CHAPTER SEVEN

Implicit Memory

As has often been shown by recent writers . . . we have not memory, but memories.
—William H. Burnham

In Chapter 6, the idea was presented that memory might be fundamentally a discrimination problem. If this is the case, it should be possible to take a situation in which an organism shows no evidence of memory, change the test conditions slightly to make the discrimination task easier, and then demonstrate that the information was retained. One area of research that focuses on this type of situation, and that has attracted much attention over the past few years, is known as implicit memory.

In this chapter, we examine implicit memory and contrast it with explicit memory. We then use this analysis to shed some light on other proposed distinctions and to compare the idea of multiple memory systems to the unitary view of memory.

Implicit Versus Explicit Memory

Implicit memory is often defined as memory without awareness. In contrast, most of the research discussed in previous chapters has examined explicit memory. The key difference is that at the time of test, subjects in an implicit memory experiment are unaware that the task they are performing is related to a particular study episode.

One distinction that is made in implicit memory research is whether the subjects are aware of the relation between the study and test phases only at encoding, only at retrieval, or at both encoding and retrieval. Unfortunately, the terms used to describe these conditions and the types of test used are not standardized. For example, Roediger (Roediger, Weldon, Stadler, & Riegler, 1992) uses the terms *incidental* and *intentional* to refer to the learning task, and *implicit* and *explicit* to refer to the test; Jacoby (1984) uses *incidental* and *intentional* to refer to the test; Schacter and Tulving (1994) use *implicit* and *explicit* to refer both to the task and to the form of memory; and Johnson and Hasher (1987; see also Richardson-Klavehn & Bjork, 1988) use *indirect* and *direct* to refer to the test, and *implicit* and *explicit* to refer to the form of memory. Furthermore, there is a separate but related area of research that examines implicit learning (Reber, 1993). All of this can be quite confusing. In this text, we use *incidental* and *intentional* to refer to the learning instructions, *indirect* and *direct* to refer to the test, and *implicit* and *explicit* to refer to the type of memory used by the subject. However, we will retain the term *implicit learning* to refer to the nonconscious acquisition of structured information.

The majority of situations considered in this book so far have involved direct tests of memory following intentional learning instructions: The subject is aware that there will be a memory test and tries to memorize the information (intentional learning). At test, the subject is aware of the particular learning episode that should be recalled, and the test instructions make direct reference to the learning episode (direct test). The type of memory used in this situation is known as explicit memory.

We examined incidental learning instructions in Chapter 5 in conjunction with the orienting instructions typically given in a levels of processing experiment. Learning is incidental because the instructions require that subjects focus on some information-processing goal (such as pleasantness ratings) rather than on remembering the information. An indirect memory test, in contrast to a direct test, occurs when "the instructions refer only to the task at hand, and do not make reference to prior events" (Richardson-Klavehn & Bjork, 1988, p. 478). The type of memory used in this situation is called implicit memory.

Indirect Tests of Implicit Memory

It is important to clarify three points with respect to implicit and explicit memory. First, as Table 7.1 illustrates, there are four possible combinations of learning (incidental versus intentional) and testing (indirect versus direct). Many studies of implicit memory fall into Cell 1 of the table, meaning that subjects do not intentionally learn the items and are not aware of the relationship between the test and the study phase. Most of the studies presented in Chapters 3 and 4 fall into Cell 4: Subjects were asked to study a list of words and at test were asked to recall the list of words just studied. Many levels of processing studies

Table 7.1 Four possible ways of combining implicit and explicit study and test instructions: Learning can be incidental or intentional, and the test can be an indirect or a direct measure

		Test Instructions	
		Indirect	*Direct*
Study Instructions	*Incidental*	Cell 1	Cell 2
	Intentional	Cell 3	Cell 4

would fall into Cell 2—implicit learning but explicit testing (for example, Postman & Phillips, 1954). In these studies, subjects are not told of the memory test prior to study, but at test they are asked to refer back to the study episode. Roediger, Weldon, Stadler, and Riegler (1992) reported an experiment that included all four cells. Although the majority of studies discussed in this chapter fit into Cell 1, it is important to note that there are other ways of assessing memory.

Second, implicit memory and implicit learning are not at all equivalent to subliminal perception. *Subliminal perception* refers to presentation of a stimulus so quickly or so quietly that it is not consciously perceived. The most famous example occurred in New Jersey in 1957, when James Vicary reported that after he flashed the message "Buy Popcorn" on the screen during a movie, popcorn sales increased by more than 50%. This is an example of subliminal perception because the theater patrons were unaware that the message had been presented. (It turns out that this episode never happened; Vicary admitted that he faked the report to try to revive his failing marketing business. See Pratkanis, 1992; Rogers, 1993.) In an implicit memory study, the subjects are aware of the stimuli as they are presented; they are simply unaware that the memory test that follows is directed toward these items.

Third, although implicit memory has received a great deal of attention during the past few years, it is not a new discovery. For example, Schacter (1989) mentions two 19th-century investigators—Dunn (1845) and Korsakoff (1889)—who accurately described implicit memory. Even Ebbinghaus (1885, p. 2; cited by Richardson-Klavehn & Bjork, 1988) claimed that prior experiences can be retained without awareness. And Claparède describes an anecdote from 1911 that conforms to an indirect test of implicit memory (Claparède, 1951; see Schacter, 1987, for an historical review).

Implicit Learning

The term *implicit learning* usually refers to "the process by which knowledge about the rule-governed complexities of the stimulus environment is acquired independently of conscious attempts to do so" (Reber, 1989, p. 219). Research on this topic has a long history; McGeoch and Irion (1952, p. 210 ff) reviewed the early research, and Reber (1993) and Stadler and Frensch (1998) have reviewed more recent work.

One common method of studying implicit learning is to examine how people learn artificial grammars. These types of studies typically have two phases. First is an acquisition phase, in which subjects are exposed to strings of letters that are consistent with the grammar; second is a testing stage, in which subjects' knowledge of the grammar is assessed.

A Markovian artificial grammar is simply a way of specifying which letters may precede and follow other letters. Figure 7.1 provides a simple example. In this system, the string PTTVPS is grammatical (it can be generated by the system), whereas the string PTTXS is not grammatical (it cannot be generated by the system). These systems are nice for studying implicit learning because they are complex enough that conscious strategies will be of little use, yet sufficiently novel that the experimenter is assured the subject enters the situation with no preexisting knowledge. In addition, the stimuli are synthetic and arbitrary. This last point is important because if implicit learning can be observed with such impoverished, artificial stimuli, it demonstrates the power and flexibility of this mode of learning (see Reber, 1993).

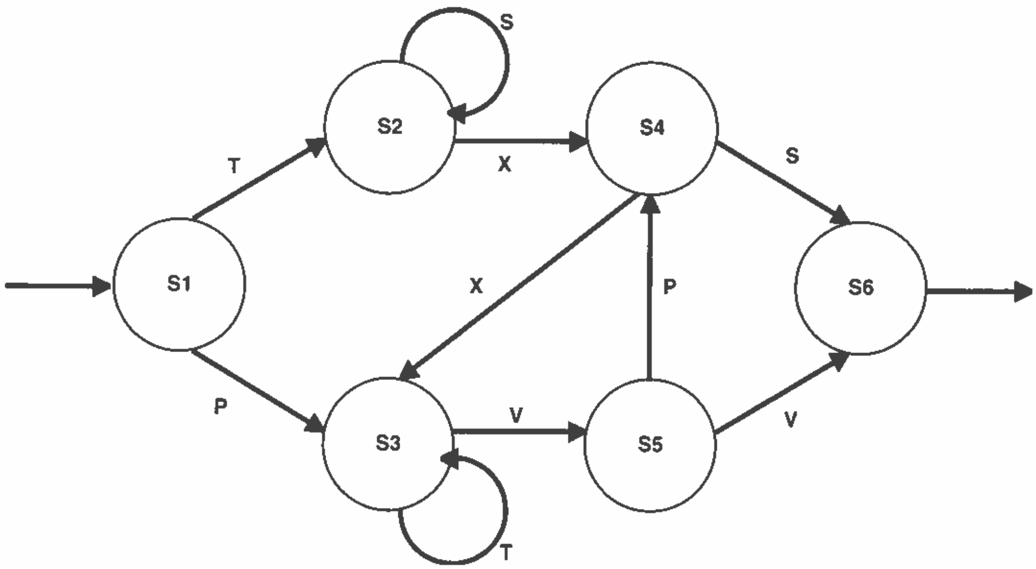

Figure 7.1 An example of an artificial grammar. Each state (e.g., S1) represents a random choice: A certain proportion of the time, the result is one direction (choose "T"); the rest of the time, the result is the other direction (choose "P"). To generate a string, one simply keeps moving through the grammar system until exiting at S6. The two shortest possible strings are TXS and PVV. Other grammatical strings include TSXXVPS, PVPS, PTVPXTVPS, and TSXS.
SOURCE: From *Implicit Learning and Tacit Knowledge: An Essay on the Cognitive Unconscious*, by A. S. Reber, p. 28. Copyright © 1993 by Oxford University Press, Inc. Used by permission of Oxford University Press, Inc.

In one study (Reber, 1967), subjects were asked to learn strings with three to eight letters in each string. Although this is intentional learning (study these lists for an upcoming test) with a direct test (recall the strings you just studied), Reber was most interested in the implicit learning that occurred. One group of subjects learned strings that were grammatical according to a Markovian artificial grammar such as the one in Figure 7.1. Another group learned random strings that conformed to no grammar. On the first trial, both groups averaged about 18 errors when recalling the strings; this demonstrates the difficulty of the task. Both groups did improve, but the group that received the grammatical strings made fewer errors than did the group with random strings. By the end of seven trials, the grammatical group was averaging fewer than 3 errors, compared to about 8 for the random group. Furthermore, subjects in the grammatical group could then use information acquired implicitly to judge quite accurately whether or not novel strings were grammatical. However, the subjects were not able to describe the rules they used to decide, and those subjects who did venture detailed accounts invariably provided rules that would not work. Implicitly learned information appears difficult to verbalize.

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One key factor affecting whether structure can be implicitly learned is the degree of organization present in the string (cf. Garner, 1974). The stimuli do not have to be perfectly predictable; Cleeremans and McClelland (1991) demonstrated that even a noisy grammar—one in which approximately 15% of the stimuli are random—can be implicitly learned. However, changes in the organization of the sequences can affect learning.

A study reported by Stadler (1995) illustrates the complexity of the issue. Stadler's task was *implicit serial pattern learning*. An asterisk appeared in one of four locations (labeled A, B, C, and D), and the subject was prompted to press one of four corresponding keys as quickly as possible to indicate the asterisk's location. Several different sequences of locations—such as BCADBCA, DACBDAC, CDBACDB, and ABDCABD—would be repeated during the course of the experiment. Because accuracy became quite high, the dependent variable was response time. In all conditions, subjects' response times decreased systematically, illustrating learning. As the subjects learned a sequence, they became able to anticipate the next location and so could respond more quickly. Specifically, the average response time on the learned sequences was approximately 220 ms faster than on unlearned sequences.

The important data come from comparing performance in the control condition to that in three other conditions. By using three conditions, Stadler (1995) could examine several different variables and determine the relative importance of each. One condition clearly affected the organization, another clearly affected the processing demands placed on the subject, and the third did both. In the first condition (pauses), the subject responded just as the control subjects did; thus, few or no resources should have been diverted from learning. However, the time between the subject's response and the next item could vary, thus disrupting the organization of the sequence. In the second condition (memory load), subjects were asked to retain a list of seven letters over several trials. This task should require some additional processing resources compared to the control condition. However, because the letters were presented prior to a block of trials and the responses were collected after the block, the task should not interrupt processes responsible for organizing the stimuli during the block. In the final condition (tone counting), subjects were asked to count the number of times they heard a particular tone. The tone could occur after the subject made a response, thereby disrupting a sequence, and the subject also had to report the number of tones heard at the end of a block, thereby requiring additional processing resources compared to the control group.

The memory load task reduced performance; the difference in response times between learned and unlearned sequences dropped to 159 ms. However, both the tone counting and pauses conditions disrupted performance even more, down to 82 ms and 93 ms, respectively. What this means, according to Stadler (1995), is that implicit learning is affected far more by changes in the structure or organization of the information to be learned than it is by tasks that require more processing.

The issue of whether learning can occur without awareness remains controversial (Stadler & Roediger, 1998). On the one hand, subjects who have demonstrated implicit learning often cannot say what the pattern is that they have learned (Curran & Keele, 1993). On the other hand, in some studies, knowledge of the sequence appears to be available on a conscious level. For example, subjects can be given a recognition test in which they are asked to rate how sure they are that the test sequence was part of the learning sequence. Shanks and Johnstone (1999) found that subjects gave higher confidence ratings to sequences that had been seen than to ones that had not, and argued that this indicated some awareness of the sequence.

Destrebecqz and Cleeremans (2001) point out that the relation between performance on a recognition task and performance on an implicit learning task is problematic only if one insists on a "process pure" assumption. If one assumes that recognition relies only on conscious awareness, then the results are a problem. However, if one assumes that both automatic (nonconscious) and recollective processes contribute to performance on a recognition task, then the results are not necessarily problematic.

To assess the relative contributions of automatic and nonautomatic processes, Destrebecqz and Cleeremans (2001) applied Jacoby's (1991) process dissociation technique (see Chapter 5). Subjects saw a sequence of dots appear in one of four locations on a computer monitor and were asked to press one of four keys to indicate where the dot had appeared. The dots' locations were determined in a way similar to the use of a Markovian grammar described above. There were two conditions, inclusion and exclusion. The inclusion condition in the learning phase had a relatively slow presentation rate. The idea was that only with a relatively large interval between dot presentations would the subjects be able to use explicit knowledge. The exclusion condition had a faster presentation rate that did not leave enough time for subjects to use explicit knowledge. In the second phase, subjects were given a recognition test in which they were asked to rate how confident they were that a sequence of dot locations had been seen in the learning phase.

Subjects learned the sequence in both the fast (exclusion) and slow (inclusion) presentation conditions. Introduction of a different pattern slowed mean response times by 100 ms in the slow condition and by 68 ms in the fast condition; if subjects had not learned a pattern, then changing to a new one should not have disrupted performance. The mean confidence ratings from the recognition task are shown in Figure 7.2. In the slow condition, in which both implicit and explicit knowledge could play a role, the subjects were able to distinguish between old and new sequences. In the fast condition, however, in which the presentation rate was too fast to allow explicit processes to play a role, the subjects were unable to distinguish between old and new sequences. These data suggest that whether implicit learning is solely implicit or also includes some explicit information will depend on the particular experimental conditions. More important, they also suggest that learning can indeed occur in the absence of awareness.

Reber (1993) argues that such implicit learning accounts for most learning about the structure of the environment. The arguments supporting this position are too complex to be summarized here, and the reader is referred to Reber's book. Nonetheless, it is clear that highly complex structures and patterns of information can be learned largely without the subject's awareness, and in some cases, without any awareness at all.

Experimental Dissociations

To illustrate how implicit memory is assessed by an indirect test, consider the following typical experiment. There are two phases and two groups of subjects. In Phase I, the subjects are shown a long list of words (perhaps 100 or so) and are asked to perform some task, such as making pleasantness ratings. The rating task ensures that the subjects process the information. In the list of words seen by the experimental group, a small proportion will be words of interest. Thus, the experimental group may see 10 key words that the control group does not see. In Phase II, some time later, the subject is asked to complete

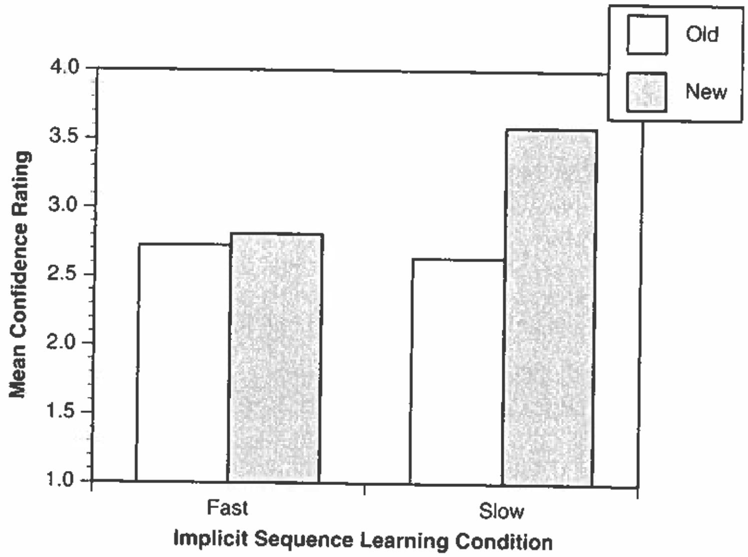

Figure 7.2 Mean recognition ratings for sequences either seen (old) or not seen (new) during an earlier implicit learning phase. A rating of 1 means the subject is certain that the item was seen during the learning phase; a rating of 6 means that the subject is certain that the item was not part of the implicit learning phase. SOURCE: Destrebecqz & Cleeremans (2001).

another task, unrelated to the first. The subject is given a long list of word fragments—such as _o_ogg_n—and is asked to fill in the blanks to make a complete word. There is no mention of the previous list of words, and there is often a delay between the two phases. In this example, the control subjects did not see the only valid English word that completes this fragment (*toboggan*), but the experimental subjects did see this word on the list. Implicit memory is demonstrated when more experimental subjects than control subjects complete the word fragment correctly. The task is incidental because the subject was not intentionally trying to study the words during Phase I, and it is indirect because the subject was not trying to recall the list of words during Phase II.

A measure commonly used in this sort of experiment is *repetition priming*—the idea that processing something a second time benefits from its having been processed previously. (A second type of priming is *association priming*, which refers to the observation that response times are often faster if a second item is semantically related to or associated with the first item. This type of priming will be discussed in Chapter 10.) Priming is typically the difference between the mean proportion of fragments completed by the experimental group and the mean proportion completed by the control group. A priming score of 0 indicates no difference, and any positive value (such as 0.10) indicates better performance for the experimental group. A direct test of memory, in contrast, would have required the subjects to recall as many of the words from the study session as they could, or to decide whether a target item shown during the test period was one of the words studied. One of the critical issues in current memory research—the nature and number of

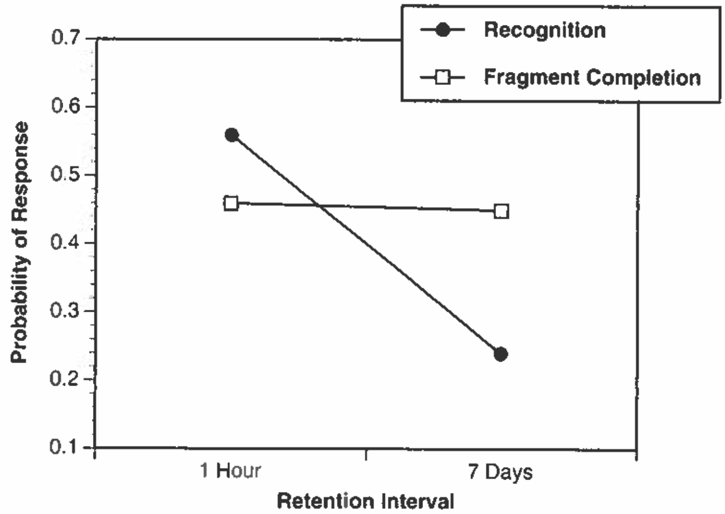

Figure 7.3 Probability of observing priming in a word-fragment completion task and probability of correctly recognizing words after a 1-hour or 1-week retention interval. SOURCE: From "Priming Effects in Word-Fragment Completion Are Independent of Recognition Memory," by E. Tulving, D. L. Schacter, and H. Stark, 1982, *Journal of Experimental Psychology: Human Learning and Memory*, 8, 336–342. Copyright © 1982 American Psychological Association. Reprinted with permission.

different memory systems—has been addressed using dissociations between indirect and direct tests of memory.

A *dissociation* occurs when one variable, such as presentation modality or word frequency, is shown to affect one test differently from another. For example, when Test A is given, subjects do better with visual than with auditory presentation; when Test B is given, the opposite pattern is observed—performance is better with auditory than with visual presentation. The discovery of such a dissociation can support the idea that the two tests tap into different memory systems. Beginning in the early 1980s, several dissociations were demonstrated between indirect and direct tests, which led researchers to think that implicit and explicit memory were two different systems. Here, we consider only two dissociations.

Tulving, Schacter, and Stark (1982) conducted an experiment with three phases. In Phase I, subjects were asked to learn a list of 96 words. In Phase II, which occurred 1 hour later, subjects received a *word-fragment completion test* or a recognition test on 48 of the studied words. Phase III took place 7 days later, when the tests were given for the other 48 studied words. Of most interest is the change in memory performance over time for the direct (recognition) and indirect (fragment completion) tests; the results are shown in Figure 7.3. For the recognition test, performance declined over the retention interval; the subjects correctly recognized fewer words after 7 days than after 1 hour. For the word-fragment completion test, the measure of interest is the amount of priming—the proportion of times the fragment was accurately completed when it was a studied item compared to the number of times it was accurately completed when it was a nonstudied item. This

Experiment *Priming Word-Fragment Completion*

Purpose: To demonstrate repetition priming effects in a word-fragment completion task.

Subjects: Twenty subjects are recommended. Ten should be assigned to the experimental group, and ten to the control group.

Materials: Table H in the Appendix lists 60 word fragments. For each subject, present 20 of these words (with no letters missing). A convenient way is to create a booklet with 1 word per page. You will also need an answer sheet containing all 60 word fragments (with the letters missing) in random order. Make sure that none of the first 10 word fragments were on the study list.

Design: The experimental group will participate in both the study and test phases; the control group will participate in only the test phase. Because each subject experiences only one condition, this is a between-subjects design.

Procedure (Phase I): Inform the subjects in the experimental group that this is an experiment on information processing that has several parts. Tell them to read each word silently to themselves. They should look at each word for 5 seconds before turning the page and going on to the next word.

Instructions (Phase I): "This is an experiment on information processing. On each page of your booklet, you will see a word. I would like you to read it silently to yourself. After you have seen all the words, I will give you further instructions. Please turn the page when I say the word *turn*. Any questions?"

Procedure (Phase II): Collect all of the booklets and wait 10 minutes after subjects have processed the words before giving the test sheet. During the interval, you can have the subjects perform any other task that does not involve words (such as circling all the occurrences of the digit 6 on a sheet of paper). Then tell them the next phase consists of completing word fragments.

Instructions (Phase II): "In this phase of the experiment, you will see a list of word fragments. For each fragment, I would like you to try to fill in the missing letters to make a valid English word. Any questions?"

Scoring and Analysis: For each subject in the control group, count the number of word fragments accurately completed. Do the same for the experimental group. Of most interest are the fragments based on words that the experimental group studied. The experimental group should have completed more words than the control group. The difference between the proportion correct for each group (experimental minus control) is the amount of priming.

Optional Enhancements: Include more subjects in each group; include another group that has a longer delay (such as 24 hours) between study and test.

SOURCE: Adapted from "Priming Effects in Word-Fragment Completion are Independent of Recognition Memory," by E. Tulving, D. L. Schacter, and H. Stark, 1982, *Journal of Experimental Psychology: Human Learning and Memory*, 8, 336–342.

value remained the same after a 1-week delay as after a 1-hour delay. These data represent a dissociation, because the independent variable—duration of the retention interval—affected the direct and indirect measures differently. The longer the retention interval, the worse the performance on the direct test; but retention interval had no measurable effect on the indirect test.

A second type of dissociation was demonstrated by Graf and Schacter (1987). Chapter 6 included a discussion of interference theory, emphasizing the prevalence of both retroactive interference (RI) and proactive interference (PI) as causes of memory failure. Graf and Schacter reported an experiment in which RI and PI affected direct tests of memory but did not affect indirect tests.

Table 7.2 Schematic representation of the conditions tested by Graf and Schacter (1987)

	Phase I	*Phase II*	*Tested On*	*Interference*
Control	A-B	C-D	A-B	
Experimental	A-B	A-D	A-B	RI
Control	C-D	A-B	A-B	
Experimental	A-D	A-B	A-B	PI

In Phase I, subjects studied word pairs, such as *shirt-window*. These first pairs are called A-B pairs. Subjects were asked to generate and read aloud a sentence that related the words in a meaningful manner, such as "The boy threw the shirt out of the window." This task involves incidental learning because subjects were not asked to learn the word pairs. In Phase II, the subjects performed the same processing with a second list of word pairs. In the control condition, this list (known as the C-D list) contained all new words . In the experimental condition, the second list was designed to produce interference by reusing the first words from Phase I. These interference lists, then, are called A-D lists. Both groups of subjects were then tested on the original A-B pairs. This design would lead to retroactive interference; that is, processing the A-D list could interfere with information already processed, the A-B list. Another set of subjects also experienced two learning sessions, but these were arranged so as to cause proactive interference. These subjects processed the A-D or C-D pairs in Phase I, and the A-B pairs in Phase II, and were then tested on the A-B pairs. In this case, previously processed information (the A-D pairs) could interfere with new information (the A-B pairs). The design is sketched out in Table 7.2.

The direct test was cued recall: The subject was provided with the A word and the first few letters of a B word and was asked to complete the stem with the originally studied word. This is a direct test because the subject is asked to refer back to a specific learning episode. The indirect test was word-fragment completion: The subject was provided with the A word and the stem of a B word and was asked to complete the stem with the first word that came to mind. This is an indirect test because the task can be completed without reference to the learning episode. To minimize the chance that subjects would become aware of the relationship between the word-fragment completion test and the study episode, only 12 A-B pairs were tested among 44 other items. A third, separate group of subjects received only Phase III; this group provides a baseline of how many fragments would be completed when there was no opportunity to learn. The subjects in both the control and experimental conditions performed more accurately than the baseline subjects did, confirming that memory was indeed playing a role. The other results are shown in Table 7.3.

First, consider the retroactive interference manipulation. On the direct test, the control subjects performed more accurately than the experimental subjects did (.55 versus .40), demonstrating the presence of RI. On the indirect test, however, the control and experimental subjects performed at about the same level, indicating no interference. The pattern is the same for the proactive interference condition: On the direct test, the control subjects outperformed the experimental subjects (.67 versus .45), whereas performance was equivalent on the indirect test. This represents a dissociation, because the manipulation of both RI and PI affected performance on one kind of test (direct) but had no effect on another test (indirect).

Table 7.3 The proportion of stems completed correctly in a cued recall (direct) test or word-fragment completion (indirect) test in either a retroactive or proactive interference design

	Retroactive Interference		*Proactive Interference*	
Test Type	*Control*	*Experimental*	*Control*	*Experimental*
Direct	.55	.40	.67	.45
Indirect	.34	.32	.32	.35

SOURCE: Based on data from Graf & Schacter (1987).

Although there are numerous other dissociations between implicit and explicit memory, there are also many situations in which parallel effects occur (Richardson-Klavehn & Bjork, 1988, p. 525). One reason for the similarities might be that no test (direct or indirect) relies solely on one type of memory, explicit or implicit. Explicit memory can be used on an indirect test, as when a subject notices that several of the word fragments can be completed with words from the pleasantness ratings task (Richardson-Klavehn & Bjork, 1988). Similarly, implicit memory can be used on a direct test, as when implicit memory facilitates encoding of recognition probes (Jacoby & Dallas, 1981). It was for this reason that Jacoby and his colleagues (Jacoby, Toth, & Yonelinas, 1993) developed the process dissociation framework presented in Chapter 5.

The process dissociation framework has been used to reexamine dissociations between implicit and explicit memory. McBride, Dosher, and Gage (2001) used the procedure to compare forgetting rates for implicit and explicit memory as measured by word-fragment completion. Subjects in the inclusion condition were asked to complete word fragments with a word they had studied; if they could not think of a word, then they were to complete the fragment with any word. Subjects in the exclusion condition were asked to avoid completing the fragment with a word they had studied. According to the process dissociation logic, both conscious (explicit) and automatic (implicit) processes can contribute to memory performance in the inclusion test, whereas only automatic processes can contribute in the exclusion test. Performance was tested at seven different retention intervals, from 1 to 45 minutes. Estimates of the relative contribution of both conscious and automatic processes were calculated at each retention interval. Results indicate that forgetting is similar for both conscious and automatic memory processes. Snodgrass and Surprenant (1989) found similar results with delays up to 14 days.

The claim the implicit memory is immune to interference has also been questioned (Lustig & Hasher, 2001a). For example, Lustig and Hasher (2001b) divided subjects into three groups: an interference group, a control group, and a baseline group. The baseline group received only word fragments and was used to determine the proportion of times a word fragment would be completed. Both the interference and control groups first saw a list of words and were asked to count the number of vowels in each word. Several filler tasks then followed before the indirect word-fragment completion test. The list of words was made up of two types of items, nontargets and targets. As in many tests of implicit memory, only 12 of the 70 word fragments corresponded to targets in the original list. The difference between the interference and control groups was that in the interference condition, the original list contained nontargets that were similar to the targets. In the control condition, the nontargets were not similar. For example, if the word fragment was *a-l--gy*, both the interference and control groups would have seen the target *allergy* in the original list; however, the interference group would also have seen *analogy*, whereas the control group would have seen *urgency*. In the interference condition, then, *analogy* is sufficiently similar to *allergy* to interfere.

Priming was above baseline for both groups, but there was less priming in the interference condition than in the control condition. This result is exactly what one would expect if implicit memory is subject to interference effects. Lustig and Hasher (2001b) suggest that the reason they obtained interference effects whereas Graf and Schacter (1987) did not was because of the cues at test. In Lustig and Hasher's study, there was only one cue, the word fragment, whereas in Graf and Schacter's study, there were two cues. In the direct test, the subject was given a cue such as *shirt-win*___ and was asked to complete the fragment using a word from the previously studied pair. Thus, *shirt* is relevant. In the indirect test, the cue is again *shirt-win*___, but no mention is made that *shirt* is relevant. Only *win*___ is relevant; the fact that it had been paired with *shirt* or some other word had no effect.

Theoretical Accounts of Implicit Memory

There are four main accounts of the implicit memory data (for extensive reviews of data and theories, see Richardson-Klavehn & Bjork, 1988; Roediger & McDermott, 1993): the activation view (Graf & Mandler, 1984), the multiple memory systems approach (Tulving & Schacter, 1990), the transfer appropriate processing view (Roediger, Weldon, & