condition. Repeated measures ANOVA indicated a main effect of study condition, $F(3,129) = 6.14$, $MSe = .02$. The LSD for comparisons between means was .07.

The critical comparison between the No Context and Generate conditions (although in the predicted direction) was not significant, despite having more observations on this test than on the word fragment completion test (440 observations as opposed to 320). Although these data are suggestive, they do not permit us to conclude that the anagram solution test is data-driven.

Comparison of measures. To determine whether performance on study conditions was a function of the type of test, an ANOVA was performed with study condition as a within-subjects factor, and test as a between-subjects factor. The critical Test $\times$ Study interaction was significant, $F(3,450) = 12.98$, $MSe = .03$, suggesting that four different tests showed different patterns of results across the study conditions.

To examine these different patterns, separate Study $\times$ Test interactions were performed for each combination of the three implicit tests (free recall was not included because there is no nonstudied baseline measure in free recall). The Study $\times$ Test interaction with word fragment completion and anagram solution tests was not significant, $F(3,222) = 1.48$, MSe $= .03$. This suggests that both anagram solution and word fragment completion show similar patterns of results across the study conditions, which would be expected if both tasks require data-driven processing. The Study $\times$ Test interaction with the category association and the anagram solution tasks was significant, $F(3,258) = 2.98$, $MSe = .02$. Despite the fact that both are implicit tests, the data reveal a functional dissociation between category association and anagram solution. Finally, the Study × Test interaction between the word fragment completion and category association tests was also significant, $F(3,222) = 5.00$, MSe $= .03$, indicating another functional dissociation between two implicit tests.

The finding of dissociations between implicit measures of memory tends to undermine the argument that dissociations between explicit and implicit measures necessarily imply the existence of different memory systems, if one assumes that a single system underlies performance on all implicit tests (Roediger, Srinivas & Weldon, 1989a). On the other hand, the results of Experiment 1, in general, support the processing view of dissociations between explicit and implicit memory tests. The category association test showed a different pattern of results from the anagram solution or word fragment completion tasks because it required conceptually-driven processing whereas the other two (especially word fragment completion) were data-driven.

Although findings in Experiment 1 are broadly consistent with the transfer appropriate processing approach, one problem emerged. Performance on the anagram solution test showed a data-driven pattern (No Context > Generate), but the difference was not significant. Experiment 2 was designed to explore further the nature of the two new implicit memory tests.

EXPERIMENT 2

In Experiment 2 we employed the levels of processing and modality manipulations to provide converging evidence for the conclusions drawn from Experiment 1. Experiment 2 was also aimed at resolving the nature of the anagram solution test, because unambiguous classification of the test as either data-driven or conceptually-driven was not possible based on the results of Experiment 1.

The Roediger et al. (1989a) approach predicts that the level of processing during study will affect test performance on conceptually-driven tests, because the typical levels of processing manipulation involves conceptual elaboration, while holding constant the display of data. On the other hand, the modality of presentation of the study material should affect performance on data-driven tests, because variation in modality affects the perception of data, but not their conceptual elaboration. From the findings in Experiment 1, one might predict that the levels of processing manipulation will affect performance on the category association test, but that the modality manipulation will not. If these predictions are fulfilled, the results will provide converging evidence suggesting that the category association test is conceptually-driven. On the other hand, if anagram solution is a data-driven task, modality of presentation, but not levels of processing, should affect performance. If anagram solution responds to both types of processing, as the results of Experiment 1 seem to indicate, then one might see slight effects of both modality and levels of processing, because anagram solution may reflect a mixture of the two processes. Finally, for purposes of validation, the word fragment completion test was also included. In accordance with previous findings, performance on this test should be little affected by the levels of processing manipulation (e.g., Roediger, Weldon, & Stadler, 1987; but see Squire, Shimamura, & Graf, 1987), but should be affected by the modality of presentation (Blaxton, 1989; Roediger & Blaxton, 1987a).

Method

Subjects

One hundred Purdue University undergraduates and 50 Rice University undergraduates participated in the experiment in partial fulfillment of a course requirement. The Rice subjects were all assigned to the word fragment completion condition, as this group was tested last. Thus, comparison between this group and the other two must be viewed with caution.

Design

Four of the five within-subjects study conditions used in the experiment were obtained by crossing levels of processing (semantic or physical orienting task) with the modality of presentation (auditory or visual). A fifth condition—a group of nonstudied items—was included to provide a baseline measure. Items processed in different ways were presented in two blocks. Thus, half of the subjects first processed the words for meaning in the semantic orienting task, whereas the other half performed the physical orienting task first. Finally, test type was varied between-subjects, so that subjects were given either the word fragment completion test, the category association test, or the anagram solution test.

Materials

The materials for this experiment were drawn from the same norms as those of Experiment 1. However, 60 new category exemplars were selected so that they were each 7 letters in length to help equate the difficulty of items on the anagram solution test. The materials were again chosen to be low frequency associates of the category names. A complete set of the materials appears in Appendix B.

Twelve items were randomly assigned to five different sets, and these were rotated through all the study conditions. This resulted in five different study lists for complete counterbalancing. In addition, because the order of the orienting task was varied, 10 different study lists were created.

Procedure

Subjects were tested in small groups of 3–7 subjects, with a total of 50 subjects assigned to each of the three test conditions. In the study phase, subjects were required to read and hear a set of 48 target words. For each block of 24 items, subjects were given different instructions. For the semantic orienting task, subjects were told to think about the meaning of the word that they saw or heard, and rate it along a scale of pleasantness that ranged from 1 (very unpleasant) to 7 (very pleasant). The task was demonstrated with an example. For the physical orienting task, subjects were told to count the number of consonants that the word contained, and were asked to circle the appropriate number on the sheet that contained numbers from 1 to 7. Thus, in either task the nature of the overt response was the same.

Within each block, items were presented visually via slide projector for a period of 6 s each, or read aloud by an experimenter twice during a 6-s period. The second presentation in the auditory condition was intended to help fill the 6-s interval, to minimize the difference from the visual condition in which the word was presented throughout the period.

Following the study phase, the experimenter gave instructions for the test phase for about 2 min. Subjects were told that in the upcoming phase of the experiment, they would help researchers develop materials for a future study. Subjects were given test booklets that either contained a set of 70 word fragments, 70 category names, or 70 anagrams, in each case 60 target items (48 studied, 12 not studied) and 10 filler items. Thus, the ratio of studied items to nonstudied items was 48:22 for all three tests. Subjects were given 30 s for each item in the test booklet. Depending on the task, they were required to solve either the word fragment or anagram as quickly as possible, or to write down as many exemplars to the category name as possible. The data were then scored for the proportion of correct responses produced on the test as a function of the study condition.

Results and Discussion

An overview of the results of Experiment 2 is presented in Table 2, which shows the proportion of responses correctly produced or solved on the category association, word fragment completion, and anagram solution tests as a function of study condition. As before, the findings for the three tests will be discussed in separate sections, followed by a section comparing the three measures.

Results from the ANOVA indicated that for all three tests, there was no effect of Order of Presentation of the two blocks at study, and there was no interaction between this variable and the study condition. Therefore, the data were collapsed across the two blocks for presentation in Table 2.

Category association test. Results indicated priming effects on the semantic orienting task for the visual and auditory study conditions (14 and 13%, respectively). There was relatively little priming on the physical orienting task for both visual and auditory conditions (2 and 3%, respectively) so that performance on the semantic tasks was, on average, 11% better than performance on the physical tasks. The two semantic and the two physical conditions did not differ from each other. These observations were confirmed by a significant effect of Study condition, $F(4,192) = 14.24$, $MSe = .02$, in a repeated measures ANOVA; LSD for comparisons between the means was .05. In a 2 × 2 ANOVA excluding the Nonstudied condition, we found a significant effect of levels of processing, $F(1,49) = 29.73$, $MSe = .02$, but no effect of modality of presentation, $F(1,49) < 1$. The interaction was also not significant, $F(1,147) < 1$.

The overall pattern suggests that category association is affected by manipulations involving conceptual elaboration (levels of processing), but is relatively insensitive to changes in surface features between study and test (modality). In conjunction with the results of Experiment 1, these data provide converging evidence that category association is a conceptually-driven test.

Anagram solution test. Comparisons between the means indicated priming effects in the Visual-Semantic, Auditory-Semantic, Visual-Physical, and Auditory-Physical conditions (26, 18, 16, and 20%, respectively). Surprisingly, performance on the Visual-Semantic condition was better than performance in all other conditions. Repeated measures ANOVA revealed a significant main effect of study condition, $F(4,192) = 24.21$, MSe = .02. The LSD for comparisons between means was .05, so significant priming was observed in all four study conditions relative to the nonstudied baseline. A 2 × 2 ANOVA (excluding the Nonstudied condition) revealed no effect of modality of presentation, $F(1,49) = 1.05$, $MSe = .01$, because the effects were in opposite directions for the semantic and physical orienting tasks. In the semantic orienting task, visual presentation was superior to auditory presentation (8% difference), but a nonsignificant reverse trend appeared in the physical orienting task. Put differently, there was a levels of processing effect (10%) for visual items, but none for auditory items. This pattern led to a significant interaction between the Levels of Processing × Modality of presentation,

TABLE 2

PROPORTION OF RESPONSES CORRECTLY PRODUCED OR SOLVED AS A FUNCTION OF STUDY CONDITION OR TEST TYPE IN EXPERIMENT 2

	Study condition				
	Semantic orienting task		Physical orienting task		
Test type	Visual	Auditory	Visual	Auditory	Nonstudied
Category association	0.37	0.36	0.25	0.26	0.23
Anagram solution	0.60	0.52	0.50	0.54	0.34
Word fragment completion	0.34	0.24	0.26	0.22	0.13

$F(1,147) = 5.54$, MSe = .02. The main effect of levels of processing also showed a marginally significant trend, $F(1,49) = 3.28$, MSe = .02 ($p < .10$).

As in Experiment 1, the results of the anagram solution test were ambiguous in attempting to determine the data-driven or conceptually-driven nature of the test.

Word Fragment Completion Test. Because the anagram solution results were puzzling, we tested a third group with the word fragment completion test. We wanted to see if we could confirm past results of no levels of processing effect (Roediger et al., 1987) and a modality effect (Roediger & Blaxton, 1987a) in word fragment completion with these materials. Although the additional group was tested at Rice rather than at Purdue (the source of the first two groups), we were primarily interested in the priming effects from the study conditions relative to their own nonstudied baseline condition rather than in comparisons between groups.

Results indicated significant priming effects in the Visual-Semantic, Auditory-Semantic, Visual-Physical, and Auditory-Physical conditions (21, 11, 13, and 9%, respectively). As in anagram solution, performance on the Visual-Semantic condition was better than on all other conditions. There was also a slight difference favoring the Visual-Shallow condition over the Auditory-Shallow conditions (4%).

Analysis of variance indicated a significant effect of Study condition, $F(4,192) = 16.85$, $MSe = .02$. The LSD for comparisons between means was .05. In a further 2 × 2 ANOVA, there was a significant Modality effect, $F(1,49) = 11.12$, $MSe = .02$, a significant Levels of Processing effect, $F(1,49) = 4.72$, $MSe = .02$, and a marginally significant interaction between these variables, $F(1,49) = 2.84$, $MSe = .01$, $p < .10$.

As in the anagram solution results, the modality effect was greater in the deep than in the shallow processing condition. Stated alternatively, the levels of processing effect appeared mostly under conditions of visual presentation.

Although the modality effect was expected on the basis of the transfer appropriate processing approach, the levels of processing effect was not, nor was the interaction of these variables. Although Squire et al. (1987) reported a levels of processing effect in primed fragment completion, work in our lab had not done so under conditions similar to those in Experiment 2 (Roediger et al., 1987). Experiment 3 was conducted, in part, to gain further evidence on these matters.

Comparison of measures. To investigate dissociations in performance among the three implicit memory measures, a repeated measures ANOVA was conducted with Study condition as the within-subjects variable, and Test type as the between-subjects variable. Results indicated a significant interaction between Study Condition and Test Type for the three tests, $F(8,584) = 4.23$, $MSe = .02$. Separate analyses for each pair of tests indicated significant interactions between Study condition and Test type for the category association test and the anagram solution test, $F(4,388) = 6.18$, $MSe = .02$, and for the category association test and the word fragment completion test, $F(4,388) = 4.27$, $MSe = .02$. The comparable interaction between the anagram solution and word fragment completion tests was marginally significant, $F(4,388) = 2.26$, $MSe = .02$, $p < .10$, reflecting the opposite trends found on the two tests for the physical orienting task.

To summarize the results of Experiment 2, the pattern of findings with the category association test supported the conclusion of Experiment 1, viz., category association is a conceptually-driven test. However, the findings for the word fragment completion, and, to a lesser extent, the anagram solution test, were inconsistent with the transfer appropriate processing framework. For both tests, the predicted modality effect (Visual > Auditory) occurred when the items were processed for meaning, but failed to occur when items were processed for physical features. Stated another way, a levels of processing effect occurred in both tasks for items presented visually, but not for items presented auditorily. Since these findings were inconsistent with our previous results obtained with the word fragment completion test (e.g., Roediger et al., 1987), we decided to attempt a replication of these findings in Experiment 3 with different materials and a different orienting task.

EXPERIMENT 3

One purpose of Experiment 3 was to attempt a replication of Experiment 2, but another was to provide an additional converging operation in attempting to classify anagram solution and word fragment completion as implicit memory tests. To this end, we manipulated the symbolic form of the studied items (pictures or words). According to the criteria specified by Roediger et al. (1989), data-driven tests should show greater priming when study and test items share the same symbolic form (e.g., study of words, a test involving their fragmented forms) than when they do not (study of pictures, a test involving fragmented words representing the names of the pictures). Weldon and Roediger (1987) provided direct evidence for this assumption of greater primed word fragment completion following study of words than of pictures.

Experiment 3 was an attempt to extend this logic to the anagram solution test. If anagram solution is data-driven, greater priming should occur from prior presentation of words than from pictures, since anagrams and words share the same symbolic form. On the other hand, if anagram solution is conceptually-driven, it should show greater priming from pictures than from words, since most conceptually-driven tests (e.g., free recall, recognition) show a picture superiority effect (e.g., Madigan, 1983).

The conditions of Experiment 3 in which subjects studied words permitted a conceptual replication of the results of Experiment 2, because we included both the levels of processing and study modality (visual and auditory) manipulations, too. One change between Experiments 2 and 3 was in the nature of the shallow processing task. In this experiment we required subjects to count the number of syllables in the words rather than the number of consonants, because we thought this is a more manageable task for the subjects studying pictures and hearing the words. We omitted the category association test from Experiment 3 because prior results showed it to be a conceptually-driven test and because we were unable to produce a set of materials that satisfied the joint criteria of being low frequency associates in an appropriate category and being represented by a picture that could be easily named.

Method

Subjects

Eighty-four Rice University undergraduates participated in the experiment in partial fulfillment of a course requirement.

Design

Six of the seven study conditions used in the experiment were obtained by crossing levels of processing (semantic or physical orienting task) with the type of material presented at study (pictures, auditory words, or visual words). A seventh, nonstudied, condition was included to provide a baseline measure. Items representing each condition were presented in blocks to subjects. The order in which the seven study conditions were presented to subjects was counterbalanced, requiring 14 study lists. Test type was varied between-subjects, so 42 subjects were given either the word fragment completion test or the anagram solution test.

Materials

One hundred and five new picture-word pairs were selected from the Snodgrass and

Vanderwart (1980) norms and the materials used by Weldon and Roediger (1987). The stimuli were selected so that name agreement among subjects for the pictures was between 88 and 100%. The materials were also selected so that the words were between 5–9 letters, in an attempt to minimize variability on the anagram solution test. A complete set of materials appears in Appendix C. Sets of 15 items were assigned to each of the seven study conditions, and the sets were rotated across conditions so that each item appeared equally often in every condition.

Procedure

Subjects were tested in groups of 2–3 people. In the study phase, subjects were given a set of 90 target items, 45 processed for meaning and 45 for physical features. In the semantic orienting task, subjects were asked to rate the target items for the pleasantness of the concept represented by the picture or word along a scale that ranged from 1–7. In the physical orienting task, subjects were asked to judge the number of syllables in the target item, and mark the number on a scale that ranged from 1–7. When the targets were pictures, subjects were asked to think of the word that corresponded to the picture, and to count the number of syllables in the word. Subjects alternated between the two tasks for blocks of 15 items, depending on the counterbalancing order. Each block of 15 items was preceded by appropriate instructions. Each target item was presented for a period of 6 s. Pictures were presented via a slide projector. Words in the visual conditions were presented on a computer screen, and words in the auditory conditions were presented on tape twice during the 6-s period.

