COGNITIVE METHODS

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IMPLICIT MEMORY TASKS IN COGNITIVE RESEARCH

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Our aim in this chapter is to describe some important issues to consider when designing and conducting implicit memory experiments. These are both conceptual questions (how can one determine if a task is implicit?) and methodological and practical issues (the nitty-gritty issues of research). Many different methods have been used under the loose banner of *implicit memory research* and various traditions have developed. We cannot cover all approaches in one chapter, but we provide an overview of some relevant methods and techniques.

As discussed in chapter 7, explicit memory tests—those assessing conscious recollection—have typically been used in memory research. These tests assess memory directly, by asking people what they can recollect (with a whole variety of procedures). For example, participants may see a set of pictures and words and be asked to recall or recognize them at a later point. Many experiments assessing implicit memory are formally rather similar to explicit memory experiments in that participants may study pictures or words, and their memories are assessed in a later test. The difference is that implicit tests measure retention indirectly, usually by having participants perform some ostensibly unrelated tasks, such as trying to name fragmented words or pictures or generating as many items as possible that belong to a certain category. Thus, implicit retention is measured by the benefit from recent study of the word or picture on the task of interest. This benefit in performance is called priming (Schacter, 1987).

The first part of our chapter describes the two main types of implicit tests that have been used and that were introduced in the preliminary chapter: perceptual and conceptual tests. In the previous paragraph, the word fragment and picture fragment naming tests represent examples of perceptual implicit tests, in that performance relies on processing at the level of the percept, whereas the category generation test is a conceptual test because performance on it relies on processing at the meaning level. In the remainder of the chapter we discuss critical issues faced when employing these tests and experimental techniques that can be used to address these issues. We end the chapter with some general advice for procedures to employ when conducting implicit memory research.

TYPES OF IMPLICIT TESTS

The perceptual and conceptual test distinction was proposed by Roediger and Blaxton (1987), following a suggestion by Jacoby (1983b). Criteria for classifying a test as predominantly of one or the other type were proposed by Roediger, Weldon, and Challis (1989; see also Blaxton, 1989; Tulving & Schacter, 1990). We consider these types of tests below. In all tests, the measure of interest is either the probability of producing a response or the speed with which the response can be produced (see Toth, 2000, for a comprehensive list of implicit memory tests).

Perceptual Implicit Memory Tests

Perceptual tests are those in which participants are typically presented with a degraded or rapid presentation of a stimulus that must be identified. Priming on such tests is highly sensitive to the perceptual format used in presentation, such as stimulus modality (auditory or visual) or type of representation (e.g., picture or word). For example, degraded words (word fragments) show more priming for items that were presented as words than as pictures at study, but degraded pictures (picture fragments) show more priming for items that were presented as pictures than as words at study (Weldon & Roediger, 1987). These tests are relatively insensitive to meaningful manipulations that greatly affect explicit tests, such as variations of orienting tasks in what are usually called levels-of-processing experiments (e.g., Jacoby & Dallas, 1981). Roediger (2003) estimated that 80% of all published implicit memory research has used perceptual implicit tests. We consider some of the most popular variations here. For the discussion below, we assume that participants have recently studied a long list of pictures and/or words. In such experiments, the items used refer to concrete objects that can be presented as either words or pictures. During the test, fragmented forms of words or pictures are presented along with some fragments representing nonstudied items, to serve as a baseline measure against which to assess priming. We turn now to some popular perceptual implicit memory tests.

Word and Picture Identification

In this type of test, the words or pictures are presented very briefly and are usually followed by a backward mask, with pretesting determining a good level of baseline performance (somewhere between 25% and 40%). The stimulus display and testing must be done by computer (or, in older research, a tachistoscope). Priming in this task is measured by the percentage of stimuli identified that had been previously presented relative to the nonstudied completion rate. Jacoby and Dallas (1981) used this technique with words in a seminal paper. Interestingly, participants report that primed items on identification tests appear to stay on the screen longer than the new words, even though they are presented for the same amount of time. In turn, subsequent studies have used these subjective reports as a measure of priming (Witherspoon & Allan, 1985). We describe this type of implicit test below.

A variant on this identification technique is to present test stimuli in increasingly complete fragments; for example, the participant gets a much degraded fragment of a picture or word, a less degraded version, and so on until the picture or word is identified. In this case, the level of degradation needed to identify the picture is the measure of interest. Snodgrass's work (Snodgrass & Corwin, 1988; Snodgrass, Smith, Feenan, & Corwin, 1987) provides a good reference for such experiments. Similarly, words can also be slowly revealed on the screen, with each successive screen presenting a clearer and more complete view of the word, with the degree of clarification needed for identification serving as the dependent measure of priming (see Hashtroudi, Ferguson, Rappold, & Chronsniak, 1988; and Johnston, Hawley, & Elliot, 1991, for examples).

Word and Picture Fragment Completion

The word fragment completion test also involves giving people degraded forms of words. Here, people see words with missing letters, such as e_e_h_n_ or a_ _a_ _in, and are asked to guess the items (*elephant* and *assassin* in these cases). Tulving, Schacter, and Stark (1982) first developed this test, which has been used frequently. Typically, participants are given about 15 seconds to complete the fragment, and often only one word in the English language will complete it. If participants cannot complete the fragment, they leave it blank and advance to the next test fragment. The picture fragment naming test is similar, except that a fragmented picture (one with missing line and corner segments) is given, and the participant's task is to name the picture from a single long exposure. Priming in both tests is measured by subtracting the proportion of fragments completed in the baseline (nonstudied) condition from the proportion completed after items had been in the study list. Weldon, Roediger, Beitel, and Johnston (1995) provide experimental examples of both word fragment and picture fragment priming.

Word Stem Completion

This is perhaps the most popular task for studying perceptual implicit memory and was used in much of the early research with brain-damaged patients (e.g., Squire, Shimamura, & Graf, 1987; Warrington & Weiskrantz, 1970). The word stem completion test is similar to the word fragment completion test, in that participants are given a perceptually degraded version of a word and are asked to complete it with the first word that comes to mind. In this task, however, they are presented with the first three letters of the word (e.g., str-) after participants had studied *strawberry*. Again, priming is measured by subtracting the proportion of word stems completed with nonstudied words from the proportion of stems completed with studied words. Unlike the case of word fragment completion, word stem completion experiments are usually designed such that 10 or more completions are possible for any word stem. This means participants can always complete the stem, and so they find the task easier than word fragment completion in which many items are skipped. One problem is that base rates are often low (10% or so) in this task and the amount of priming obtained is sometimes small (relative to priming on word fragment completion tests). Still, in direct comparisons of word fragment and word stem completion, the tests behave rather similarly (Rajaram & Roediger, 1993; Roediger, Weldon, Stadler, & Riegler, 1992). Nelson and his colleagues have developed variants of stem completion tests in which participants get the last few letters of words rather than the first few letters (e.g., Nelson, Schreiber, & Holley, 1992).

Other Perceptual Tests

Several other perceptual implicit tasks have been used, although much less frequently than ones described in the previous sections. As in the previous tests, participants study stimuli (typically pictures or words) and are given a task to examine the influence of the studied stimuli on performance. First, there are auditory counterparts to most of the tests already described, such that one can have an auditory identification task that involves identifying words presented in noise, or auditory equivalents of word stem and word fragment completion (see Pilotti, Bergman, Gallo, Sommers, & Roediger, 2000; Pilotti, Gallo, & Roediger, 2000; Schacter & Church, 1992). Other tests include duration judgments as discussed earlier (how long was the stimulus presented?), the lexical decision task (deciding whether or not a letter string is a word; see Duchek & Neely, 1989), the anagram solution task (solving anagrams for studied and nonstudied words, see Srinivas & Roediger, 1990), and the homophone spelling task (showing priming in spelling an auditorily presented word such as *reed* when this sound/meaning of the word had been primed; see Jacoby & Witherspoon, 1982).

Two nonverbal tasks are picture naming (Mitchell & Brown, 1988), in which participants quickly name pictures, and object decision, in which participants see drawn forms and have to decide whether each could represent a real object (Schacter, Cooper, & Delaney, 1990). As in the lexical decision task, the participant must make a decision by pressing one of two keys to indicate whether the presented object is possible or impossible (rather like deciding that a letter string is or is not a word). Although all of these tests are usually considered perceptual implicit memory tests, it is difficult in some cases to apply the operations specified by Roediger et al. (1989) to determine if they meet the proposed criteria. Still, there is reason to believe that these tests are perceptual in nature.

Performance on the implicit memory tests just described depends on perceptual analysis of items, and priming depends primarily on the match in perceptual processing between study and test presentations (Roediger, 1990). A reasonable question is whether these tests are more or less equivalent to one another, or whether they differ in important ways. It is surprising that relatively few attempts have been made to compare perceptual implicit tests directly, although it is known that the verbal and pictorial types of test differ markedly in the types of prior experience that produce priming (Weldon & Roediger, 1987; Weldon et al., 1995). As mentioned earlier, this sort of inquiry does show distinctions among these types of perceptual tests (studying words leads to an advantage on verbal tests, whereas studying pictures leads to an advantage on picture tests).

Rajaram and Roediger (1993) directly compared priming on four verbal implicit memory tests that involved visual test presentations of words: word identification, word fragment completion, word stem completion, and anagram solution. Groups of participants were exposed to items during study by reading words, hearing words, seeing pictures representing the names of the item, or (for the baseline condition) not being presented with the items at all. After study, participants received one of four types of test. The amount of priming from the three study conditions relative to the baseline is shown in Figure 8.1. As can be seen, despite some differences in priming across the four tests, visual presentations of words always produced greater priming than did auditory presentations, whereas both created more priming than did pictorial presentations. (In many experiments, little or no priming occurs from studying pictures on verbal tests and, similarly, little priming occurs from studying words on pictorial tests; see McDermott & Roediger, 1994; Srinivas, 1993). Of course, other tests such as homophone spelling may reveal a quite different pattern, but at least with regard to the four tests they used, Rajaram and Roediger concluded that these verbal implicit memory tests were broadly similar across these variables.

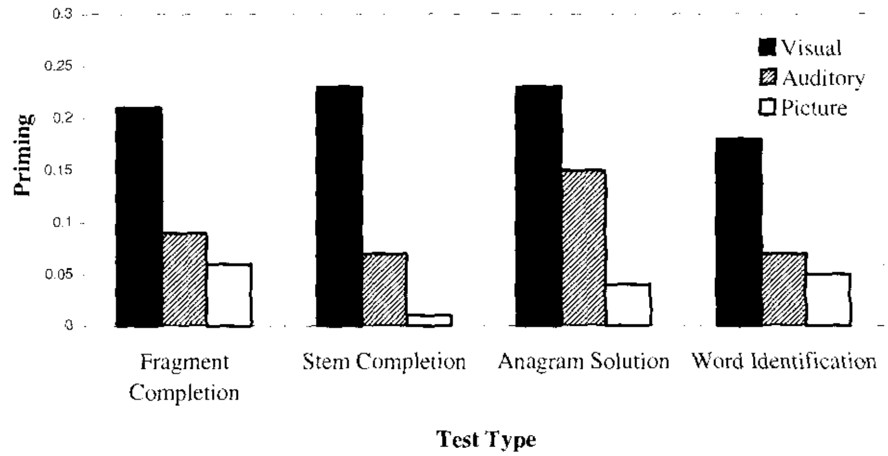

Figure 8.1. Relative priming on four implicit memory tests as a function of study condition. From "Direct Comparison of Four Implicit Memory Tests," by S. Rajaram and H. L. Roediger III, 1993, *Journal of Experimental Psychology: Learning, Memory, and Cognition, 19,* pp. 765–776. Copyright 1993 by the American Psychological Association. Reprinted with permission.

Conceptual Implicit Memory Tests

Conceptual tests represent the other class of implicit memory tests. These tests are relatively insensitive to perceptual factors manipulated at encoding (e.g., reading rather than hearing words does not affect priming). Instead, priming on these tests relies on the similarity of conceptual analysis of the items between study and test. The greater the overlap in conceptual processing, the greater the priming on these tests. As with perceptual implicit test items, performance on the nonstudied (baseline) conditions should be assessed to ensure that it is neither too high nor too low to observe priming. A general problem on some conceptual implicit tests is that the levels of priming can be fairly low, which makes them hard to study as a function of independent variables. In addition, these tests are much less frequently used and studied relative to perceptual tests. Perhaps 10% of all implicit memory tests have used conceptual implicit tests, and relatively few studies have employed both perceptual and conceptual implicit tests (a tradition begun by Blaxton, 1989).

Word Association

Perhaps the most commonly used conceptual implicit test is the word association test (see Shimamura & Squire, 1984). Participants study a list of words (e.g., including *bread*) and during the test they are given a set of weakly associated words (e.g., *wheat*) and are asked to produce associated words for 15 or 30 seconds. The interest is in how much prior study of *bread* will prime people to produce it as an associate to *wheat*, relative to the nonprimed condition (producing *bread* as an associate to *wheat* when *bread* was not studied in the list).

Category Production

The category exemplar production test is similar to the word association test, except that people are given category names on the test and are asked to produce as many examples from the category as they can in 30 seconds. So, participants study a list of words that are all from different categories (e.g., *trout, shoes, bureau*) and are later given a list of categories corresponding to studied items (e.g., *fish, clothing, furniture*) and some corresponding to nonstudied items (e.g., *professions*). At test, participants read the category labels and are told to write down category members within a specified period of time. Priming is obtained when people are more likely to produce a category exemplar when they have studied it than when they have not. Srinivas and Roediger (1990) provide an example of this test.

General Knowledge

Another way to measure conceptual implicit memory is to have people study a list of words (e.g., *strawberry*) that are answers to general knowledge questions (e.g., "What fruit wears its seed on the outside of its skin?"). Blaxton (1989) used this test. Included in the test, of course, are several general knowledge questions for which answers have not been presented in the study phase, to assess priming. The increase in general knowledge answers for studied items over nonstudied items is attributable to priming.

Other Conceptual Tests

There are several other conceptual implicit memory tests that can be used. These tests differ from the tests just described in two ways. First, they do not require production of the studied word, which is sometime preferable with certain populations that may differ in production ability (such as younger and older adults). Second, these tests also differ slightly from the others in that they contain the percept of the studied word. As such, these tests may demonstrate some perceptual priming, in addition to conceptual priming.

One example is the category verification test. As with the category production test, participants study lists of items from different categories (e.g., *strawberry*). At test, however, they are given a category name and a possible exemplar and are asked to indicate whether or not the item is a member of the category (A *type of fruit: strawberry*). Because people rarely make errors on this test, priming is typically measured in reaction time to either verify or disconfirm category membership. Priming is measured by examining the decrease in reaction time to respond to studied exemplars as compared with nonstudied exemplars. Tenpenny and Shoben (1992) provide a good example of use of this test.

Other tests include subjective judgments of fame and truth. In the case of fame, people read nonfamous names (Sebastian Weisdorf). On a later test people judge whether a name is of a famous person. Familiarity with the names (as a result of study) is misattributed to the belief that the name is famous, so Sebastian Weisdorf may be mistakenly judged to be a famous name (Jacoby & Kelley, 1987). One can also ask people whether certain statements are true or false (e.g., Hasher, Goldstein, & Toppino, 1977). In this test, as in the previous one, people are more likely to say that a statement is true when they have seen the statement previously than when they have not, the mere-truth effect. Thus, implicit memory is measured by a change in one's subjective judgments. Changes in subjective judgments have also been demonstrated for judgments of difficulty: people judge that anagrams are easier when they have studied their solutions than when they have not (Kelley & Jacoby, 1996), and they judge that reading passages is easier when they have read them before than when they have not (Kelley, 1999).

The study of conceptual implicit memory tests is still in its infancy. Many variants of these tests can be created from numerous conceptual tasks. The study of conceptual implicit tests may, in the long run, be seen as more important than perceptual tests. After all, the knowledge distilled from educational experiences and from other forms of past learning is typically expressed in making judgments and decisions in life with more of an implicit than an explicit retrieval orientation. That is, in making a decision in business we rarely consciously think back to what we have learned but rather seem to bring the totality of our past experience to bear in making a current judgment. Our past experience with the relevant concepts then is expressed in our judgments, decisions, and behavior.

CRITICAL ISSUES IN IMPLICIT MEMORY RESEARCH

In this section of the chapter we consider some central issues in implicit memory research that all researchers face, along with tips on how to handle these issues. In many cases, there are no absolute right or wrong answers to tricky issues raised during such research, but rather more and less effective ways to address them.

Equating Processing Demands

In a typical study exploring implicit memory, the experimental contrast is between performance on one explicit memory test and one implicit memory test with some independent or participant variable manipulated. For example, Roediger and Blaxton (1987) contrasted free recall with word fragment completion as a function of modality of presentation; Jacoby and Dallas (1981) contrasted performance on perceptual identification with recognition memory. The attempt in these cases is to compare a conscious, aware (recollective, explicit) form of memory with one that is unconscious or unaware or nonrecollective or implicit. Operationally, explicit and implicit tests differ by instructions, with the former tests using intentional recollection instructions ("recall or recognize recent events") and the latter using incidental retrieval instructions in which participants are simply told to perform the task as well as possible (Jacoby, 1984; Roediger & McDermott, 1993). Although this intentional/incidental contrast is the variable of interest, one confounding issue is that explicit and implicit tasks differ in processing demands that the tasks place on the cognitive system. For example, free recall and word fragment completion, two tasks studied by Roediger and Blaxton (1987) among others, differ not only in their intentionality of retrieval, but also in their processing demands. Most implicit memory tests require perceptual reanalysis of the studied item in completing the task, whereas typical explicit tests draw more on conceptual processing (Roediger, 1990). Recognition and perceptual identification, the tests used by Jacoby and Dallas (1981), seem better because in both tasks participants receive the whole stimulus. However, even these two tasks may differ somewhat in their processing demands because in one test the item is presented slowly (recognition) and in the other it is presented for very brief periods (30 ms). The simultaneous mismatch in processing demands and intention to retrieve between explicit and implicit tasks can hamper the conclusion drawn in comparisons between test types.

One solution that can be employed to blunt this problem has been called the *retrieval intentionality criterion* by Schacter, Bowers, and Booker (1989). Experiments that use the retrieval intentionality criterion hold constant all conditions of testing except for the instructions, which should either tell the participant to refer to the study list to do the task (explicit instructions) or make no mention of the study session (implicit instructions). (Study conditions in explicit and implicit test comparisons are held constant as a matter of course.)

Consider an experiment by Roediger et al. (1992). In one condition, participants studied a long list of words under two encoding conditions, one that directed participants' attention to the physical features of words and the other of which directed attention to meaning. At test, four different groups of participants were given either word stems or word fragments as cues with either intentional (explicit) or incidental (implicit) instructions. Note that the processing demands of the test are now equated; two groups of participants are tested with word stems under either explicit or implicit instructions, and two other groups receive word fragments with the same instructions.

The results of Roediger et al.'s (1992) experiment are shown in Figure 8.2 (for word stem tests) and Figure 8.3 (for word fragment tests). In each case, the type of orienting task (physical or semantic) had a large effect on

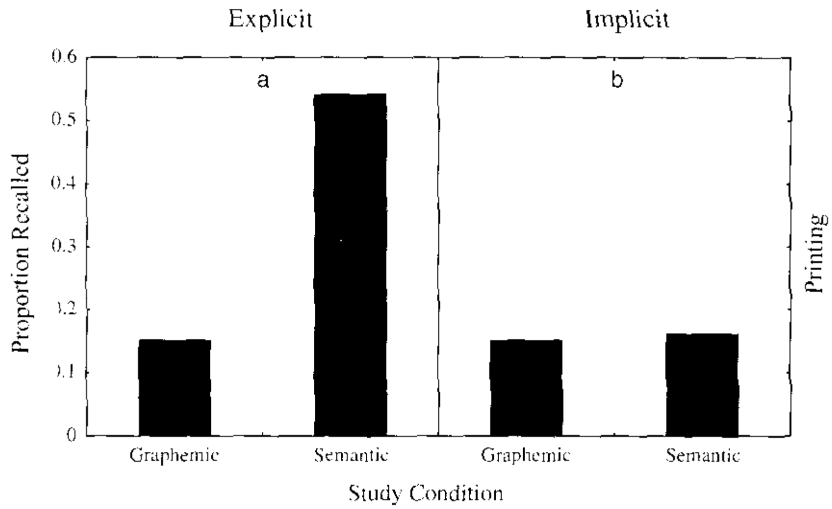

Figure 8.2. Performance on the stem completion task as a function of the type of instructions (explicit or implicit) and study condition. From "Direct Comparison of Two Implicit Memory Tests: Word Fragment and Word Stem Completion," by H. L. Roediger, M. S. Weldon, M. L. Stadler, and G. L. Riegler, 1992, *Journal of Experimental Psychology: Learning, Memory, and Cognition, 18,* pp. 1251–1269. Copyright 1992 by the American Psychological Association. Reprinted with permission.

performance on the explicit test but little or no effect on the amount of priming on the implicit test, even with processing requirements (producing an item to a stem or fragment) held constant. The important point is that strong differences between explicit and implicit tests can still be found even with the overt processing demands of the task equated.

The retrieval intentionality criterion is used on some perceptual implicit tests, but it is difficult to extend the logic to all implicit tests. For example, in word identification, where items are presented extremely briefly, it would be difficult to have an explicit counterpart of the test that equated processing requirements (although see Richardson-Klavehn, Lee, Joubran, & Bjork, 1994, Experiment 3). Similarly, the logic can be used on conceptual implicit memory tests, but because these tests and explicit tests are both conceptual in nature, it might be harder to find dissociations between tests.

Another criterion that has been generally used to define tests as implicit is whether the test shows preserved priming in amnesic patients. The assumption is that amnesics are at least impaired in explicit, conscious recollection and in the most severe cases, such as H. M. (Milner, 1966), K. C. (Tulving, 1989), or E. P. (Hamann & Squire, 1997; Stark & Squire, 2000), such a form of memory may be lacking altogether. The important point is that strong differences between explicit and implicit tests can still be found even with the overt processing demands of the task equated. If such patients show perfectly intact priming on a task, then the task would seem to be rea-

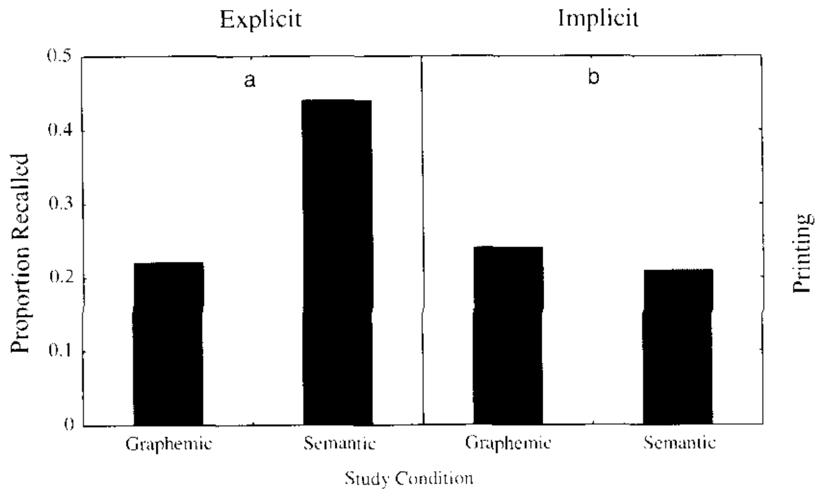

Figure 8.3. Performance on the fragment completion task as a function of the type of instructions (explicit or implicit) and study condition. From "Direct Comparison of Two Implicit Memory Tests: Word Fragment and Word Stem Completion," by H. L. Roediger, M. S. Weldon, M. L. Stadler, and G. L. Riegler, 1992, *Journal of Experimental Psychology: Learning, Memory, and Cognition, 18,* pp. 1251–1269. Copyright 1992 by the American Psychological Association. Reprinted with permission.

sonably classified as implicit. This logic is true as far as it goes, but the fact that amnesic patients show intact priming on the task in one experiment does not necessarily mean that the task has the same status when used under somewhat different conditions, with different participant groups, in other experiments. Nonetheless, some tasks are generally classified as implicit because of having met the criterion of being intact in amnesic patients. We turn next to the general problem of minimizing aware uses of memory in healthy populations of participants.

Limiting Conscious Recollection on Implicit Tests

Implicit tests are designed to measure unintentional uses of memory, but many researchers have worried that performance on these tests can become contaminated by consciously controlled uses of memory. Such contamination is not a great danger when patients with severe memory impairments are tested, but much implicit memory research uses healthy participants such as college students. These participants are told to perform a task (such as completing word fragments or word stems) to the best of their ability, with *no mention made of the possibility of using conscious recollection.* Still, participants may realize during the course of the test that some items they are producing correspond to those to which they were exposed earlier in the experiment, and they may then begin to engage in conscious recollection.

Consider the test of word fragment completion. As discussed previously, in this test participants study a list of words (e.g., *booklet*) and are later given fragments of those words (e.g., b_o_ _et), as well as other fragments of nonstudied words. Participants are told to complete the fragment with the first word that comes to mind. The danger is that the participant will notice that the solution to the word fragment appeared in the previous study list and then begin to treat the rest of the test as an explicit memory test, intentionally trying to complete each fragment with a studied word (Schacter et al., 1989). In the light of this concern, care should be taken to create conditions that limit participants' awareness of the relation between study and test to minimize the probability that participants will turn the implicit test into an explicit test.

Several strategies might be used to try to ensure that an implicit test will measure incidental retrieval (Roediger & McDermott, 1993). One strategy is to use incidental learning instructions before encoding. That is, the fact that participants are in an experiment about memory at all is disguised. Participants may be told that they are in a psycholinguistics experiment in which they will have several tasks involving characteristics of words, or in a perception task involving the rating of pictures. Words or pictures could then be presented, and participants could be asked to rate them on various characteristics. After this first phase, participants may be given various filler tasks before they are then given the implicit memory test (e.g., completing fragmented pictures or words). They are told that the task is a psycholinguistic (or perceptual) task that will measure how various types of word or picture fragments cue perception of words and pictures. With these cover stories (and mild deception) participants are less likely to use intentional recollection during the test.

Often the experimenter wants to use intentional learning instructions during study, so the strategy described earlier cannot be used. (Actually, evidence from several experiments shows that the intentional/incidental manipulation during study does not influence priming on implicit tests, anyway; see Roediger & McDermott, 1993, for a review). In this situation researchers customarily present the implicit memory test as one in a series of distractor tasks (part of some other research project) before the (explicit) memory test that participants expect (e.g., Weldon & Roediger, 1987). For example, after studying a list of words under intentional encoding conditions, participants may solve arithmetic problems, then may try to complete fragmented forms of famous names (B_n_ am_n F_a_kl_n) and then a series of fragmented words (the implicit test). At the beginning of the word fragment completion test, the first 30 items might be filler fragments that are not part of the experimental conditions to ensure that participants have an incidental retrieval orientation with respect to the study list (that is, they just see their task as one of completing fragments, not remembering). Even after list items are introduced, keeping the proportion of studied items on the test list low may help to ensure an implicit retrieval orientation, too (although see Challis & Roediger, 1993). For example, if the participants studied 50 words, a researcher might use a test list that contains a total of 150 test word fragments, so that only one out of three studied words appears in the test. (As noted earlier, these studied items should not appear early in the test list, either.) After completing the word fragment test, participants may be given the recall or recognition test that they expect. Also, when the test fragments or stems are presented at a relatively rapid rate, the test seems to be more purely incidental (Weldon, 1993).

The previous example considered word fragment completion, but the same considerations apply to other implicit tests. As in the example with 50 studied words and 150 test fragments, it is critical to use rather large stimulus sets in implicit memory tests, for at least two reasons. First, if the researcher has participants study a list of only 10 items and then gives the test of 30 items 20 minutes later, it is quite likely that participants may recognize the 10 studied items as having been from the previous phase of the experiment, and so they may be encouraged to engage in explicit retrieval strategies to recall the items. Second, with at least 40 or more study items, it becomes inefficient for participants to engage in explicit strategies even if they do recognize some items as being from the study list. That is, it is easier for them to solve the task at hand with an implicit retrieval orientation than to try to consciously retrieve items from the list, and one might assume participants will use an easy strategy relative to a hard one.

Some researchers have argued that the great worry about contamination of implicit tests by intentional strategies is overblown (Roediger & McDermott, 1993). However, it can be argued that some implicit tests may be more susceptible to explicit contamination than others. In particular, implicit tests that require speeded responses may not provide adequate time to think back and explicitly recall items from the study list. For example, in word or picture identification tests, items are displayed on the computer screen, and participants are required to name them as quickly as possible. Because the stimulus presentation is fast and the test is speeded, there is little time, and little advantage, for participants to try to recall whether the words appeared in the previous list. How can a researcher gauge if an implicit test is compromised by intentional recollection?

DETECTING AWARENESS AND EXPLICIT CONTAMINATION ON IMPLICIT TESTS

Even with all of these precautions in place, it is still possible for participants to become aware that some of the items on the test were from the study phase of the experiment. How can one assess if this is a problem? Several techniques are available.

Posttest Questionnaires

A posttest questionnaire can be included after any implicit memory test to assess retrospective awareness of the study–test relationship and the possible use of explicit memory strategies. For example, Bowers and Schacter (1990) developed a set of questions to determine whether participants were aware of the fact that the task involved production of list items and whether participants changed their retrieval strategy if they did become aware. Their technique has been adopted by many other researchers. The typical strategy is to begin probing with open-ended questions (e.g., "Did you notice any relation between the word fragment test we gave you and other parts of the experiment?") and move on to more specific questions. However, the meaning of such questionnaire data is open to interpretation, depending on how leading the question is and what participants may have done if they did become aware. For example, many participants may realize that some items on the test appeared in the study list, but they might realize this only after they have completed the fragment or named the stem. That is, retrieval may have been completely incidental, with recognition occurring after the implicit retrieval has occurred. This problem—dubbed *involuntary conscious recollection* by Richardson-Klavehn, Gardiner, and Java (1994)—may not compromise the measurement of priming on implicit memory tests unless participants report changing their strategy to use conscious recollection in the retrieval attempt itself (answering "yes" to the question, "Did you try to remember items from the list when you were given the fragments?"). Still, posttest questionnaire data can be useful because they can permit the researcher to analyze participants' performance separately on the basis of their type of awareness of the relation between the study and test (completely unaware; aware that study items appeared on the test but no change in reported strategy; aware with a change reported in strategy, etc.). This practice is increasingly used in the literature and has demonstrated some interesting dissociations (e.g., Geraci & Rajaram, 2002).

Retrieval Intentionality Criterion

A second strategy to assess whether implicit memory tests are compromised by intentional recollection is the retrieval intentionality criterion discussed earlier. Consider work with word-stem completion and word-fragment completion tests. In both cases the stems or fragments are displayed for several seconds (rather than for fractions of a second, as in word identification tests). Participants tend to respond relatively quickly to word stems and provide a response for almost all stems on the test. On the word fragment test, however, the responses are often slow, and many fragments are not completed even after 10 or 15 seconds. Squire et al. (1987) proposed that word stem tests were more likely to measure incidental retrieval relative to word fragment tests because of these differences and others.

Roediger et al. (1992), in an experiment described earlier, tested Squire et al.'s hypothesis by using the retrieval intentionality criterion. They manipulated the type of orienting task participants performed on words during study (a perceptual or a semantic task) and then gave word fragment and word stem tests with both implicit and explicit instructions. The results have already been shown earlier, but let's examine them again with this issue in mind. For the word-stem test, the manipulation of orienting task had a large effect on the explicit form of the test (see the righthand panel of Figure 8.2) but no effect on the implicit test. This outcome replicates the finding of Graf and Mandler (1984), among others, showing that a manipulation of orienting task affects intentional but not incidental retrieval. Now look at the results of the word fragment completion test in Figure 8.3. The basic pattern of results is the same as in word-stem completion. The explicit form of the test shows a large effect of orienting task, but the implicit form of the test shows no effect. If participants were using intentional recollection in the word fragment completion test, performance should resemble (at least to some degree) the results in Figure 8.3b, which shows performance under intentional retrieval conditions. However, the same amount of priming occurred under semantic encoding conditions and under perceptual encoding conditions, which means that word stem and word fragment completion tests seem equally free of contamination by explicit retrieval strategies.

The retrieval intentionality criterion is difficult to apply in all types of implicit memory tests. For example, the strategy of varying orienting task during study and showing a lack of effect on an implicit test does not work for conceptual implicit tests, because these tests (even when measuring incidental retrieval) show positive effects of semantic relative to perceptual processing (e.g., Srinivas & Roediger, 1990). Therefore, other types of dissociations must be used for conceptual implicit tests. That is, the retrieval intentionality criterion can still be used, but other variables must be manipulated to show dissociations between explicit and implicit forms of the test (e.g., see work by Hashtroudi et al., 1988).

Process Dissociation Procedure

A third strategy of separating intentional from incidental retrieval has been proposed by Jacoby (1991). He argued that attempts to isolate pure types of processing (incidental or automatic processing on the one hand, and intentional or consciously controlled processing on the other) are unlikely to be completely successful even when questionnaires or the retrieval intentionality criterion are used. So, although implicit tests are designed and assumed oftentimes to rely on unconscious automatic processes, they are not immune to more consciously controlled processes. Similarly, and just as seriously, explicit memory tests may be affected by incidental or automatic retrieval. To address these issues Jacoby and his colleagues developed the process dissociation procedure (PDP) that incorporates a technique called the opposition method (see Jacoby, 1991, 1998; Jacoby, Toth, & Yonelinas, 1993). Here we sketch in the logic of the procedure, but the method can be a bit tricky to use; perhaps the best general user's guide to the PDP is in Jacoby (1998).

In the PDP technique as applied to implicit memory tests, participants study a set of material such as words in a list (often under several encoding conditions) and then take one of two types of tests with different retrieval instructions called inclusion and exclusion instructions. The test cues are held constant (e.g., the same word stems might be presented on both the inclusion and exclusion test). Consider again a word-stem completion test (see Jacoby et al., 1993 for an experiment that used this procedure). After studying a long list of words such as *mercy* under various encoding conditions, participants are given the stems of words, such as mer¬, that could be completed with either a studied word on the previous list (e.g., *mercy*) or a nonstudied word (e.g., *merit*). On a typical cued recall test, people would be given a cue and asked to use the cue to remember the studied word. Here, as in all explicit memory tests, correct recall of the item could be achieved through either intentional recollection of the study episode or a more automatic process in which the item pops to mind and is then recognized. The inclusion test instructions are similar to those in a typical explicit memory task in that participants are asked to respond to the cue with an item from the study list; however, if they cannot remember the item, they are instructed to guess, so the test includes the product of intentional recollection and, failing that, incidental or automatic priming resulting from familiarity. On an exclusion test, participants are told to respond to the word stem without using a word from the studied list. So, if *mercy* comes to mind and they recognize it from the list, they should not respond with *mercy* but they must respond with *merit* or *merchant* or some other word beginning with *mer*. Now participants' use of conscious recollection opposes their responding with a list word; if they respond with the list word (above the nonstudied base rate of producing the list word when it has not been recently studied) then this effect is due to incidental retrieval that is unopposed by recollection.

The logic of the PDP is that inclusion performance is driven by both intentional and incidental (or automatic) retrieval, whereas exclusion performance is produced only by incidental (automatic) retrieval. If we assume that these processes are independent, then an estimate of intentional recollection in a particular condition or a particular participant can be derived by subtracting performance under the exclusion instruction from performance under inclusion instruction. That is, if Inclusion performance = Probability of retrieval using intentional recollection + Probability of recollection using automatic retrieval, whereas Exclusion performance = Probability of recollection using automatic retrieval, then the difference between the two reflects the influence of intentional recollection.

Probability of recall in the exclusion condition represents a measure of performance that is driven by incidental or automatic processes. This automatic use of memory is analogous to implicit memory (in that it is the information that leaks into memory and affects behavior without intention or awareness). However, several researchers (Richardson-Klavehn & Gardiner, 1996; Richardson-Klavehn et al., 1994) have suggested that the automatic form of memory measured by the PDP may not be completely analogous to priming on implicit memory tests because the PDP assumes that forms of memory that are automatic are also unconscious. Indeed, there is some research suggesting that this may not be true and that, as discussed earlier, there may be involuntary conscious recollection such as when an item is retrieved automatically but then the person recognizes it as having been from the recent study experience. The point is that volition, or intention to retrieve, can be a separate and orthogonal construct from conscious awareness. Although this theoretical discussion is somewhat of an aside, the problem does cut to the core of measuring the construct of implicit memory, which is retrieval affected by recent experience occurring without intention or volition.

ADDITIONAL TIPS FOR CONDUCTING IMPLICIT MEMORY EXPERIMENTS

In this last section we return to a few issues that are relevant to designing and carrying out experiments on implicit memory. We have mentioned these earlier, in passing, but deal with them more fully in this section. These are the related issues of norming materials to determine appropriate base-rate levels of performance and pretesting experimental conditions to ensure the existence of priming in the procedures.

Preexperimental norming of material is critical to ensuring sensitive tests of priming. Ideally, it is best to arrange conditions so that performance in the baseline condition is in the range of 25% to 35%. In other words, for a word-fragment completion test, the baseline completion rate should be fairly low so that one can obtain priming of various magnitudes (if it is possible). If the base-rate completion level is too high, it is difficult to obtain priming because performance may be near the ceiling of the scale. Conversely, base-rate levels that are too low might mean that the tasks created are too difficult and that one could not show priming because of floor effects. Baseline issues must be considered in all implicit memory tests. For example, in a task such as category exemplar production, one must be careful to choose exemplars that are not the most common or uncommon items in the category (don't pick *robin* or *kiwi* in the *birds* category because of the danger of ceiling and floor effects, respectively). As these examples demonstrate, norming of test materials is a critical first step in conducting an implicit memory study. Unfortunately, no sets of norms exist for many different implicit memory tests, although authors of many articles do supply their materials for those studies (but rarely do they supply the baseline completion rates for each possible item).

Another helpful step is to try to discern the approximate amount of priming that can be expected from different tests before one conducts an experiment. Prior pilot testing can help answer this question and then researchers can tinker with materials or procedures if they believe that problems exist. In general, perceptual implicit memory tests such as word fragment completion show priming rates of about 20% to 40%. If you obtain priming levels much higher than that, you may want to check whether your findings may have been compromised by explicit memory performance. Priming on conceptual implicit tests is generally much lower—around 5% to 20%. For this reason, it can be much more difficult to (a) obtain priming and (b) obtain differences in priming across experimental conditions with conceptual implicit memory tests.

Another practical issue to keep in mind when designing a study is the average priming duration for the task you want to use. The average priming duration is important to know to help you decide on an appropriate test delay. The duration of priming for perceptual tests may be more robust than for conceptual tests. Priming on perceptual tasks can be very long-lasting, with some studies showing evidence of priming for days (Jacoby, 1983a; Tulving et al., 1982) or weeks (Komatsu & Ohta, 1984; Sloman, Hayman, Ohta, Law, & Tulving, 1988), and evidence for long-lasting perceptual priming is even found in amnesic patients (Cave & Squire, 1992). On the other hand, priming, as measured by conceptual tests, has been shown to decrease sharply within an hour and a half (Hamann, 1990; but see Goshen-Gottstein & Kempinsky, 2001, for evidence of some conceptual priming for up to three weeks). However, most typical experiments with college students have used relatively immediate tests, so this consideration has not played too much of a role.

CONCLUSION

Conducting implicit memory research can be quite tricky, although the recommendations provided in this chapter can help researchers begin. Our other advice is to obtain some of the major articles that address the technique(s) you wish to use and carefully read the methods sections of those papers. However, watch for the fact that the field can change in its research practices as techniques improve on the basis of past work. For example, Jacoby and Dallas (1981) provided a classic demonstration using the implicit test of word identification, Tulving et al. (1982) first used the word fragment completion test, and Jacoby (1991) launched the process dissociation procedure. However, any of these researchers would probably make somewhat different choices in designing these experiments today, as the field has progressed. Therefore, it is good to model your new efforts with excellent recent examples from the literature on these techniques, which might show you how experimental procedures have changed and improved over time.

REFERENCES

Blaxton, T. A. (1989). Investigating dissociations among memory measures: Support for a transfer-appropriate processing framework. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 15*, 657–668.

Bowers, J. S., & Schacter, D. L. (1990). Implicit memory and test awareness. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 16*, 404–416.

Cave, C. B., & Squire, L. R. (1992). Intact and long-lasting repetition priming in amnesia. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 18*, 509–520.

Challis, B. H., & Roediger, H. L. (1993). The effect of proportion overlap and repeated testing on primed word fragment completion. *Canadian Journal of Experimental Psychology, 47*, 113–123.

Duchek, J. M., & Neely, J. H. (1989). A dissociative word-frequency levels-of-processing interaction in episodic recognition and lexical decision tasks. *Memory & Cognition, 17*, 148–166.

Geraci, L., & Rajaram, S. (2002). The orthographic distinctiveness effect on direct and indirect tests of memory: Delineating the awareness and processing requirements. *Journal of Memory and Language, 47*, 273–291.

Goshen-Gottstein, Y., & Kempinsky, H. (2001). Probing memory with conceptual cues at multiple retention intervals: A comparison of forgetting rates on implicit and explicit tests. *Psychonomic Bulletin & Review, 8*, 139–146.

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

Hamann, S. B. (1990). Level-of-processing effects in conceptually driven implicit tasks. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 16*, 970–977.

Hamann, S. B., & Squire, L. R. (1997). Intact perceptual memory in the absence of conscious memory. *Behavioral Neuroscience, 111*, 850–854.

Hasher, L., Goldstein, D., & Toppino, T. (1977). Frequency and the conference of retrieval validity. *Journal of Verbal Learning and Verbal Behavior, 16*, 107–112.

Hashtroudi, S., Ferguson, S. A., Rappold, V. A., & Chrosniak, L. D. (1988). Data-driven and conceptually driven processes in partial-word identification and recognition. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 14,* 749–757.

Jacoby, L. L. (1983a). Perceptual enhancement: Persistent effects of an experience. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 9,* 21–38.

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

Jacoby, L. L. (1984). Incidental versus intentional retrieval: Remembering and awareness as separate issues. In L. R. Squire & N. Butters (Eds.), *Neuropsychology of memory* (pp. 145–156). New York: Guilford Press.

Jacoby, L. L. (1991). A process dissociation framework: Separating automatic from intentional uses of memory. *Journal of Memory and Language, 30,* 513–541.

Jacoby, L. L. (1998). Invariance in automatic influences of memory: Toward a user's guide for the process-dissociation procedure. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 24,* 3–26.

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

Jacoby, L. L., & Kelley, C. M. (1987). Unconscious influences of memory for a prior event. *Personality and Social Psychology Bulletin, 13,* 314–336.

Jacoby, L. L., Toth, J. P., & Yonelinas, A. P. (1993). Separating conscious and unconscious influences of memory: Measuring recollection. *Journal of Experimental Psychology: General, 122,* 139–154.

Jacoby, L. L., & Witherspoon, D. (1982). Remembering without awareness. *Canadian Journal of Psychology, 36,* 300–324.

Johnston, W. A., Hawley, K. J., & Elliot, J. M. (1991). Contribution of perceptual fluency to recognition judgments. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 17,* 210–223.

Kelley, C. M. (1999). Subjective experience as basis of "objective" judgments: Effects of past experience on judgments of difficulty. In D. Gopher & A. Koriat (Eds.), *Attention and performance XVII* (pp. 515–536). Cambridge, MA: MIT Press.

Kelley, C. M., & Jacoby, L. L. (1996). Adult egocentrism: Subjective experience versus analytic bases for judgment. *Journal of Memory and Language, 35,* 157–175.

Komatsu, S., & Ohta, N. (1984). Priming effects in word-fragments completion for short- and long-term retention intervals. *Japanese Psychological Research, 26,* 194–200.

McDermott, K. B., & Roediger, H. L. (1994). Effects of imagery on perceptual implicit memory tests. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 20,* 1379–1390.

Milner, B. (1966). Amnesia following operation on the temporal lobes. In C. Whitty & O. Zangwill (Eds.), *Amnesia* (pp. 109–133). London: Butterworth.

Mitchell, D. B., & Brown, A. S. (1988). Persistent repetition priming in picture naming and its dissociation from recognition memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 14,* 213–222.

Nelson, D. L., Schreiber, T. A., & Holley, P. E. (1992). The retrieval of controlled and automatic aspects of meaning on direct and indirect tests. *Memory & Cognition, 20,* 671–684.

Pilotti, M., Bergman, E. T., Gallo, D. A., Sommers, M., & Roediger, H. L. (2000). Direct comparison of auditory implicit memory tests. *Psychonomic Bulletin & Review, 7,* 347–353.

Pilotti, M., Gallo, D. A., & Roediger, H. L. (2000). Effects of hearing words, imaging hearing words and reading on auditory implicit and explicit memory tests. *Memory & Cognition, 28,* 1406–1418.

Rajaram, S., & Roediger, H. L., III. (1993). Direct comparison of four implicit memory tests. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 19,* 765–776.

Richardson-Klavehn, A., & Gardiner, J. M. (1996). Cross-modality priming in stem completion reflects conscious memory, but not voluntary memory. *Psychonomic Bulletin & Review, 3,* 238–249.

Richardson-Klavehn, A., Gardiner, J. M., & Java, R. I. (1994). Involuntary conscious memory and the method of opposition. *Memory, 2,* 1–29.

Richardson-Klavehn, A., Lee, M. G., Joubran, R., & Bjork, R. A. (1994). Intention and awareness in perceptual identification priming. *Memory & Cognition, 22,* 293–312.

Roediger, H. L. (1990). Implicit memory: retention without remembering. *American Psychologist,* 45, 1043–1056.

Roediger, H. L. (2003). Reconsidering implicit memory. In J. S. Bowers & C. Marsolek (Eds.), *Rethinking implicit memory* (pp. 3–18). Oxford, England: Oxford University Press.

Roediger, H. L., & Blaxton, T. A. (1987). Effects of varying modality, surface features, and retention interval on priming in word-fragment completion. *Memory & Cognition, 15,* 379–388.

Roediger, H. L., III, & McDermott, K. B. (1993). Implicit memory in normal human subjects. In F. Boller & J. Grafman (Series Eds.) & H. Spinnler & F. Boller (Vol. Eds.), *Handbook of neuropsychology: Vol. 8. Memory, dementia, perception of time, music and faces* (pp. 63–131). Amsterdam: Elsevier.

Roediger, H. L., Weldon, M. S., & Challis, B. H. (1989). Explaining dissociations between implicit and explicit measures of retention: A processing account. In H. L. Roediger & F. I. M. Craik (Eds.), *Varieties of memory and consciousness: Essays in honor of Endel Tulving* (pp. 3–41). Hillsdale, NJ: Erlbaum.

Roediger, H. L., Weldon, M. S., Stadler, M. L., & Riegler, G. L. (1992). Direct comparison of two implicit memory tests: Word fragment and word stem completion. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 18,* 1251–1269.

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

Schacter, D. L., Bowers, J., & Booker, J. (1989). Intention, awareness, and implicit memory: The retrieval intentionality criterion. In S. Lewandowsky, J. C. Dunn, & K. Kirsner (Eds.), *Implicit memory: Theoretical Issues* (pp. 47–65). Hillsdale, NJ: Erlbaum.

Schacter, D. L., & Church, B. A. (1992). Auditory priming: Implicit and explicit memory for words and voices. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 18*, 915–930.

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

Shimamura, A. P., & Squire, L. R. (1984). Paired-associate learning and priming effects in amnesia: A neuropsychological study. *Journal of Experimental Psychology: General, 113*, 556–570

Sloman, S. A., Hayman, C. G., Ohta, N., Law, J., & Tulving, E. (1988). Forgetting in primed fragment completion. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 14*, 223–239.

Snodgrass, J. G., & Corwin, J. (1988). Perceptual identification thresholds for 150 fragmented pictures from the Snodgrass and Vanderwart picture set. *Perceptual & Motor Skills, 67*, 3–36.

Snodgrass, J. G., Smith, B., Feenan, K., & Corwin, J. (1987). Fragmenting pictures on the Apple Macintosh computer for experimental and clinical applications. *Behavior Research Methods, Instruments, & Computers, 19*, 270–274.

Squire, L. R., Shimamura, A. P., & Graf, P. (1987). Strength and duration of priming effects in normal subjects and amnesic patients. *Neuropsychology, 25*, 195–210.

Srinivas, K. (1993). Perceptual specificity in nonverbal priming. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 19*, 582–602.

Srinivas, K., & Roediger, H. L., III. (1990). Classifying implicit memory tests: Category association and anagram solution. *Journal of Memory and Language, 29*, 389–412.

Stark, C. E. L., & Squire, L. R. (2000). Recognition memory and familiarity judgments in severe amnesia: No evidence for a contribution of repetition priming. *Behavioral Neuroscience, 114*, 459–467.

Tenpenny, P. L., & Shoben, E. J. (1992). Component processes and the utility of the conceptually-driven/data-driven distinction. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 18*, 25–42.

Toth, J. P. (2000). Nonconscious forms of human memory. In E. Tulving & F. I. M. Craik (Eds.), *The Oxford handbook of memory* (pp. 245–266). New York: Oxford University Press.

Tulving, E. (1989). Memory: Performance, knowledge, and experience. *European Journal of Cognitive Psychology, 1*, 3–26.

Tulving, E., & Schacter, D. L. (1990). Priming and human memory systems. *Science, 247*, 301–306.

Tulving, E., Schacter, D. L., & Stark, H. A. (1982). Priming effects in word-fragment completion are independent of recognition memory. *Journal of Experimental Psychology: Human Learning and Memory, 8*, 336–342.

Warrington, E. K., & Weiskrantz, L. (1970). Amnesic syndrome: Consolidation or retrieval? *Nature, 228*, 628–630.

Weldon, M. S. (1993). The time course of perceptual and conceptual contributions to word fragment completion priming. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 19*, 1010–1023.

Weldon, M. S., & Roediger, H. L., III. (1987). Altering retrieval demands reverses the picture superiority effect. *Memory & Cognition, 15*, 269–280.

Weldon, M. S., & Roediger, H. L., Beitel, D. A., & Johnston, T. R. (1995). Perceptual and conceptual processes in implicit and explicit tests with picture fragment and word fragment cues. *Journal of Memory and Language, 34*, 268–285.

Witherspoon, D., & Allan, L. G. (1985). The effect of a prior presentation on temporal judgments in a perceptual identification task. *Memory & Cognition, 13*, 101–111.