

VARIETIES OF MEMORY AND CONSCIOUSNESS

Essays in Honour of Endel Tulving

edited by

HENRY L. ROEDIGER, III
Rice University

FERGUS I.M. CRAIK
University of Toronto



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1 Explaining Dissociations Between Implicit and Explicit Measures of Retention: A Processing Account

Henry L. Roediger, III
Rice University

Mary Susan Weldon
University of California, Santa Cruz

Bradford H. Challis
Purdue University

Explicit measures of memory refer to tasks in which people are directly tested on episodes from their recent experience; in performing the tasks people are instructed to remember events and presumably are aware that they are recollecting recent experiences. Implicit measures of retention are those on which subjects are not told to remember events, but simply to perform some task; retention is measured by transfer from prior experience (relative to an appropriate baseline), and presumably conscious recollection is not necessarily involved (Graf & Schacter, 1985). Explicit memory tasks are the standard warhorses of the experimental psychologist's armamentarium for investigating memory: free recall, cued recall, recognition, and various judgments (frequency, modality, feeling-of-knowing, etc.). Implicit measures of retention are transfer tasks in which performance on the critical task is influenced by prior experience, without the prior experience necessarily being reflected on explicit measures. Examples of implicit tasks are reading inverted text, naming fragmented words or pictures, or naming words or pictures from brief displays. Great interest has recently been displayed in the relation between explicit and implicit measures of retention, because they are shown to behave differently as a function of many independent variables (Schacter, 1987). The purpose of the present chapter is to consider functional dissociations between these two classes of tasks and to sketch a theory rationalizing their interrelation.

The first section of the chapter reviews an approach to explaining dissociations developed within the domain of laboratory memory tasks. This approach is based on Tulving's (1983) ideas of the encoding/retrieval paradigm and the

encoding specificity principle. These ideas are compared to similar notions from other domains, and the general heading of transfer-appropriate processing is used to refer to this class of ideas. We argue that the notion of transfer-appropriate processing permits an understanding of dissociations between explicit and implicit measures of retention. The second section briefly reviews dissociations between explicit and implicit measures of retention, as a function of both subject variables (e.g., amnesia produced by brain injury) and independent variables under experimental control (e.g., the levels of processing manipulation). The third section considers the standard explanations of functional dissociations between measures of retention in terms of differing memory systems, particularly the episodic/semantic distinction and the declarative/procedural distinction. Criticisms of these approaches are also briefly described. The fourth section is devoted to spelling out an alternative theory that, in many ways, embodies the notion of encoding specificity to explain the dissociations between explicit and implicit retention. The fifth section of the chapter is aimed at specifying these ideas better and providing further evidence about their validity. The sixth and final section addresses problems of the transfer-appropriate processing approach and suggests future research. The chapter is capped by a few concluding comments on the issues raised.

RETRIEVAL PROCESSES AND ENCODING SPECIFICITY

At the risk of considerable oversimplification, Endel Tulving's career can be marked by three primary lines of contribution. Although these overlap, one can point to the decade of the 1960s as concerned with the organization of memory, particularly subjective organization in multitrial free recall; to the 1970s as concerned with the effectiveness of retrieval cues and with recall/recognition comparisons; and to the 1980s with the issue of whether or not human memory is subserved by distinct systems. Of course, this division of Tulving's career into phases is imperfect, because the seed for the major issue of each decade was planted in the prior one. Thus concern with retrieval cues began in the 1960s (Tulving & Pearlstone, 1966) and with memory systems in the 1970s (Tulving, 1972). Nonetheless, the division proves useful in identifying the main thrust of research for the decade. The basic argument in the first three sections of this chapter maintains that Tulving uncovered important truths about memory in the 1970s—the encoding specificity decade—and that these ideas also work to explain the data taken as evidence for separate memory systems—functional dissociations among measures of retention (Roediger, 1984). These cryptic remarks are fleshed out later.

Tulving and Pearlstone (1966) showed that category names could serve as excellent retrieval cues in aiding recall of words belonging to semantic categories, relative to performance under free recall conditions. The advantage of cued

to free recall surpassed 200% in some of their conditions, which dramatizes the necessity for distinguishing between the information available in memory (what is stored) and the information accessible on a test (what can be retrieved under a particular set of test conditions). The quest to know what information a person has stored in memory and how it is organized will always founder on the fact that any procedure to assess these issues will only reveal what a person knows under a particular set of retrieval conditions. Thus theories of cognitive structure must always specify a set of retrieval conditions operating during testing (Anderson, 1978).

After Tulving and Pearlstone's (1966) impressive demonstration, interest grew in the factors that caused retrieval cues to be effective (e.g., Thomson & Tulving, 1970; Tulving & Osler, 1968). Numerous experiments were conducted to determine the necessary relation between retrieval cues and stored experiences for successful recollection. The general principle that emerged from numerous experiments came to be known as the encoding specificity principle (or hypothesis): "... recollection of an event, or a certain aspect of it, occurs if and only if properties of the trace of the event are sufficiently similar to the retrieval information" provided in the retrieval cues (Tulving, 1983). Many lines of evidence can be provided to support this assertion, but the most convincing conforms to the encoding/retrieval paradigm shown in Fig. 1.1 here. An experiment using the encoding/retrieval paradigm incorporates conditions in which both encoding and retrieval conditions are manipulated orthogonally. Usually experimenters wish to vary the similarity between encoding and retrieval conditions, a property illustrated by letters in Fig. 1.1. Encoding conditions A and B are crossed with retrieval conditions A' and B', which are similar to encoding conditions A and B, respectively. If the encoding specificity principle holds, performance in conditions A-A' and B-B' (where encoding and test conditions match) should be better than in conditions A-B' and B-A' in which the encod-

The Encoding/Retrieval Paradigm

		Retrieval Condition	
		A'	B'
Encoding Condition	A	A A'	A B'
	B	B A'	B B'

FIG. 1.1. The encoding/retrieval paradigm. Minimally, two encoding conditions (A and B) are crossed with two retrieval conditions (A' and B'). Retention should be enhanced in conditions represented by cells in which the best match exists between study and test conditions (AA', BB') relative to the other conditions (AB', BA'). Adapted from Tulving (1983, p. 220).

ing and retrieval conditions match less well. Numerous experiments have revealed such effects (see Tulving, 1983, pp. 226–238, for 14 examples), so discussion here is limited to a single case that illustrates the point.

Morris, Bransford, and Franks (1977) reported an experiment dealing with the issue of how manipulations designed to influence the level of processing of studied stimuli affected performance on different types of memory tests. The usual expectation is that deeper, more meaningful processing should aid retention compared to processing that encourages only shallow or superficial coding (Craik & Lockhart, 1972; Craik & Tulving, 1975). Morris et al. (1977, Experiment 1) crossed phonemic (or rhyme) and semantic (meaningful) conditions at both study and test. Subjects studied words such as EAGLE in sentence frames designed to effect either phonemic or semantic encoding ("_____ rhymes with legal" or "_____ is a large bird"). The subjects responded *yes* or *no* to each statement, and we consider results based on tests of items to which the subjects responded *yes* during study.

The subjects' memories were tested in two different ways. Half the subjects were tested on a standard recognition test in which studied words were intermixed with nonstudied words and the task was to identify the studied words. Morris et al. (1977) assumed that the subjects accomplished this task by referring to the meaning of the test words, and thus that one should expect better performance for words encoded semantically rather than phonemically. Indeed, just this pattern was found, as can be seen in the left column of Fig. 1.2. The other test used by Morris et al. was a rhyme recognition test. Subjects were told that the test items would include words that rhymed with the studied words and that they should discriminate these rhyming words from the distractors that did not rhyme with the targets. On this rhyme recognition test the standard levels of processing effect reversed, with phonemic encoding producing better performance than semantic encoding, in general conformity with the encoding specificity principle. The data are shown in the right column of Fig. 1.2. Similar experiments and results were reported by Fisher and Craik (1977) and McDaniel, Friedman, and Bourne (1978), although typically there was no advantage of rhyme encoding on the phonemic test. That is, the standard levels of processing effect disappeared but did not reverse on their versions of phonemic tests.

Several general lessons can be drawn from the research described in this section. First, the encoding/retrieval paradigm is useful for studying the interactive effect of encoding and retrieval conditions in order to investigate the encoding specificity hypothesis. Second, many demonstrations of cross-over interactions or functional dissociations have been found by researchers employing the encoding/retrieval paradigm. Even such robust effects as levels of processing can disappear (Fisher & Craik, 1977; McDaniel et al., 1978) or even reverse (Morris et al., 1977) under the appropriate test conditions. Tulving (1979) used such demonstrations to argue that the notion of levels of processing may be superfluous in describing data from such experiments; rather, such experiments

		Retrieval Condition	
		Semantic (A)	Rhyme (B)
Encoding Condition	Semantic (A)	.84	.33
	Rhyme (B)	.63	.49

FIG. 1.2. Transfer-appropriate processing. Study conditions biased encoding towards rhyme (phonemic) encoding or semantic encoding; test conditions were arranged to tap either one or the other dimension. Data are taken from Morris, Bransford, & Franks (1977, Experiment 1).

demonstrate the interactive nature of remembering as embodied in the encoding specificity principle, without need for separate "levels" of information to be postulated. Morris et al. (1977) made a similar argument, but cast their view under the rubric of transfer appropriate processing. The general argument is similar to the encoding specificity principle, but (they argued) more general: study conditions foster good performance on later tests to the extent that the test permits appropriate transfer of the knowledge gained during study (see also Bransford, Franks, Morris, & Stein, 1979; Stein, 1978).¹ We return to this argument below as a possible avenue to understanding dissociations between explicit and implicit measures of retention.

DISSOCIATIONS BETWEEN EXPLICIT AND IMPLICIT MEASURES OF RETENTION

The main challenge of this chapter is to provide an account of dissociations between explicit and implicit measures of retention as a function of various independent and subject variables. First it is necessary to provide a brief review of such dissociations, but we do so by providing examples of important findings rather than by reviewing the literature exhaustively. Readers can consult recent excellent reviews by Shimamura (1986), Schacter (1987), and Richardson-Klavehn and Bjork (1988) for fuller treatments.

¹Craik (1979) and Lockhart (1979) argued that the concept of different levels is still needed, in addition to the transfer-appropriate processing ideas, to account for the data in Fig. 1.2 and elsewhere. The reason is that performance is usually substantially better in the Semantic study–Semantic test condition than in Phonemic study–Phonemic test condition (see Fig. 1.2). Thus, even under transfer appropriate test conditions, deeper levels permit better performance. (But see Tulving, 1979, for an alternative view.)

Some form of distinction between explicit and implicit retention is quite old, being honored in the writings of many philosophers (see Schacter, 1987). Even within experimental psychology the distinction dates to Ebbinghaus's (1885/1964) great book (Roediger, 1985). However, modern interest in the distinction is relatively recent and has its origins in work with amnesic patients. Patients are classified as amnesic when some brain injury renders them seemingly incapable of retaining new experiences; more technically, they suffer a profound anterograde amnesia. Studies of famous cases such as H. M., whose amnesia was due to a temporal lobectomy, and other more typical forms of amnesia (e.g., numerous cases of Korsakoff's syndrome) led to the conclusion by about 1970 that amnesics were incapable of transferring verbal information from a relatively intact short-term store to a long-term memory (e.g., Baddeley & Warrington, 1970). Researchers were aware that even profound amnesics such as H. M. were capable of learning and retaining motor skills at about the same levels as were normal subjects (e.g., Corkin, 1968), but retention of verbal information in amnesics survived only at very low levels, if at all, after a period of brief distraction following its study.

This picture of retention in amnesics began to change around 1970 because of reports by Warrington and Weiskrantz (1968, 1970) indicating that amnesics occasionally showed normal levels of performance on certain verbal tests. These early claims were, of course, disputed and discussed because they seemed inconsistent with so much prior literature and thinking. But many more recent studies have confirmed Warrington and Weiskrantz's findings and have indicated the variables responsible for their occurrence. Their prototypic experimental study is considered here.

Warrington and Weiskrantz (1970, Experiment 2) presented four amnesic patients (three Korsakoffs and one with a temporal lobectomy) words to remember and then assessed their retention on four tests. Sixteen control patients without brain damage were similarly tested. Today we would probably classify two of the four tests as involving explicit retention (free recall and recognition) and two of the tests as involving implicit retention (completing fragmented words in which each letter was degraded, and completing words when given three-letter stems). In the latter two tests the measure of interest is repetition priming, or the advantage in completing the words due to prior study. (The words were selected so that they could not be completed in the fragmented form without prior study.)

The results for the two explicit memory tests, recall and recognition, are shown in the top panel of Fig. 1.3. As usual, the amnesic patients showed poorer retention than did the control subjects; if anything, the surprise is that amnesic patients performed as well as they did on these tests. The results in the bottom panel show performance of the two groups on the two implicit tests, and the interesting observation is that priming was intact for amnesic patients. They completed the words as well as the control patients in both cases. (The slight difference favoring controls given the three letter word stems was not signifi-

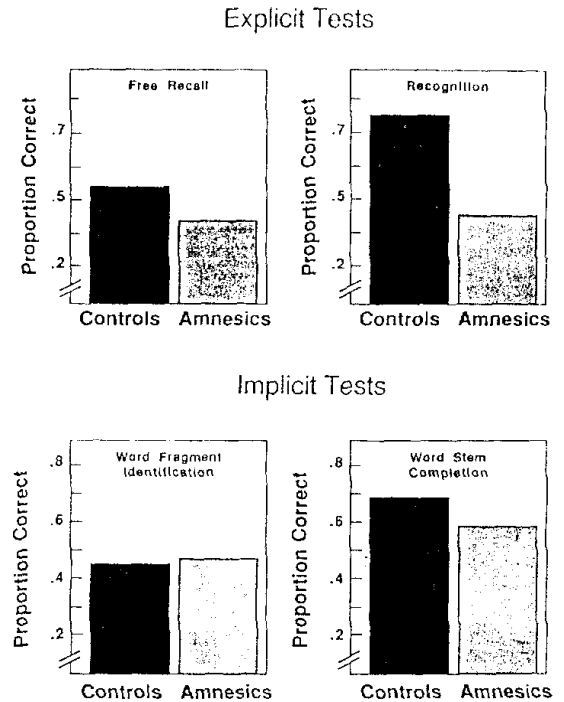


FIG. 1.3. Intact retention of verbal information in amnesics. Amnesics performed more poorly than controls on explicit tests (recall and recognition), but showed equal priming on implicit tests (word fragment identification and word stem completion). Data from Warrington and Weiskrantz (1970, Experiment 2).

cant.) Thus, on what would now be called implicit tests of retention, amnesics performed as well as control subjects in retaining verbal information.

Similar results have now been obtained by many researchers using a number of different tasks. Shimamura (1986) has reviewed this research and found that amnesics show intact priming on at least eight different tasks, listed here in Table 1.1 along with an illustrative reference. Seven of the eight tasks use verbal materials, so intact retention of verbal materials (as measured implicitly) is well established.

TABLE 1.1
Tasks Showing Preserved Learning in Amnesia
(adapted from Shimamura's, 1986, review)

Task	Illustrative Study
1. Fragmented picture identification	Warrington & Weiskrantz (1968)
2. Word completion	Warrington & Weiskrantz (1970)
3. Lexical decision	Moscovitch (1982)
4. Perceptual identification	Nissen, Cohen, & Corkin (1981)
5. Spelling of homophones	Jacoby & Witherspoon (1982)
6. Preference judgments	Johnson, Kim, & Risse (1985)
7. Free association of related information	Gardner, Boller, Moreines, & Butters (1973)
8. Word completion with new associates	Graf & Schacter (1985)

Graf, Squire, and Mandler (1984) have reported an important condition necessary for establishing priming in at least some of these paradigms: the nature of the instructions given to the subjects. In their Experiment 3, amnesic and control subjects were tested with the same type of three-letter word stems as were used by Warrington and Weiskrantz (1970). However, subjects were given instructions either to use the stems as cues to recall words from the recently presented list (explicit memory instructions), or to produce any word that began with those three letters (implicit memory instructions). Graf et al. showed that when given explicit retention instructions, amnesics performed much worse than did normals; however, when given implicit instructions they showed the same level of priming. This demonstration is impressive, because the same overt cues (word stems) were used in both test conditions. Thus, the necessary condition for preserved priming in amnesics is not simply the presentation of powerful cues—if that were the case, amnesics should perform well on recognition tests—but also the instructions, set, or attitude subjects take toward the task. When amnesics are given indirect or implicit tests in which the memorial nature of the task is disguised, they perform at levels comparable to normal subjects. Thus, amnesics' ability to encode verbal information may be intact; their difficulty may be in gaining awareness of the stored information.

Many experiments with amnesics can thus be viewed as revealing a functional dissociation between a subject variable (brain damage or not) and different retention tests (explicit and implicit). However, similar dissociations can be seen within normal memory as a function of many independent variables. For example, Jacoby and Dallas (1981) manipulated levels of processing in the standard way and showed the usual powerful effects on an explicit recognition test, but no effect on the amount of priming in a perceptual identification test in which subjects had to name words presented quite briefly. That is, the amount of priming on the perceptual identification test was the same regardless of the level

of processing the words received during prior presentation. Graf, Mandler, and Haden (1982) and Graf et al. (1984) reported little effect of levels of processing on priming in the word stem completion task, and Roediger, Weldon, Stadler, & Riegler (in preparation) replicated this finding and extended it to a different word completion test (completing words with letters omitted, e.g., c_a_p_g_e, for *champagne*).

Another experiment of this ilk reported by Jacoby (1983) is presented in some detail, because it is critical for the argument to be developed later. Jacoby had subjects study antonyms in one of three conditions. In the Context condition subjects saw *hot-COLD* and read the second word aloud; in the Generate condition subjects saw *hot-???* and were to generate the target; in the No Context condition they saw *XXX-COLD* and were to read the target aloud. Thus, in all three conditions subjects spoke the target word aloud, but the response was effected by different means; namely, processing the data in the No Context condition, processing the concept's meaning in the Generate condition, and presumably a mixture of these processes in the Context condition.

Following presentation of words under these three conditions, different groups of subjects received one of two different types of test. One was a standard recognition test in which studied targets were intermixed with new words and the task was to indicate the previously studied words. The results of this task are shown at the top of Fig. 1.4 and replicate the generation effect (Slamecka & Graf, 1978; Winnick & Daniel, 1970); that is, words generated during prior study were better recognized than those read with no relevant semantic context, with the context condition falling in between. Shown at the bottom of the figure is the amount of priming produced by these study conditions on the perceptual identification test (the percentage correct as a function of the prior study condition, compared to performance on nonstudied words). Now the pattern of results that was seen on the recognition test reverses, with best performance resulting from the No Context study condition and the least priming coming from the Generate study condition. Opposing patterns of performance on an explicit and implicit test provide the strongest form of functional dissociation and indicate that such dissociations are not limited to subject variables such as brain damage.

PREVALENT THEORETICAL ACCOUNTS OF FUNCTIONAL DISSOCIATIONS

The most popular accounts of functional dissociations between memory measures are in terms of distinct memory systems. The general form of the argument is that performance of one memory system is reflected in one measure (say, recall or recognition) and operation of the other system is reflected in some other measure (say, priming in word stem completion). The leading candidates for the different systems are the episodic and semantic systems proposed by Tulving

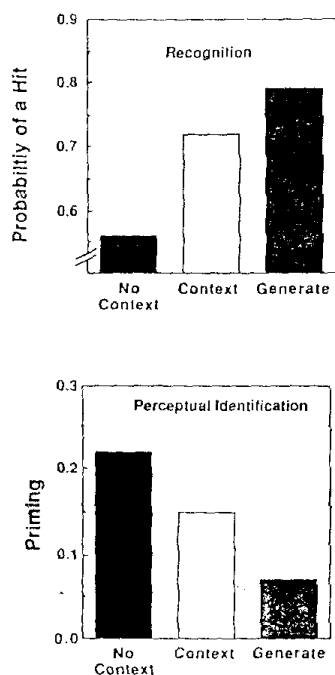


FIG. 1.4. Dissociation between retention measures in normals. Items generated during study were recognized better on a later test than items read during study, but read items produced greater priming than generated items in perceptual identification. Data from Jacoby (1983, Experiment 2).

(1972, 1983) and the procedural and declarative systems championed by Squire (1986, 1987), among others. After some preliminary remarks about memory systems, we briefly consider these two dichotomies.

Good a priori reasons exist for supposing that the human brain has several different means for representing information and permitting access to it. One argument comes from comparative psychology: It is difficult to believe that the human brain has not developed more systems to retain information than exist in

simple organisms such as *aplysia*, which nevertheless do reveal the ability to learn (see Sherry & Schacter, 1987, for this comparative approach). Also, other cognitive systems such as vision have separate subsystems specialized to transmit different types of information about the world, such as localization of an object and its identity (Weiskrantz, 1986), so it is plausible that more than one memory system exists, too. Empirical evidence also exists from laboratory studies with monkeys (e.g., Mishkin & Appenzeller, 1987) and other mammals (e.g., Olton, this volume) that convincingly argues for distinct brain mechanisms underlying different forms of learning. However, the exact mapping of this elegant neuroscientific work onto the various memory systems proposed by those studying human memory is hazardous; certainly it is not enough for a theorist to say that others have found evidence for systems, and therefore they must be the systems proposed by the theorist. Rather, one would like the systems to have at least some surface resemblance and, as much as possible, to show that the same factors are at work in humans with certain patterns of brain damage and with animals similarly damaged through experimental means. Although tantalizing leads for such comparisons currently exist, in our opinion they are far from being well established at this point.

In this chapter we primarily consider evidence for distinct systems from functional dissociations in normal remembering, although at the end we return to the issue of dissociations in pathological cases (amnesics). Functional dissociations in both normal and pathological states have been viewed as critical evidence for the distinction between memory systems (see Squire, 1987; Tulving, 1983), so it seems fair to evaluate the distinction using this evidence.

The dissociations from the experiments by Warrington and Weiskrantz (1970) and Jacoby (1983) described earlier can be taken as strong support for the distinction between separate episodic and semantic memory systems. Tulving states that

Experiments following the logic of experimental dissociation involve the manipulation of a single variable and comparison of the effects of the manipulation in two different tasks, one episodic, the other semantic. Dissociation is said to have occurred if it is found that the manipulated variable affects subjects' performance in different directions in the two tasks. . . . The finding of dissociation would be regarded as support for the distinction between episodic and semantic memory systems. (Tulving, 1983, p. 73)

In the studies described earlier (and many others) recall and recognition (episodic tasks) are dissociated from priming in word stem completion and perceptual identification (semantic memory tasks).

Whether or not dissociation results should be taken as evidence for the episodic/semantic memory distinction has been questioned on various grounds by several commentators (e.g., Hintzman, 1984; McKoon, Ratcliff, & Dell, 1986;

Neely, this volume; Roediger, 1984). For example, the form of the interaction between independent variables and retention tests in normals is not predicted by the theory; that is, why should a variable such as generating versus reading (Jacoby, 1983) or levels of processing (Jacoby & Dallas, 1981) have large effects on episodic memory and no effect (levels) or an opposite effect (generating) on priming with a semantic memory task? And surely all dissociations between tasks should not necessarily reflect operation of different systems, or we would soon have evidence for many different systems (a recall system and a recognition system, for example). These and other vexing problems are yet to be worked out (see McKoon et al., 1986; and Tulving's, 1986, reply), but in the absence of a better theory, dissociations between memory measures might be taken as tentative evidence for the existence of separate systems.

The same dissociations used as evidence for the episodic/semantic distinction by Tulving are used as evidence for the declarative/procedural systems by Squire (1986, 1987). Recently Tulving (1984, 1985) has also argued that a distinction between these systems is needed. The classic distinction between declarative and procedural knowledge (Ryle, 1949) is between knowing that (stating knowledge propositionally) and knowing how (operating on the environment in ways difficult to verbalize, as in riding a bicycle). Both episodic and semantic memory would then be conceived as representing declarative or propositional subsystems distinct from procedural memory. One possible arrangement suggested by Squire (1987) is represented in Fig. 1.5, where it can be seen that several disparate abilities are represented in procedural memory. For example, both classical conditioning and priming in word stem completion are considered to reflect procedural memory. Note that this usage strains the usual meaning of the term, because completing word stems would seem to have a relatively light motor component, probably no greater than in a standard cued recall task (considered to be episodic and declarative).² Thus although tasks can be reasonably well assigned to reflect episodic or semantic memory by Tulving's criteria (Tulving, 1983, pp. 77-78), the situation becomes much more complicated once more memory systems are introduced and allowance is made for overlapping processes in the various systems and subsystems (Tulving, 1984). Indeed, others have argued that the concatenation of systems within systems has become too byzantine and complex (McKoon et al., 1986). Even though a priori considerations and ablation studies with animals may indicate separate neural systems for handling information, these neural paths may not represent anything like the distinct systems proposed in current theories. Weiskrantz (this volume) has noted that

²Of course, there is no necessary reason to adhere to the criterion of classifying tasks as procedural only if they involve heavy motor components. Kollers and Roediger (1984) argued for an approach involving "procedures of mind," whereby mental skills (perceiving, remembering, reading, thinking) could be conceived as having properties similar to physical skills. This approach is broadly congruent with the one proposed in the next section of this chapter.

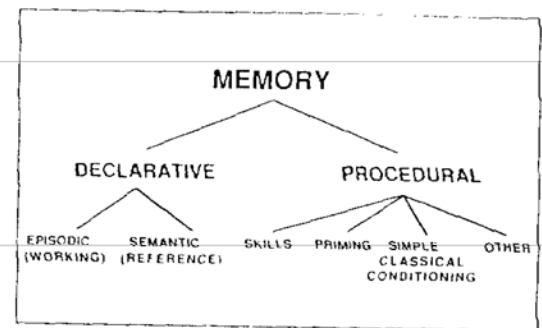


FIG. 1.5. A tentative taxonomy of memory proposed by Squire (1987). Declarative memory includes propositional and imaginal information that can be brought into consciousness. Procedural memory includes cognitive and motor skills, classical conditioning, habituation, sensitization, various perceptual effects, and other instances in which experience facilitates the engagement of specific cognitive operations.

nature provides neither pure lesions for disrupting systems nor pure tasks for measuring them, and he has endorsed a task analytic approach for an understanding of dissociations (see Moscovitch, 1984, for similar ideas). In the next section we propose an alternative to the systems approach that is both simpler and more complete in that it also provides a task analysis.

TRANSFER-APPROPRIATE PROCEDURES

The approach developed here borrows ideas from several predecessors. The general thrust of the argument resembles that of the encoding specificity hypothesis towards explaining encoding/retrieval interactions in episodic memory experiments, but the processing assumptions are slightly different. In particular, the present approach is based on Kollers' procedural viewpoint (Kollers, 1973, 1979; Kollers & Roediger, 1984), the transfer-appropriate processing ideas from the Vanderbilt group (Bransford et al., 1979; Morris et al., 1977; Stein, 1978), and a particular distinction introduced by Jacoby (1983). The component ideas are therefore not particularly novel, but their amalgamation is new, and they are being employed here for other means. The general ideas were stated in previous chapters by Roediger and Blaxton (1987b) and Roediger and Weldon (1987), but we develop them further here.

Four basic assumptions underlie our approach to explaining dissociations between explicit and implicit measures of retention. First, we assume that memory tests benefit to the extent that the operations required at test recapitulate or overlap the encoding operations performed during prior learning. This idea restates the proposal of many theorists (e.g., Kolers & Roediger, 1984; Morris et al., 1977; Tulving & Thomson, 1973, among others) and seems relatively uncontroversial. Second, we assume that explicit and implicit memory tests typically require different retrieval operations (or access different forms of information), and consequently will benefit from different types of processing during learning. This second assumption is spelled out more fully in the next two. The third assumption is that most explicit memory tests rely on the encoded meaning of concepts, or on semantic processing, elaborative coding, mental imagery, and the like. A wealth of evidence shows that variables such as levels of processing, elaborative coding in sentences or images, or meaningful organization in schemas enhances retention on explicit tests such as recall and recognition. We refer to explicit tests as requiring conceptually driven processing, following Jacoby (1983). The fourth assumption is that most standard implicit memory tests rely heavily on the match between perceptual processing during the learning and test episodes. As commonly used, many implicit tests (repetition priming in perceptual identification, lexical decision, fragment or stem completion, etc.) seem to tap the perceptual record of past experience, to borrow the phrase of Kirsner and Dunn (1985). We refer to these tests as data-driven (Jacoby, 1983). Thus, variations in conceptual processing will have little effect on such implicit memory tests, but variations in surface features between study and test will greatly affect priming. (On the other hand, variations only in surface features should have little effect on conceptually driven tests.)

We believe that a theory based on the four postulates stated previously can well explain the bulk of the experimental evidence usually interpreted as support for distinct memory systems. However, before taking on this challenge, let us clarify the approach by denying two erroneous inferences people have drawn from our previous writings. (a) We are not saying that all explicit memory tests are conceptually driven and all implicit memory tests are data-driven. In explicit tests, subjects are instructed to remember experiences; in implicit tests they are not. We describe later attempts to design explicit, data-driven tests and implicit, conceptually driven tests. Our assumption states that most implicit tests that have typically been used are data-driven, and most explicit tests are conceptually driven, but nothing inherent in the nature of explicit or implicit tests forces this correlation. (b) We do not consider the proposed distinction between data-driven and conceptually driven processing as a dichotomy into which all memory tasks can be placed, but rather as representing endpoints on a continuum. In the next section of the chapter we present ideas about how tasks can be classified and ordered along this continuum and what variables might influence placement of a task. We should add, too, that we do not mean to imply that the continuum of

processing types is the only feature that permits a task analysis, but we do believe that it represents an important feature for reasons that will become clear.³

A first step is to account for dissociations between explicit and implicit tests produced by experimental variables. We use two examples and more appear in the next section. Consider first Jacoby and Dallas' (1981) finding that manipulation of levels of processing, by orienting tasks that directed subjects' attention to different features of words, produced large effects on recognition, but had no effect on the amount of priming in perceptual identification. This outcome was replicated by Graf and Mandler (1984) with the implicit test of word stem completion and by Roediger et al. (in preparation) with both word stem and word fragment completion. The explicit tests of recognition and recall are assumed to be primarily conceptually driven, and so should be affected by variations in processing induced by the standard levels of processing manipulation. On the other hand, the "data" (words) presented during the study phase are the same in each condition and presumably must be processed through the visual system to achieve lexical access no matter what further processing requirements are demanded. This processing of data, which is assumed to be relatively constant across the processing manipulations, therefore transfers equally to the data-driven implicit memory tests.

A welcome complement to this asymmetric dissociation (an effect on explicit retention, no effect on implicit retention) would be a dissociation in which an experimental variable had opposing effects on the two types of test. Jacoby (1983) provided just such an interaction in an experiment described earlier (see Fig. 1.4). Generating words during study produced better retention on an explicit memory test (recognition) than did reading them out of context, but the latter condition produced greater priming in perceptual identification than did generating. Blaxton (1985, Experiment 1) provided a conceptual replication of this finding using the explicit test of free recall and the implicit test of primed word fragment completion. Reading a word obviously involves more data-driven processing than generating it (a case in which the word is not seen), and thus transfers better to a data-driven test. Generating words from associative cues (hot-???) involves more elaborative processing than does reading the target (XXX-COLD), and therefore transfers better to a conceptually driven test. Thus, the procedural framework in which a distinction is drawn between the broad classes of data-driven and conceptually driven processes accounts well for the dissociations between explicit and implicit tests reviewed here.

The transfer-appropriate procedural approach does not provide the only account of these dissociations, however. They can be equally well described, albeit

³Data- and conceptually driven processing are considered as components of tasks, and one must be careful to distinguish the preponderance (or balance) of the two processing modes in a given situation, without denying that other features of the task are important, too. For example, dissociations between tests can be achieved by manipulating variables, such as word frequency, that may not affect the mode of processing (data-driven or conceptually driven).

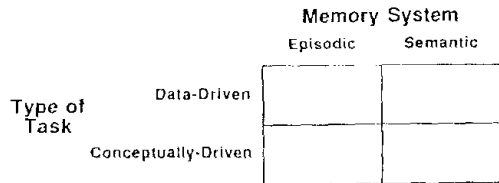


FIG. 1.6. Experimental design needed to distinguish between the effects of memory system (episodic/semantic) and type of processing (data-driven vs. conceptually driven) when interpreting dissociations among memory tests.

at a general level, in terms of distinct memory systems. Depending on one's preference, recognition and recall could be manifestations of operations in the declarative or episodic memory system(s), whereas priming on implicit tests could result from changes registered in the semantic or procedural systems. This approach could account for the general presence of dissociations between measures, although the transfer-appropriate processing approach has the advantage of accounting for the form of the interaction as well as its existence. Still, the dissociations reviewed above cannot be taken as decisive evidence favoring the transfer-appropriate procedures approach.

The reason for the indeterminacy of the issue based on the above data can be seen in Fig. 1.6, in which alleged memory systems form the columns and alleged modes of processing form the rows. These are two difficulties with the logic used by most researchers studying dissociations between measures. First, virtually all researchers have chosen to study dissociations between tasks tapping episodic and semantic memory (or declarative/procedural memory) by manipulating an independent variable and examining its effect on one measure of episodic memory and one measure of semantic memory. (The Warrington & Weiskrantz, 1970, experiment portrayed in Fig. 1.3 is a welcome exception.) With only one task representing each system or type of processing, any form of interaction can be interpreted as reflecting operation of the systems. A second problem, besides comparison of only two tasks, is that in virtually all previous experiments a confounding has existed between the system being tapped and the form of processing required by the tasks. Tests tapping episodic or declarative retention are almost always conceptually driven—free recall, cued recall with associative cues, or recognition memory. On the other hand, tests believed to tap semantic or procedural memory are usually data-driven—perceptual identification, word fragment and word stem completion, and lexical decision. The resulting interactions usually taken as evidence for different systems (or procedures) can thus always be given an account in terms of the alternate view.

Because dissociations are a prime source of evidence for the distinction between memory systems, we should ask how strong this evidence is. With regard to the picture in Fig. 1.6, do dissociations between measures of retention fall mainly between systems (the left and right columns), or can dissociations be found within systems, too? If dissociations between measures of retention are routinely found within systems, and if they are explicable by other principles, then dissociations between measures thought to reflect the operation of different systems must be given less weight as support for the systems viewpoint. Specifically, if dissociations between episodic (or semantic) memory tasks can be obtained, then one must either pursue post hoc arguments that postulate increasing numbers of memory systems, or seek a more parsimonious general principle that predicts such dissociations both within and between the alleged systems.

Let us first consider the case of possible dissociations within episodic memory, in the left hand column of Fig. 1.6. We need not review this evidence extensively, because experimental dissociations within episodic memory are so plentiful and well known. The numerous interactions in the standard encoding/retrieval paradigm (Fig. 1.1) that are taken as support for the encoding specificity principle all exemplify dissociations within episodic memory. One such dissociation is shown in Fig. 1.2, representing results from Morris et al. (1977). Dissociations within episodic retention are well established (see Tulving, 1983, chapter 11).

Fewer results are available to address the issue of dissociations within measures reflecting semantic (or procedural) memory, for the reason that few researchers have employed more than one test of semantic (procedural) memory in the same experiment under the same study conditions. One example revealing a strong dissociation within two semantic (procedural) tasks has been provided by Weldon and Roediger (1987, Experiment 4). They had subjects study a long series of pictures and words prior to an unspecified memory test. (Pictures represented easily named objects, and across subjects specific items were counterbalanced between the two modes of presentation.) After studying the words and pictures, different groups of subjects took one of two types of implicit memory test. One group was given the word fragment completion test, as employed by Tulving, Schaeter, and Stark (1982), in which letters are omitted from words and subjects are told to complete the word. The second group was given a picture fragment naming test in which subjects were given severely degraded pictures and were told simply to name each with the first word to come to mind. In both implicit tests, one-third of the test items represented studied pictures, another third represented studied words, and a final third were nonstudied items that served as a baseline for measuring priming in the other conditions.

The results of the experiment are shown in Fig. 1.7, which portrays the amount of priming on each test as a function of study condition (words or pictures). As is apparent, pictures produced much greater priming than did words on the picture fragment identification test, whereas words produced greater prim-

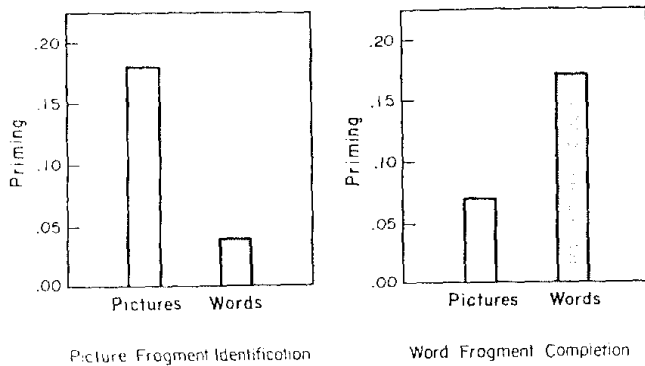


FIG. 1.7. Dissociation between two semantic memory tests. Pictures produced more priming than words on a picture fragment identification task, but words produced more priming on the word fragment completion test. Data from Weldon and Roediger (1987, Experiment 4).

ing than pictures on the word fragment completion test. The results show a strong dissociation between two semantic or procedural memory tests, and we suspect that many other interactions of this form could be produced.⁴ Such dissociations within the semantic or procedural memory system are quite natural from the procedural view, because both word fragment completion and picture fragment identification are data-driven tests and thus the match between surface features in the study events and test stimuli should determine performance. The results in Fig. 1.7 conform exactly to this expectation. On the other hand, these data showing dissociations between two semantic or procedural tests are difficult to interpret within the systems framework, unless one is willing to postulate more systems. Indeed, perhaps the data in Fig. 1.7 support the operation of separate verbal and imaginal systems (Paivio, 1986) within semantic or procedural memory. But, if so, one would then be postulating three memory systems to explain four data points. Certainly the transfer-appropriate processing idea is more parsimonious.

The foregoing review indicates that it is probably as easy to discover experimental dissociations within memory systems, either episodic/semantic or pro-

⁴In a related endeavor, Witherspoon and Mosevitch (in press) show stochastic independence between two tests both thought to tap the semantic or procedural system. This demonstration undercuts the use of stochastic independence between tests tapping different systems as support for separate systems, just as the present analysis criticizes the use of functional independence as such a criterion.

cedural/declarative, as it is to find dissociations between systems. This lessens one's enthusiasm for considering dissociations between measures as crucial evidence in the debate about memory systems and their nature. Three experiments reported in a dissertation by Blaxton (1985) reinforce this view. Experiment 2 is described briefly, but the general logic of all three was the same. Blaxton developed four tests of memory that were intended to fill the four quadrants of Fig. 1.6, with there being two versions of episodic (or declarative, or explicit) tests and two types of semantic (or procedural or implicit) tests. One test of each type was considered to be data-driven and one was conceptually driven. The episodic, conceptually driven test was free recall and the data-driven, semantic memory test was word fragment completion. These tests comprised the usual confounded comparison used to produce dissociations between episodic and semantic memory. The other two tests were novel. The data-driven, episodic test was graphemic cued recall in which subjects were given cues that looked (and sounded) like the target word in the list. For example, subjects might be given a cue word such as HAMHOCK to serve as a retrieval cue for HEMLOCK, with the instruction that the cue shared surface features with the target, but no semantic features. (The test is episodic, because subjects were told to use the cues to retrieve members of the recently studied list.) The conceptually driven semantic memory measure was priming in answering general knowledge questions. Subjects were required to answer questions such as "What did Socrates drink at his execution?", with the relevant target (HEMLOCK) having been studied under various conditions or not at all. Instructions to subjects were simply to answer questions, and no reference was made to the prior list; the relation between the query and target was conceptual and did not depend on surface similarity. Hence the test was of semantic memory, and was conceptually driven.

The four test conditions described here were administered to different groups of subjects following two different study conditions in Blaxton's (1985) Experiment 2. The study manipulation was simply whether or not words were presented visually or auditorily within the study list, there being a block of words in each mode for subjects taking each test. Modality often has large effects on implicit memory tests (e.g., Jacoby & Dallas, 1981) and little or no effect on explicit tests of long-term memory (e.g., Murdock & Walker, 1969). The question addressed by Blaxton was whether this dissociation was inherent in tests tapping different memory systems, or was produced by different modes of processing at retrieval. She expected that modality would have large effects on data-driven tests in which test stimuli were presented visually and thereby matched better the study items presented visually, but that little or no modality effect would be apparent on conceptually driven tests, regardless of the putative memory system tested. The results fully confirmed this reasoning, as is apparent in Fig. 1.8. First, examine the lower left and upper right quadrants of the figure, which illustrate a typical dissociation between episodic and semantic memory. Modality had no statistically significant effect on free recall (with a slight auditory

advantage), but visual presentation produced much greater priming than did auditory presentation in word fragment completion. However, examination of the two cells constituting the other diagonal leads to the conclusion that mode of processing, and not the memory system tapped, constitutes the basis for the dissociation. A modality effect was found on the other data-driven test, even though it tested episodic memory; but no modality effect was found on the other conceptually driven test, even though it tapped semantic memory. Fig. 1.8

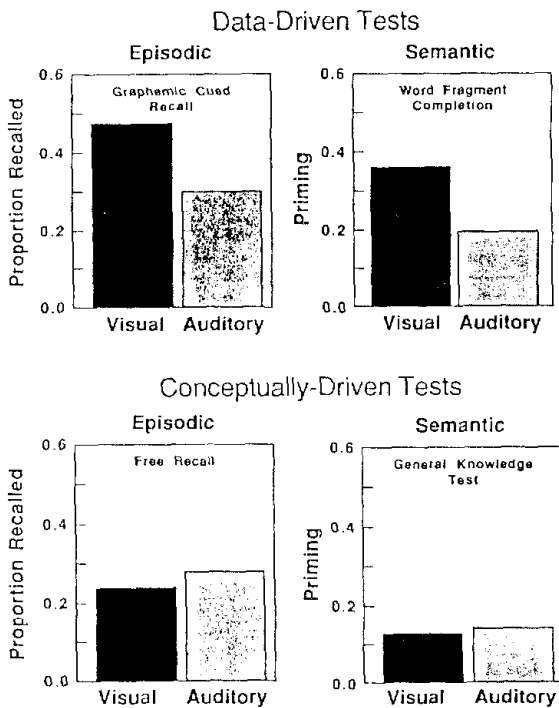


FIG. 1.8. Comparison of the effects of type of processing vs. memory system. The effects of study modality differ as a function of the type of processing involved in the retrieval tests, so that visual data-driven tests show large modality effects but conceptually-driven tests do not. Note that the distinction between episodic and semantic memory systems does not accommodate these results. Data from Blaxton (1985, Experiment 2).

shows that modality of presentation can produce dissociations within both episodic and semantic memory. The distinction between modes of processing provides a better account of the obtained dissociations in Blaxton's (1985) experiments than does postulation of memory systems, a statement that also aptly summarizes the gist of this section.

SPECIFYING THE TRANSFER OF PROCEDURES APPROACH

Critics of the idea of memory systems have complained about the obscurity of the theorizing (e.g., McKoon et al., 1986), raising such central problems as how memory systems are defined, or how operational definitions may be provided that will permit unambiguous knowledge of what system a test taps. In other papers one of us has been similarly critical of the fuzziness of memory systems as they are usually postulated (Kolers & Roediger, 1984; Roediger, 1984; Roediger & Blaxton, 1987b). However, our own critics have remarked to us (in letters, reviews, and bemused public observations) that they do not perceive any great advantage in specificity of theorizing in our description of dissociations in terms of transfer-appropriate processing. In this section we attempt to address this issue, elaborating on the remarks made in prior sections. We illustrate our arguments with data mostly from the word fragment completion test, because it is the one we have used most extensively, but we believe that the argument holds for other data-driven tests, too.

To reiterate points made earlier, we argue (a) for a procedural approach in which emphasis is placed on the mental operations performed during learning experiences and during test episodes, and on the interrelation of the two; (b) that performance will benefit to the extent that procedures invoked by the test recapture those used during prior learning; and (c) that an important dimension for this account lies in whether procedures are directed more at surface features of stimuli during study and test (data-driven processing) or at the deeper meaning of the stimuli (conceptually driven processing). The first two assumptions are stated rather generally, but are so familiar in one form or another in many different theories of learning and memory that we feel no further need to defend them here. The challenge comes in arguing that the data-driven/conceptually driven distinction first applied in this area of inquiry by Jacoby (1983) deserves its privileged status.

At the risk of seeming hopelessly old-fashioned in these days of wild and woolly cognitive science, we propose to ground our theorizing in operational definitions of our concepts, with these buttressed by converging operations (Garner, Hake, & Ericksen, 1956). These steps have the advantage of making our theoretical concepts amenable to observation, communication, and disconfirmation.

Operational Definitions

The distinction between data-driven and conceptually driven processing is undeniably fuzzy in our prior writings (Roediger & Blaxton, 1987b; Roediger & Weldon, 1987), and so here we propose a straightforward operational definition that would classify any task that uses verbal materials as either data-driven or conceptually driven. The crucial comparison (following Jacoby, 1983) is between the No Context and the Generate conditions within a generation experiment, in which a word (or other material) is either presented to the subject to be read out of context (XXX-COLD), or is produced by the subject in response to a related semantic clue (hot-??).⁵ We assume that reading a word without an appropriate semantic context involves data-driven processing, whereas generating a word from an associate or synonym involves conceptually driven processing. Thus, when the subject says "cold" following the display of XXX-COLD, we assume that the processes involved are largely bottom-up, or data-driven; on the other hand, when "cold" is spoken following "hot-???", we assume the processes involved are top-down, or conceptually driven (because no "data" for cold were displayed). Reading a word in context (hot-COLD), as in several of Jacoby's (1983) experiments, presumably involves both data-driven and conceptually driven processing.

From these assumptions, the following operational definitions of data-driven and conceptually driven tests follow: (a) Data-driven tests are those in which items studied in No Context conditions produce better performance than those studied under Generate conditions; and (b) conceptually driven memory tests are those in which items produced in Generate conditions produce performance superior to those studied in No Context conditions. Again, reading a word out of context involves data-driven processing, whereas generating it from associative clues involves conceptually driven processing.

Armed with these operational definitions, we can classify priming in perceptual identification as strongly data-driven (Jacoby, 1983), whereas typical recognition, free recall, and semantic cued recall tests are categorized as conceptually driven. (Recognition may have a small data-driven component—perceptual fluency as proposed by Jacoby & Dallas, 1981, or activation as proposed by Mandler, 1980—but others disagree; Watkins & Gibson, 1988.) Other explicit and implicit tasks can now be classified as data-driven or conceptually driven based on this operational definition. For example, Blaxton (1985, Experiment 1) sought to justify her classification of five tasks as data-driven or conceptually

TABLE 1.2
Proportion Correct from Blaxton (1985)

Type of Test	Study Condition		
	Generate	No Context	Nonstudied
Free recall	.30	.19	—
Semantic cued recall	.67	.51	.04
General knowledge questions	.50	.33	.25
Graphemic cued recall	.34	.45	.06
Word fragment completion	.46	.75	.27

driven based on a comparison of items studied in No Context and Generate conditions. Four of the five tasks (free recall, graphemic cued recall, word fragment completion, and answering general knowledge questions) were described previously, and the fifth test was semantic cued recall (e.g., POISON as a cue for HEMLOCK). Her basic results from the No Context/Generate comparison are shown in Table 1.2, where it can be seen that free recall, semantic cued recall, and priming on general knowledge questions can all be classed as conceptually driven (Generate greater than No Context), whereas graphemic cued recall and priming in word fragment completion are data-driven (No Context greater than Generate) by our operational definition.

Not all implicit memory tasks have been investigated sufficiently to know whether or not they should be classified as data-driven or conceptually driven, but priming in lowering visual duration thresholds (Winnick & Daniel, 1970; Clarke & Morton, 1983) and in the lexical decision task (Monsell, 1985; Neely & Tekman, in preparation) meet our criterion of No Context surpassing Generate conditions. We speculate that priming in word stem completion also will turn out to be data-driven by our definition. The important point is that any verbal task can be classified. For example, workers in social cognition have recently become interested in the role of priming on person perception (e.g., Srull & Wyer, 1980). In a typical paradigm, subjects are exposed to some material during a first phase in which (for example) many of the words have a hostile connotation. During an ostensibly unrelated second phase, they are asked to rate hypothetical people in terms of their personality traits when given various ambiguous behaviors. The measure of interest is how much the prior phase affects accessibility of the category (hostile) in describing the behaviors, compared to ratings of subjects who were not exposed to the material in the first phase. The general finding is large priming effects on measures of category accessibility that persist even over a delay of one week (Srull & Wyer, 1980). E. S. Smith and Branscombe (in press) asked whether category accessibility might qualify as a conceptually driven measure of implicit retention. They had subjects either read priming words in the first phase of an experiment, or generate them from conceptual clues. Later,

⁵Note that the comparison recommended here is not the one used in standard generation effect experiments (e.g., Slamecka & Graf, 1978), which is between items read in context (hot-cold) and those generated (hot-??). This last comparison is useful for studying the generation effect, because study conditions are held constant except for overt presentation of the target. However, for purposes of distinguishing data-driven and conceptually driven processes, the No Context/Generate comparison is more appropriate.

TABLE 1.3
Proportion Correct in Smith and Branscombe's (in press) Experiment

Type of Test	Study Condition		
	Generate	No Context	Nonstudied
Category accessibility	.52	.43	.34
Free recall	.61	.45	—
Word fragment completion	.43	.62	.41

on the category accessibility test, subjects were given a description of behaviors that were ambiguous and were asked to provide a one-word trait adjective to describe the behavior. Two other groups of subjects were given the same materials during the study phase but then were asked either to free recall the material or to complete words from fragments. (One set of traits was not presented during the study phase to assess priming on the category accessibility and word fragment completion tests.)

The results showed that priming in category accessibility can be classified as a conceptually driven implicit memory test, because the test revealed an advantage of items studied under Generate compared to No Context conditions. The basic results are shown in Table 1.3, where it can also be seen that a generation effect was obtained in free recall, but that No Context items produced superior priming to Generate items in primed fragment completion (replicating Blaxton, 1985). The Smith and Branscombe experiment illustrates well how a new implicit memory test can be classified as data-driven or conceptually driven via the No Context/Generate contrast (see also Srinivas & Roediger, in preparation).

Providing operational definitions for data-driven and conceptually driven processing in terms of the No Context/Generate contrast may pose problems, because the standard generation effect (involving a Context/Generate contrast) has recently been shown to be subject to numerous variables that may affect our definition. For example, it may disappear under between-subject conditions (Begg & Snider, 1987; Slamecka & Katsaiti, 1987; but see Hirshman & Bjork, 1988; McDaniel, Waddill, & Einstein, 1989) and with low-frequency words (Nairne, Puse, & Widner, 1985). Also, if the generation procedure is data-driven and the test is data-driven, then one might expect positive generation effects, or an advantage of Generate to Read (Gardiner, 1988; Nairne, 1988). Thus in applying our definition, one should bear in mind the clearest comparison, as specified in Jacoby (1983): (a) the No Context condition should involve reading words in a neutral context to enhance data-driven processing during study, and the Generate condition should involve producing words with minimal overt data (letters) specifying the target word; (b) the generation process must be driven by a conceptually related context, such as a synonym, antonym, or associate; and (c) a within-subjects contrast at study is preferred, to show opposite effects on the two classes of test with study conditions held constant.

We turn attention now to converging operations to specify tests as data-driven or conceptually driven. In brief, data-driven tests should be greatly affected by manipulations of surface information between study and test and relatively immune to manipulations involving conceptual elaboration. Conversely, conceptually driven tests should be little affected by manipulations of surface information, but strongly affected by conceptual elaboration.

Manipulation of Surface Variables

Earlier work by Roediger and Blaxton (1987b) presented considerable evidence that primed word fragment completion was greatly affected by surface variables, so here we provide just a brief review. The general notion is that if a task is defined as data-driven by No Context study conditions producing greater priming than Generate study conditions, then this test should also be greatly affected by other variations in surface information. Assuming a visual, linguistic test, these surface manipulations would include such things as modality (greater priming from visual rather than auditory study), symbolic form (greater priming from words rather than pictures), and language (greater priming from words in the same language as the test fragments, rather than from a different language). These same variables should reveal no effect or opposite effects on conceptually driven tests such as free recall. These predictions have been borne out for the word fragment completion test (see Durgunoglu & Roediger, 1987; Roediger & Blaxton, 1987a; Weldon & Roediger, 1987).

A summary of evidence concerning surface variables appears in Fig. 1.9. Plotted on the ordinate is the amount of priming (proportion of completed fragments following study of the concept minus proportion completed without prior study) and on the abscissa is the type of stimulus change between study and test. A word of caution is in order, because the data presented in Fig. 1.9 were collected from several experiments using different subjects, materials, and item sets; nonetheless, the data appear orderly. On the far left appears the amount of priming obtained when little or no change exists between study and test in the format in which the items appear. When typography is changed between study and test (handprinted in uppercase letters, typed in lower case letters) priming drops somewhat, but when items were presented auditorily and tested visually much less priming occurred (Roediger & Blaxton, 1987a, Experiments 1 and 2). Interestingly, when words were presented auditorily but subjects were asked to imagine their appearance when typed, priming increased compared to the unstructured auditory case (third column from the left compared to the fourth). When subjects studied pictures they showed slight but statistically significant priming on the word fragment completion test (Roediger & Weldon, 1987; Weldon & Roediger, 1987). The four columns on the far right reveal that little or no priming from other conceptual relations occurred in primed fragment completion. In completing a fragment such as M RE L for UMBRELLA, subjects showed no statistically significant effect from prior study of a synonym of the

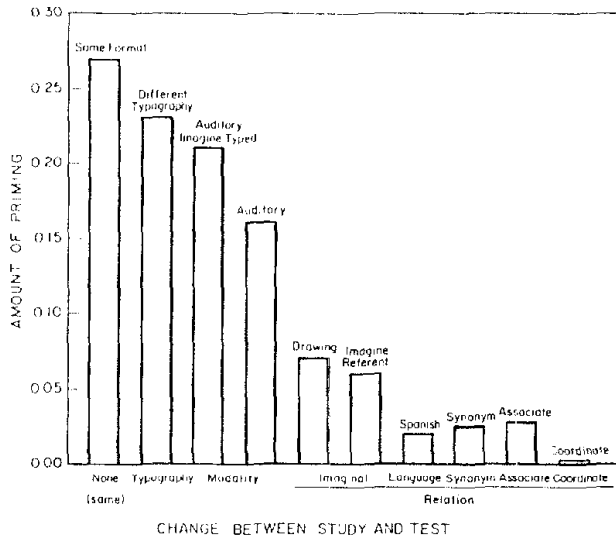


FIG. 1.9. Effects of surface variables on priming. Priming on the word fragment completion test declines as the match between the surface features of the study items and test fragments decreases. From Roediger and Blaxton (1987b).

concept (PARASOL), or an associate (RAIN), or a category coordinate (RAIN-COAT), or (for fluent bilinguals) a translation equivalent (PARAGUAS)—see Durgunoglu and Roediger (1987) and Roediger and Challis (in preparation). (We return to the last manipulations in the next section.)

The general conclusion to emerge from Fig. 1.9 is that the amount of priming falls off as a function of the dissimilarity between the study and test events. The interpretation is that the procedures induced by processing of study and test events become increasingly dissimilar as a function of the perceptual dissimilarity. Although we cannot take space to review the literature here, a similar case can be made that repetition priming in perceptual identification, lexical decision, and word stem completion are also quite sensitive to manipulations of surface features, which agrees with our speculation above that these represent data-driven tests.

One problem for the notion that primed fragment completion constitutes a data-driven test is that the amount of cross-modal priming is so great, and yet the

surface forms between auditory study and the visual fragment completion test are so different. If primed fragment completion is data driven, why should cross-modal priming be so great? A tentative answer may be that priming in word fragment completion (and probably other data-driven tests) does not depend only on a match of low-level surface features, but may depend as well on higher-level processes involved in word recognition ("lexical memory," as some would have it). Auditory and visual word recognition may involve overlapping processes at these higher levels, even though some other procedures may be mode specific. Kolers (1975) studied transfer in reading of transformed text in which reading a misoriented sentence of text was preceded by subjects either (a) reading the sentence in the same transformed orientation, (b) reading it in normal orientation, (c) hearing it read to them, or (d) hearing it in an alternate language that the subjects knew well. Transfer in speed of reading the target sentence occurred for all four study conditions, but these were ordered as given above from (a) to (d), with the last two conditions about equal. He interpreted the data as indicating that comprehension in all four study conditions necessitated procedures that were used in reading the target sentences later, but more procedures were shared when the prior sentence was read in inverted orientation. Tanenhaus, Flanigan, and Seidenberg (1980) have reported evidence consistent with the idea that orthographic features of words are automatically generated even when people only hear the words. Such features would help support priming on data-driven tests. Thus the extensive cross-modal priming in word fragment completion (as well as in word stem completion; Graf, Shimamura, & Squire, 1985) may provide an important key in determining what processes are involved in repetition priming (see Weldon, 1988).

Manipulation of Conceptual Information

The second converging operation for definition of tasks as primarily data-driven or conceptually driven is that manipulation of conceptual operations should affect performance on conceptually driven tests but have little effect (or an opposite effect, depending on the match in procedures between study and test events) on data-driven tests. A wealth of evidence supports the idea that levels of processing (Craik & Lockhart, 1972), imagery (Paivio, 1986), organization (Tulving, 1968), and other forms of elaborative processing have large positive effects in performance on conceptually driven tasks such as free recall and recognition. The issue is then whether parallel effects are found in data-driven tests; on the present account they should not occur, or should occur only weakly if the task has a small conceptually driven component. In general, evidence from perceptual identification falls in line, because Jacoby and Dallas (1981) reported no effect of levels of processing on priming while finding a large effect on recognition. Graf and Mandler (1984) and Graf, Squire, and Mandler (1984)

generally replicated this finding with primed word stem completion, although they often found a weak trend toward a "levels" effect across experiments. Roediger et al. (in preparation) found no levels of processing effect in primed word fragment completion, nor in word stem completion. Similarly, Carroll, Byrne, and Kirsner (1985) found no effect of processing level on repetition priming in picture naming or in perceptual identification of pictures, and Kirsner, Milech, and Standen (1983) found no effect of levels in the lexical decision task (but see Duchek & Neely, in press).

Turning to other research with primed fragment completion, so far every experiment has produced results exactly as expected. For example, Weldon and Roediger (1987, Experiment 1) had subjects study pictures and words and then take either a free recall test or the word fragment completion test. Pictures are thought to provide richer encoding than words, either through multiple codes (Paivio, 1986) or through stronger representation of semantic information (Nelson, 1979), so better performance would be expected for pictorial than verbal stimuli on conceptually driven tests. On the other hand, processes involved in the study of words (rather than pictures) should be more similar to those involved in word fragment completion. The results are shown in the top panel of Fig. 1.10 and conformed exactly to these expectations.

Durgunoglu and Roediger (1987) included conditions in a larger experiment that exemplified the same logic. They showed fluent Spanish-English bilinguals a mixed list of Spanish and English words and then gave them either a free recall or a word fragment completion test, with the fragments always presented in English. Because Spanish was the dominant language for most of these subjects, one can probably assume a richer code for Spanish than for English words and, as shown in the lower panel of Fig. 1.10, they recalled Spanish words slightly better than English words. However, with the greater match from study of English words to completing English fragments, the reverse pattern was obtained on primed fragment completion. Thus, in both experiments the conditions that could be assumed to provide richer conceptual processing produced better performance on the conceptually driven test of free recall, but this trend was reversed on the data-driven fragment completion test.

Roediger and Challis (in preparation) tested the same prediction in a different way. In two experiments they presented subjects with a long list of words followed by either a free recall test or a word fragment completion test. Three study conditions were of primary interest: (a) words were presented once in the list (*elephant*), (b) words were presented twice (*elephant-elephant*), or (c) words were presented and followed by a conceptually related word (*elephant-pachyderm*). When two items were presented, the lag between them was also manipulated, from zero (massed presentation) up to 31 intervening items. We assumed that re-presentation of the word as in condition (b) would force subjects to reprocess both the surface features and the word's meaning, at least with spaced presentations when one could assume that the word would be fully reprocessed

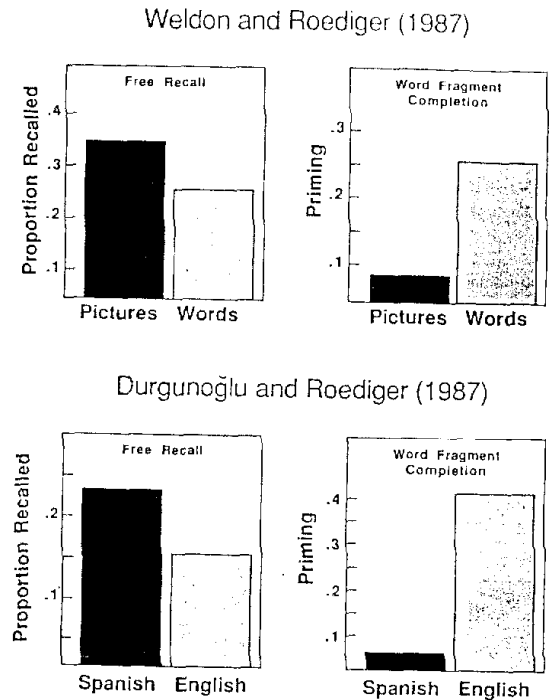


FIG. 1.10. Dissociation as a function of study format. In the top panel, pictures produced better performance than words on a conceptually driven free recall test, but words produced more priming than pictures on the data-driven word fragment completion test. Analogous results are shown in the bottom panel as a function of the language in which the words were studied. Data in the top panel are from Weldon and Roediger (1987, Experiment 1), and those in the bottom panel from Durgunoglu and Roediger (1987).

(Jacoby, 1978). Thus positive effects would be expected on either data-driven or conceptually driven tests. On the other hand, for the conditions that involved conceptual repetition, subjects would be expected to elaborate the conceptual processes but (because of the dissimilarity in surface features) no further data-driven processing would be expected of the target item due to the repetition of the

concept. Thus conceptual repetition should aid recall of *elephant* in free recall, but should leave unaffected the amount of priming in word fragment completion.

The results are shown in Fig. 1.11 for conditions in which presentations were spaced, combining data across two experiments so that each point is based on between 1,296 and 1,944 subject \times item observations, depending on the condition. Free recall results, in the top panel, show that repetition of a word under spaced conditions produced a sizeable increment in recall compared to its single presentation. Of primary interest is the finding that conceptual repetition also enhanced recall of the target item, as predicted, but only about half as much. The primed fragment completion results appear in the bottom panel, where a different pattern is evident. Presenting the same word twice under spaced conditions enhanced the amount of priming, but conceptual repetition produced no benefit at all compared to priming from a single presentation. In Fig. 1.9 we showed results indicating that semantic priming does not occur in fragment completion, at least with a delay of some 15 minutes between study of a word (*pachyderm*) and test on its fragmented alternate form (LFPAN); the results in the bottom of Fig. 1.11 extend this finding by showing that even when the target has been studied, conceptual repetition fails to enhance priming.

Taken together, the results from this section support the conclusion that the data-driven task of primed word fragment completion is insensitive to manipulations of conceptual factors. Little research exists as to whether or not the same conclusion holds for other implicit tests that we believe to be data-driven, but priming in perceptual identification and word stem completion show little or no effect of levels of processing. Also, presentation of pictures, or of words in an alternate language for bilinguals, produces little or no effect on priming in perceptual identification or lexical decision (e.g., Kirsner, Miclech, & Stumpfel, 1986; Kirsner, Smith, Lockhart, King, & Jain, 1984).

Test Orientation

One other dimension critical to determining the nature of retention tests is test orientation or retrieval orientation (Graf & Mandler, 1984; Nelson, Canas, Bajo, & Keelean, 1987). This dimension refers to the instructions that subjects are given when tested. On explicit tests, subjects are given instructions to retrieve recent experiences; on implicit tests, subjects are usually given some sort of cue and simply told to produce the first thing to come to mind that somehow fits or completes the cue. We believe that implicit instructions, when given in conjunction with perceptually degraded test stimuli, constrain the subject to be primarily guided by the surface features of the cue. That is, data-limited test stimuli must be resolved on the basis of perceptual operations.

This conclusion is derived in part from experiments by Weldon and Roediger (1987; see too, Weldon, Roediger, & Challis, 1989). They found the usual pictorial advantage in free recall when people studied pictures rather than words.

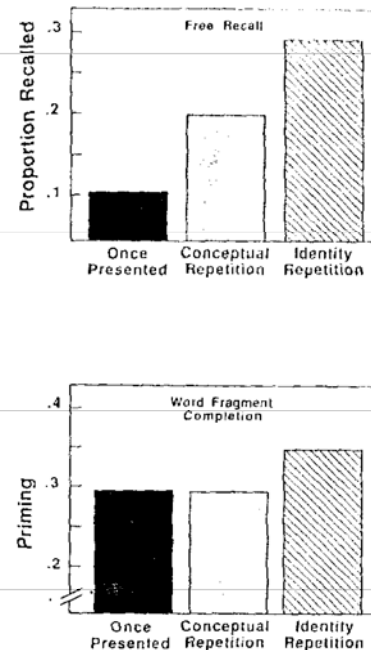


FIG. 1.11. Repetition effects in free recall and word fragment completion. Both identity repetitions (umbrella-umbrella) and conceptual repetitions (umbrella-parasol) improved free recall over single presentations. On the word fragment completion test, however, only identity repetitions, which repeated identical surface forms, boosted priming beyond levels obtained with single presentations. Data from Roediger and Challis (in preparation).

but this reversed on priming in word fragment completion (see the top panel of Fig. 1.10). Prior study of words produced greater priming than prior study of pictures, which the authors attributed to the data-driven nature of the test. But many other studies in the literature have shown that the picture superiority effect is obtained in tests of word recognition (see Madigan, 1983). That is, prior study of a picture of an elephant (instead of study of the word) supports better recognition of the word *elephant* on a later test. Yet surely the word *elephant* on the test

matches the studied word better than its pictorial counterpart. The test word in recognition should also provide a better match than the fragment, *__LEP-__AN__*, and yet primed fragment completion is a data-driven test and word recognition (where more data are presented) is not. Why? Test orientation must play a critical role. In fragment completion and other implicit tests subjects are told to produce the first thing that comes to mind in response to the fragment, which constrains them to be guided by surface features of the fragment. In standard slow-paced recognition tests, on the other hand, perceiving the word is easy; the challenge is to match the concept derived from the test word to the memories of recent experiences. Therefore, recognition is less affected by the match of perceptual processing between study and test events.

In summary, test instructions also play a role in determining processing mode. Although it is certainly possible to implement a data-driven episodic memory test, it is difficult to keep subjects focused on the perceptual nature of word cues and away from their meaning (Blaxton, 1985). Explicit test instructions seem to encourage conceptually driven processing, probably because we normally retrieve the meaning of events. Implicit test instructions, in conjunction with data-limited displays, probably encourage more superficial processing and attention to surface features. However, we suspect from our own work that when subjects are given cues perceptually similar to target items but with explicit instructions, it will be difficult to override data-driven retrieval (Roediger & Weldon, 1987; Weldon et al., 1989).

ADVANTAGES AND DISADVANTAGES OF THE TRANSFER OF PROCEDURES APPROACH

We believe that the procedural approach described in this chapter accounts well for dissociations in remembering, at least for the bulk of the evidence collected from normal subjects. The ideas are similar to those proposed by Tulving and Thomson (1973), Morris et al. (1977), and Kolers and Roediger (1984) to account for numerous phenomena in other domains, so the breadth of explanatory power should be great. A major premise of this approach is that the existence of dissociations among measures of retention does not require postulation of special systems. As Kolers and Roediger (1984) noted, it is not the fact of "dissociations that needs to be explained, for that is the natural state of affairs: it is the characteristics of tasks—and relations among their underlying procedures—that needs explaining" (p. 439).

In this chapter we have tried to specify our ideas, particularly with regard to the distinction between data-driven and conceptually driven processing. We have provided an operational definition that should permit investigators to determine whether a particular task employing verbal materials is data-driven or conceptually driven. We have also specified converging operations. These statements

permit falsification of the theory. For example, tasks classified as purely data-driven should not be affected by encoding variables that cause elaboration of processing, but should be affected by manipulations of surface features. Similarly, tasks determined to be conceptually driven by our litmus test of a positive generation effect should be unaffected by manipulations of surface variables, but should be influenced by elaborative factors. The procedural approach also predicts the form of an interaction or dissociation among study and test conditions, rather than simply predicting some dissociation.

The primary drawback we see in the procedural approach is its inability to account easily for certain phenomena found in amnesic patients. The primary impetus for our investigations of dissociations among memory measures came from observations in amnesic patients, so ideally we would like the ideas to apply forcefully to phenomena in that domain. And they do, but only up to a point. Perhaps the most natural extrapolation would be to argue that amnesics should show preserved priming on data-driven tests of retention, but not on conceptually-driven tests. The perceptual record may be intact for amnesics, so this story would go, but their brain injury may have rendered them incapable of deriving benefits from elaborative processing. A check of the data bearing on this hypothesis may be made by referring back to Table 1.1, which lists the tasks on which amnesics show preserved priming, according to Shimamura's (1986) review. The data-driven hypothesis of preserved priming works well for most of the tasks—repetition priming in completion of fragmented pictures and words, lexical decision, perceptual identification, and (arguably) for preference judgments and for spelling of homophones, although little is known about these last two tasks. However, preserved priming in free association tasks with semantic cues (e.g., Gardner, Boller, Morenes, & Butters, 1973) and in word completion with new associates (Graf & Schacter, 1985) cannot be covered by the simple view that preserved priming always reflects data-driven processing. Because preserved priming has been shown on what seem to be conceptually driven tasks, we must abandon the simplest extension of our ideas to the full range of amnesic tasks.

The failure of our theory to deal with the full range of preserved priming in amnesics is unfortunate, but we hardly see any reason to abandon it on that account. Part of the problem is simply the greater specificity of our views on what should be preserved. All the tasks in Table 1.1 might be said to reflect procedural knowledge, or alternatively the operation of semantic memory. But these terms and their contrasts (declarative and episodic, respectively) are not as well specified as are the postulated forms of processing discussed previously. We do not have operational definitions of either set of terms, much less a set of converging operations.

Moscovitch (1984) reviewed the literature on preserved priming in amnesia and concluded that three features appeared in all tasks on which preserved priming occurs. First, the tasks were highly structured so that the goals and

means to achieve them were clear. Second, the strategies and responses needed to accomplish the tasks already existed in the subjects' repertoires. Third, task performance did not require reference to particular postmorbid episodes. One could posit a memory system that had just these properties, of course, and say that it was spared in amnesia, but we prefer Moscovitch's (1984; Moscovitch, Winocur, & McLachlan, 1986) functional approach that focuses on specification of the necessary and sufficient procedural requirements for determining preserved priming (see Weiskrantz, this volume, too).

CONCLUSIONS

We have argued for a theory emphasizing transfer-appropriate processing, and against the notion of separate memory systems, to explain dissociations among measures of retention. We now retreat from this hard line by making a few additional points in conclusion. First, as we noted earlier, it seems likely that more than one memory system exists in the human brain for comparative and phylogenetic reasons. The human brain is larger and more complex than any other brain and it seems likely that more complicated mechanisms exist than in many creatures with less complex neural structures and relatively simple abilities to learn. Second, elegant animal work by Mishkin and Appenzeller (e.g., 1987), Olton (this volume), and others clearly shows operation of different neural structures in various forms of learning. However, the direct relevance of this evidence for the particular theories advanced to account for preserved priming in amnesics, and other dissociations among memory measures, is not clear at this time. The reason is related to the first point: the animal work has been conducted with systems less complex than the human brain. The interesting observations from amnesics and from normals is that intact priming occurs even for verbal material, and thus work with rats or even monkeys may not uncover how this verbal information is represented. Third, we must admit that there is no inherent reason that an approach specifying both memory systems and something like processing modes or procedures cannot be partially correct. Neural structures require processing for their operation, and procedures must be carried out by the brain. A theory specifying both structural bases and processing assumptions is needed (Anderson, 1978), but those presently on the scene emphasize either structure to the relative neglect of processing assumptions (the systems approaches) or processing assumptions to the relative neglect of structure (our own approach). We defend our own bias at the present stage of knowledge as more fruitful, because it focuses attention on the procedural (behavioral) aspects of performance and deflects attention away from the metaphysics of identifying hidden systems and wondering in what complex arrangements they may be ordered. In contrast, our own approach lays out a program of research needed for its proper test, which

will also provide a wealth of basic information about the tasks thought to reflect implicit retention.

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