After the study phase, subjects were instructed for about 2 min and told that the experimenters were developing materials for a future study. Subjects were given brief descriptions of one of the two "puzzle-solving" tasks, and were instructed to solve the word fragments or anagrams with the first response that came to mind. One hundred and fifty fragments or anagrams (90 studied items, 15 "baseline" items, and 35 fillers) were presented on a computer to the subject. The fillers were drawn from the same norms as the target words. Twenty of the filler items appeared at the beginning of the test phase to encourage an implicit retrieval orientation, and the other 15 were interspersed among the targets. Each item was displayed on a screen for 15 s or until the subject hit a key to enter the correct response. The computer recorded the accuracy of the response, as well as the response times for each item.

Results and Discussion

Table 3 contains a summary of the results of Experiment 3. The proportion of correct responses and the mean solution times in each study condition are presented for the word fragment completion and the anagram solution tests. Again, a discussion of the two tests will follow in separate sections.

TABLE 3

PROPORTION OF RESPONSES CORRECTLY SOLVED AND SOLUTION TIMES (IN S) AS A FUNCTION OF STUDY CONDITION AND TEST TYPE IN EXPERIMENT 3

	Study condition						
	Semantic orienting task			Physical orienting task			
Test type	Pictures	Visual	Auditory	Pictures	Visual	Auditory	Nonstudied
Word fragment completion	0.43	0.59	0.51	0.50	0.61	0.52	0.43
	(3.1)[a]	(2.7)	(3.3)	(3.5)	(2.9)	(3.5)	(3.6)
Anagram solution	0.57	0.70	0.65	0.59	0.67	0.61	0.56
	(5.3)	(4.1)	(4.7)	(4.8)	(3.9)	(4.4)	(5.1)

[a] Numbers in parentheses refer to solution times.

Word fragment completion test. The results in Table 3 show a pattern revealing a data-driven test. Visual presentation of words provided greater priming than did auditory presentation for the semantic orienting task (8% difference with proportion correct, 0.6 s with solution time) and for the physical orienting task (9% and 0.6 s). No levels of processing effect occurred in the either the visual or the auditory conditions. Pictures produced slight priming effects but they were inconsistent across the two dependent measures.

We first analyzed the results by a one-factor, repeated analysis of variance. The main effect of study condition was significant both with proportion correct, $F(6,246) = 16.17$, $MSe = .01$, and solution time, $F(6,246) = 2.75$, $MSe = 1.76$, as the dependent measures. The LSD for comparison between means was .05 with proportion correct, and .6 with solution time, substantiating the patterns described in the above paragraph. In addition, we also conducted a repeated measures ANOVA for verbal items alone (excluding the picture study conditions and the nonstudied condition), to aid comparison to the results of Experiment 2. With proportion correct as the dependent measure, the results indicated a significant modality effect, $F(1,41) = 22.47$, $MSe = .01$, but neither the levels of processing effect nor the interaction was significant ($F < 1$). Similar results were obtained with solution time as the dependent measure, with only a significant modality effect, $F(1,41) = 13.60$, $MSe = 1.14$.

The results of the word fragment completion test in Experiment 3 were consistent with most previous findings in that we found modality effects at both levels of processing, no levels of processing effects with words presented either visually or auditorily, and little priming from pictures (Blaxton, 1989; Roediger & Blaxton, 1987a; Roediger et al., 1987). Because these findings agree with most earlier work on this test, the curious finding in Experiment 2 (depressed performance on the Visual-Physical condition relative to the Visual-Semantic condition) may not be reliable. Alternatively, because others have also occasionally noted a small levels of processing effect in primed word fragment completion (Squire et al., 1987), the effect may sometimes occur for unknown reasons. Whatever the cause of the findings in Experiment 2, the results of Experiment 3 are consistent with transfer appropriate processing framework. Now we may ask whether performance on the anagram solution test would show similar trends, which would similarly suggest that it is data-driven.

Anagram solution test. The trend in the anagram solution results was, once again, not clear cut. A modality effect appeared, with priming greater for visually presented words in both the semantic (5% difference with proportion correct, 0.6 s with solution time) and physical (6% and 0.5 s) orienting tasks. With proportion correct as the dependent measure, a small levels of processing effect was obtained with verbal materials; greater priming occurred for items processed meaningfully (3 and 4% for words read and heard, respectively, during study). However, with solution time as the dependent measure, there was a slight trend favoring the physical over the meaningful orienting conditions. Finally, presentation of pictures produced no reliable priming in either encoding condition, though a slight trend favored the physical over the meaningful orienting condition.

A one-factor, repeated ANOVA revealed a significant effect of study condition with proportion correct as the dependent measure, $F(6,246) = 7.16$, $MSe = .02$, and with solution time as the dependent measure, $F(6,246) = 7.61$, $MSe = 1.36$. The LSD for the comparison between means was .06 for proportion correct, and .5 s for solution time. Again, a repeated ANOVA was conducted for the verbal items alone, to aid comparisons between Experiments 2 and 3. With proportion correct as the dependent measure, results revealed a significant modality effect, $F(1,41) = 5.50$, $MSe = .02$, and a significant levels of processing effect, $F(1,41) = 4.74$, $MSe = .01$, but the interaction between the two was not significant, $F < 1$. With solution time as the dependent measure, only the modality effect was significant, $F(1,41) = 11.79$, $MSe = 1.04$.

These data suggest that anagram solution is largely data-driven (a modality effect, and little priming from pictures), although it may have a small conceptually-driven component (the slight levels of processing effect).

Comparison of measures. To investigate dissociations between the two implicit memory measures in this experiment, a 7 × 2 repeated measures analysis of variance was conducted with study condition as a within-subject variable, and type of test (anagram solution or word fragment completion) as the between-subjects measure. The interaction between Study condition and Test Type was not significant with proportion correct as the dependent measure, $F(6,492) = 1.46$, $MSe = .02$, suggesting that performance on the different study conditions did not differ reliably as a function of the test in question. With solution time as the dependent measure, the interaction was marginally significant, $F(6,492) = 2.06$, $MSe = 1.6$, $p < .10$, probably reflecting slight differences between the two tasks in the picture conditions. In word fragment completion, a slight difference was found favoring the condition where pictures were rated meaningfully (0.4 s), while in anagram solution, the difference favored pictures rated for physical features (0.5 s). Overall, the data suggest that word fragment completion and anagram solution share a data-driven component, but anagram solution may include a stronger conceptually-driven component as well.

General Discussion

The primary purpose of the present experiments was to classify two interesting, but little investigated, memory tests by observing how they responded to manipulation of variables that have well-documented effects on other tasks. Another implicit test that has been more extensively studied, word fragment completion, was included for comparison purposes (as was an explicit test, free recall, in Experiment 1). We will consider implications of the results for each of the implicit tests and then turn to the matter of accounting for dissociations among tests.

Associating to category names. The effects of the manipulated variables on priming of words in associating to category names were clear cut and produced a pattern indicative of a conceptually-driven test (as specified by Roediger et al., 1989). In Experiment 1, generating words from conceptual cues produced greater priming than did reading words with no semantic context. In Experiment 2, rating words for pleasantness produced greater priming than did counting their letters, but the modality of presentation produced no differential effect on priming. Because conceptual factors (generating versus reading, levels of processing) affected priming, whereas a surface manipulation (modality of presentation) did not, primed category association may be regarded as conceptually-driven.

Because the pattern of results in the category association test is similar to that seen in free recall as a function of the same variables, one may question our assumption that the category association test is truly implicit. In defense of our assumption, we used test instructions like those in other implicit tests such as word fragment completion and perceptual identification, which is the critical feature in defining implicit tests (see Gardiner et al., 1989 and Schacter, et al., 1989 for the reasoning behind this assumption). In addition, recent evidence produced by Hamann (1989) shows that three densely amnesic patients, who by definition are incapable of using explicit memory, show priming on the category association test, and also show a levels of processing effect. For these reasons, it seems reasonable to classify category association as an implicit test.

Word fragment completion. We included word fragment completion as an implicit test to verify that a data-driven pattern of performance could be obtained with the current set of materials. In general, our expectations based on past work (e.g., Blaxton, 1989; Roediger & Blaxton, 1987a,b) were confirmed. In Experiment 1, reading words out of context produced more priming than did generating words from conceptual cues.

The results of Experiment 3 showed a modality effect (visual presentation produced more priming than did auditory presentation), no levels of processing effect, and little or no priming from prior presentation of pictures. The results of Experiment 2 were partially inconsistent with the general picture emerging from the other two experiments, as well as with much of the literature. A modality effect appeared when words were processed for meaning during study and a levels of processing effect occurred for visually presented items. We have no good account for the discrepant findings of Experiment 2; from our perspective, the amount of priming in the Visual Shallow condition was "too low" by about 10%. We simply note that this anomaly did not occur in Experiment 3, nor did it appear in the Roediger et al. (1987) experiment. Thus we continue to regard primed word fragment completion as largely, but not exclusively, data-driven. However, the matter probably deserves further study, because others have also reported a levels of processing effect in primed fragment completion (Squire et al., 1987).

Anagram solution. The results of the anagram solution task showed a mixed pattern, sometimes seeming data-driven, and at other times conceptually-driven. We had expected that the task would be data-driven, largely on the basis of Jacoby and Dallas' (1981) mention of obtaining similar effects in anagram solution as in perceptual identification. In Experiment 1, reading words without context did produce slightly, but not significantly, more priming than did generating them from conceptual cues. The anagram solution results of Experiment 2 were puzzling, as they were too for word fragment completion. A modality effect occurred, but only under the semantic orienting condition. (Alternatively, a levels of processing effect occurred when words were presented visually, but not auditorily.) Unlike the case with word fragment completion, Experiment 3 did not resolve the puzzles raised in Experiment 2 but reinforced them. Following study of words, subjects taking the anagram solution test showed both a levels of processing effect (albeit small) and a modality effect. Presentation of pictures also led to no reliable priming effects in either orienting task. The safest conclusion seems to be that primed anagram solution involves a mixture of data-driven and conceptually-driven processing, at least under the conditions employed in our experiments.

Why did primed anagram solution appear as, at best, weakly data-driven, contrary to our expectation and Jacoby and Dallas' (1981) findings? One possibility lies in our construction of anagrams, which were random rearrangements of the letters in a word. As the examples in the appendices show, this procedure serves to make the appearance of the anagram quite different from the word. Jacoby (personal communication) notes that the anagrams used in the Jacoby and Dallas (1981) experiments were formed from shorter words and were not random arrangements of the letters. Perhaps the perceptual operations used in untangling bizarre letter strings such as in our experiments bear little resemblance to those involved in perceiving the words, hence accounting for the weak effects of data-driving variables. The similarity of encoding operations between study and test presentations is likely to be much greater from prior study of a word to its identification from a brief display (Jacoby, 1983) or to its completion in fragmented form (Blaxton, 1989). Perhaps if anagrams were constructed that bore more resemblance to the word (for example, keeping the first and last letters the same), perceptual operations in decoding the anagram would resemble those in perceiving the word and evidence for data-driven processing would be more robust. These matters await further investigation.

Dissociations between tests. The present results reveal dissociations between explicit and implicit tests of memory, adding to a growing list (Richardson-Klavehn & Bjork, 1988; Schacter, 1987). For example, the variables in Experiment 1 dissociated free recall from (a) primed word fragment completion and (b) primed anagram solution. The usual interpretation of such findings is that the dissociated tests are tapping different memory systems. Free recall might be tapping episodic memory and primed fragment completion the "traceless quasi-memory system" (Hayman & Tulving, 1989); or free recall might tap declarative memory and primed fragment completion procedural memory (Squire, 1986).

Researchers proposing these typologies, and others, typically perform experiments in which a single test tapping each system is examined as a function of certain independent variables. If these variables reveal dissociations, the result is interpreted as support for the putative systems. This approach assumes, at least by omission, that dissociations cannot be found between tests tapping the same system. Results of the experiments reported here, in agreement with other work (Blaxton, 1989; Weldon & Roediger, 1987), show that this is not so. For example, in Experiments 1 and 2 primed category association was dissociated from primed word fragment completion and from primed anagram solution. Also, primed anagram solution showed a slightly different pattern of results from word fragment completion as function of certain study variables (e.g., levels of processing, reading versus generating target words). If a single system underlies performance on all three priming tasks, such dissociations would not be expected. Roediger et al. (1989a) review extant knowledge about dissociations between implicit tests and their implications.

Dissociations between implicit tests are inconsistent with the memory systems view only if a single system is assumed to underlie performance on all implicit tests. Recently, Schacter (in press) and Tulving and Schacter (1990) have proposed that distinct memory systems produce priming on implicit memory tests. One is a perceptual representation system that provides for data-driven processing. The other is a semantic memory system that codes meaning and is responsible for priming effects in such tasks as free association (or for conceptually-driven processing). The dissociations between implicit tests in our experiments would then be explicable by arguing that word fragment completion is subserved by the perceptual representation system and category association by the semantic system.

Although our data and others can be explained by postulating additional memory systems, we are skeptical of where this approach will lead. A recent survey counts some 30 different memory systems, established largely on neuropsychological evidence (Roediger, in press). Only a few years ago priming was viewed as a manifestation of semantic memory, or procedural memory, but now special systems are seen as necessary just for priming phenomena. Those researchers who propose strongly modular views of neural functioning (e.g., Gazzaniga, 1989) point the way to many more, very specific, memory systems. Elsewhere we have endorsed the strong criteria proposed by Sherry and Schacter (1987) for postulating memory systems and argued that, if rigorously applied, most current proposals do not measure up (Roediger, Rajaram, & Srinivas, in press).

In our opinion, and in agreement with others (especially, Craik, 1983; Jacoby, 1988; Kolers & Roediger, 1984; and Moscovitch, 1984), a more appropriate interpretation of dissociations between tests, whether explicit or implicit, can be found in the notions of transfer appropriate processing (Morris et al., 1977). These ideas were embodied in the motivation and interpretation of the present experiments and, in general, have proved successful (see Roediger et al., 1989b). Manipulations during study will transfer with greater or lesser facility to particular tests depending on the match between the types of processing encouraged at study and those required by the particular tests employed. This is not to say that no problems exist for the processing approach, as the puzzling levels of processing effect in primed fragment completion in Experiment 2 attests to the contrary. The distinction between data-driven and conceptually-driven processing is one useful dimension in a task analysis, in our opinion, but certainly not the only one. The unit of analysis in priming experiments is another important dimension, as illustrated especially in recent work by Hayman and Jacoby (1989) and Levy and Kirsner (1989). Other thorny issues confront proponents of this approach, too. Still, in our opinion, specifying the "procedures of mind" engaged in such tasks points the way to their proper understanding (Kolers & Roediger, 1984). The present results aid in understanding processes operating in three implicit memory tests.

APPENDIX A

Study and Test Materials in Experiment 1

The first line shows the sentence used for generation; the next provides the target word, the category name, the word fragment, and the anagram used on the tests.

1. Lightning often occurs with t ___________ .
thunder Weather Phenomena t h _ _ _ e r tderhun
2. In fall, you clear leaves with a r ___________ .
rake Tools r _ _ e aerk
3. Dogs often have ticks and f ___________ . fleas
Insects f _ e a _ flsea
4. Trumpets and saxophones are often made of b ___________ .
brass Metals b _ _ s s sbars
5. Bourbon is another term for w ___________ .
whiskey Beverages w _ i s _ e _ seikwhy
6. Just as there are trembling poplars there are weeping w ___________ .
willows Trees _ _ l l _ w s sliwowl
7. A brook is also called a s ___________ .
stream Natural earth formationss _ r _ _ m temars
8. A room that is just below the roof is called an a ___________ .
attic Parts of a building _ _ _ i c citat
9. A cab is also called a t ___________ .
taxi Vehicles t _ _ i xait
10. A nun is often referred to as a s ___________ .
sister Members of the clergy _ i s _ e r triess
11. Baby clothes are either blue or p ___________ .
pink Colors _ _ n k kipn
12. Hydro-electricity is a means of getting electricity from w ___________ .
water Fuels w _ _ _ r trewa
13. A substance that is put in water and toothpaste to reduce cavities is f ___________ .
fluoride Chemical elements f _ u o _ _ _ e rodieflu
14. The hunters were out by the lake, shooting at a flock of Canadian g ___________ .
geese Birds g _ _ s _ segee
15. Many people like Mexican food with spicy jalapeno p ___________ .
peppers Vegetables p _ _ p _ r _ eprpeps
16. Huck Finn floated down the Mississippi on a r ___________ .
raft Types of ships _ _ f t frat
17. A mule is similar to a d ___________ .
donkey Animals d _ n _ _ _ endoyk
18. If someone is accused of stealing a car, he may be accused of grand l ___________ .
larceny Types of Crime l _ _ c _ _ y celaryn
19. Leaves turn bright orange in early a ___________ .
autumn Seasons _ u t _ _ n amnutu
20. In ancient times, people near the Mediterranean spoke either Latin or G ___________ .
Greek Languages _ r e _ k krege
21. Older children like to play with jigsaw p ___________ .
puzzles Toys _ u z _ l _ s pleszuz
22. The Pharaohs built the great pyramids in E ___________ .
Egypt Countries _ g y _ _ ptyge
23. A cord to hold up pants that is often made of leather is a b ___________ .
belt Articles of Clothing b _ _ t tlbe
24. A doctor often works with a n ___________ .
nurse Occupations or Professions n _ _ s e rusne
25. Rugby is similar to s ___________ .
soccer Sports _ _ c _ e r cocsre
26. Abe Lincoln grew up in a log c ___________ .
cabin Types of Dwelling _ a b i _ nacbi
27. A term related to wife is a h ___________ .
husband Relatives h _ s _ _ _ d dushnab
28. A periodical that contains technical articles is also called a j ___________ .
journal Reading material _ o _ _ n _ l lojaurn
29. Jeans are often made of corduroy or d ___________ .
denim Types of cloth _ e n _ m minde

30. In a sentence such as "The dog chased the cat," the phrase "the dog" would be the s ___________ .
subject Parts of speech s _ _ j _ c t bustjec
31. A popular breakfast would consist of eggs and b ___________ .
bacon Meats b _ c o _ nocba
32. A dried plum is called a p ___________ .
prune Fruits _ r u _ e runpe
33. A type of chair that has no back and is often used in a bar is called a s ___________ .
stool Articles of Furniture _ t _ _ l otosl
34. You would throw a javelin just as a primitive hunter would throw a s ___________ .
spear Weapons s p _ _ r earps
35. The church choir is often accompanied by a person playing an o ___________ .
organ Musical instruments o _ g _ _ grnao
36. Another word for cologne is p ___________ .
perfume Cosmetics p _ _ f _ _ e preeumf
37. Heroin is related to c ___________ .
cocaine Drugs c _ _ a _ n _ acocine
38. Next to the heart, one would find the l ___________ .
lungs Parts of the Human Body _ _ n g s ungls
39. The headquarters of the Catholic Church is in R ___________ .
Rome Cities _ o m _ meor
40. In the solar system, Pluto is close to U ___________ .
Uranus Planets _ r a n u _ usuran

APPENDIX B

Study and Test Materials in Experiment 2

Targets	Category Names	Word Fragments	Anagrams
1. sweater	Article of clothing	s _ e _ t e _	teswear
2. sadness	Emotion	_ _ d n _ _ s	dassens
3. dentist	Profession	_ _ n t _ s t	sintted
4. bowling	Sport	_ o w _ i _ g	glinwob
5. magenta	Colors	_ a g _ n t _	tamenga
6. hearing	Senses	_ e _ r _ n g	grinhea
7. trailer	Type of dwelling	t _ a _ _ e r	railter
8. malaria	Diseases	m _ l _ _ i _	liraama
9. parents	Relatives	p_ _ e _ t s	strapen
10. geology	Sciences	_ _ o _ o _ y	lyogego
11. orchids	Flowers	_ r _ h i _ _	dischor
12. peaches	Fruits	_ e _ c h _ s	pseache
13. dresser	Furniture	_ r e _ s e _	redsser
14. willows	Trees	_ i l _ o _ s	sliwowl
15. Chinese	Languages	_ _ i n _ s _	senchei
16. grenade	Weapons	g _ e _ _ d e	nagrede
17. piccolo	Musical instrument	_ i c _ _ l _	colocip
18. cocaine	Drugs	_ o _ a i _ e	nicocea
19. mascara	Cosmetics	_ a s c _ _ _	scarams
20. kidneys	Organs of the body	_ _ d _ _ y s	neysdik
21. thunder	Weather phenomena	_ h u _ d _ r	drethnu
22. crowbar	Carpenter's tools	_ _ o w _ _ r	browrac
23. vulture	Birds	_ _ l _ u r _	trueluv
24. termite	Insects	t _ r m _ _ e	miteert
25. crappie	Fish	_ r a _ p _ e	rapiepc
26. uranium	Metals	u _ _ n _ _ m	miuranu
27. calcium	Chemicals	c _ l _ _ u m	cicalum
28. steamer	Ships	s _ e _ m _ _	reamset
29. garnets	Precious stones	_ _ r n _ t s	ragnest
30. journal	Reading material	_ o u r _ _ _	lajounr
31. admiral	Military titles	_ d _ i r _ l	ramdial
32. giraffe	Animals	g _ _ a _ f e	rageffi
33. flannel	Types of cloth	f _ _ n _ e _	lannfle
34. spatula	Kitchen utensils	_ p _ t _ _ a	stupala
35. subject	Parts of speech	_ _ b j _ _ t	busectj
36. larceny	Types of crime	_ _ r c _ n y	relancy
37. oregano	Substance to flavor food	_ r e _ _ n _	roeogan
38. volcano	Natural earth formations	_ o l _ a n _	calvoon

39. chimney	Part of a building	_ h _ m _ _ y	minhcey
40. tractor	Vehicles	_ _ a c _ o r	rtaoctr
41. rattles	Toys	_ _ t t _ e _	attlers
42. cabbage	Vegetables	_ _ b _ a g _	babcage
43. venison	Meats	v _ n _ s _ _	sonevin
44. pudding	Desserts	_ _ d d _ n g	dipdung
45. forceps	Surgical tools	_ _ r c _ p _	pescfor
46. guineas	Foreign currency	_ u _ n _ a s	seaguin
47. rhombus	Geometrical shapes	r _ o _ b _ s	rhuboms
48. pythons	Snakes	_ y _ h _ n s	ponsthy
49. Judaism	Religions	_ _ d _ i s _	midasju
50. turtles	Reptiles	_ u r _ l _ s	surtlet
51. decades	Units of time	_ e c _ d _ _	seddace
52. furlong	Units of distance	f u _ _ o _ g	gurlofn
53. trapeze	Parts of a circus	_ r _ p _ z _	prazeet
54. loafers	Types of footwear	_ _ a f _ r _	serfalo
55. muffler	Parts of a car	m _ f _ l _ _	fumlerf
56. pendant	Pieces of jewelry	_ _ _ d _ n t	nadpent
57. martini	Alcoholic beverages	m a _ _ i n _	nitrami
58. limeade	Nonalcoholic beverages	l _ m _ _ d _	adelime
59. compass	Measuring devices	_ o m _ s _ s	sampsco
60. propane	Fuels	_ r o _ _ n e	panoper

Appendix C

Study and Test Materials in Experiment 3

Targets/Picture Names	Anagrams	Word Fragments
1. scissors	sirscoss	_ c i _ s _ _ s
2. lemon	noeml	_ e _ o n
3. cloud	oulcd	_ l _ u d
4. snake	kanes	_ n _ k _
5. doorknob	knodroob	d _ o r _ _ o _
6. dress	sreds	_ r e s _
7. spoon	ponos	s _ _ o n
8. pineapple	napielppe	_ i n _ a _ _ l e
9. elephant	pelethan	_ l _ _ h a _ t
10. basket	betkas	b _ s _ e t
11. flower	lewfor	_ l _ w _ r
12. accordion	cordionac	_ c c _ r _ _ _ n
13. mushroom	shoromum	_ u s _ r o _ m
14. potato	tootap	_ o t _ t _
15. glass	slags	_ l _ s s
16. carrot	racrto	_ a r _ o _
17. glove	evogl	_ l _ v e
18. skunk	knusk	_ k _ n k
19. clock	kolcc	_ l o c _
20. grapes	ragesp	_ r _ p _ s
21. guitar	tuirag	_ u _ t a r
22. hammer	ramhem	_ a m _ e r
23. wheel	hewle	_ h _ e l
24. heart	reath	_ e a _ t
25. bicycle	libcyec	b _ c _ c _ e
26. horse	roseh	_ o r _ e
27. kangaroo	orangoka	_ _ n g _ r o _
28. barrel	rabler	_ a r _ e l
29. ashtray	trashay	_ s _ t _ a y
30. knife	fenik	_ n i _ e
31. chair	rihca	_ h a _ r
32. ladder	dalred	_ a d _ e r
33. windmill	winilldm	_ i n _ m _ l _
34. lobster	soblert	_ o b _ t _ r
35. turtle	rutlet	_ u r _ l e
36. monkey	konyem	_ o n _ e y
37. candle	landec	c _ n d _ e
38. mountain	tounnaim	_ o u n _ a _ n
39. balloon	nooblal	_ _ l l o _ n
40. onion	nooni	_ n _ o n
41. peanut	tunape	p _ _ n u _
42. envelope	lopeveen	_ n v _ _ o p _
43. football	tooblalf	f _ _ t _ a _ l
44. penguin	ginpeun	_ e n _ u i _
45. snowman	namowsn	_ n o _ _ a n
46. pitcher	tipchre	_ i t _ h _ r
47. cannon	aonncn	c a _ _ o n
48. escalator	caselarto	_ s c _ l _ t o _
49. pliers	spleri	_ l i _ r s
50. crown	worcn	c r _ w _
51. turkey	rutyek	_ u r _ _ y
52. button	tubnot	_ u _ t o n
53. intestine	sintteine	_ n t _ s _ i _ e
54. chain	nicah	_ _ a i n
55. rabbit	bartib	_ a b _ i t
56. pencil	lincep	_ _ n c _ l
57. ruler	relru	_ u l _ r
58. sailboat	toalbais	s _ i _ b _ a _
59. camel	melac	_ a m _ l
60. tomato	matoot	t _ m _ _ o

61. bottle	tolebt	_ o t _ l e
62. screw	wercs	_ c r _ w
63. banana	nabaan	_ a n _ n _
64. pretzel	terpzle	p _ e t _ e _
65. xylophone	lopehonyx	_ y _ o p _ o _ e
66. shirt	thris	s _ _ r t
67. arrow	worar	_ r r _ w
68. spider	dipser	s _ i _ e r
69. butterfly	futbertly	_ u t _ e r _ l _
70. squirrel	quirlers	s _ u i _ r _ _
71. anchor	ranoch	_ n c _ _ r
72. stool	lotos	_ t o o _
73. swing	winsg	_ w _ n g
74. folder	dolref	_ o l _ e r
75. table	leabt	_ a _ l e
76. cigar	girca	c _ g _ r
77. thumb	tmuhb	t _ u m _
78. camera	macrea	c _ _ e r _
79. tiger	geitr	_ i g e _
80. sandwich	danswchi	_ a n _ w _ c _
81. umbrella	bumralle	_ m _ r e _ l _
82. watch	cawth	_ a t _ h
83. tornado	ronatdo	_ o r _ a d _
84. whistle	isthlew	_ h _ s _ l e
85. pumpkin	kinmupp	p u _ _ k _ n
86. window	donwiw	_ i _ d _ w
87. zebra	beraz	_ e _ r a
88. church	hruhcc	c h _ r _ _
89. ambulance	bulamance	_ m b _ _ a n _ e
90. cactus	sutacc	_ a c _ u s
91. diamond	miadnod	_ i _ m _ n d
92. elevator	vaeletor	_ _ e v _ _ o r
93. fireplace	pirelafec	_ i _ e p _ a c _
94. igloo	lioog	i _ l _ o
95. newspaper	papreswen	n _ _ s _ a p _ r
96. apple	lepap	_ p _ l _
97. octopus	tocopsu	_ c t _ p _ s
98. parachute	churapate	_ a _ a c _ u t _
99. toaster	oastter	_ o a _ t _ r
100. pyramid	ramydip	p _ _ a _ i d
101. submarine	marsubnei	_ u b _ _ r i _ e
102. telescope	scopteele	_ e l _ _ c o _ e
103. giraffe	rafefig	_ i r _ _ f _
104. unicorn	corunni	_ n i _ o r _
105. waterfall	rfalwatel	_ a t _ r _ a l _

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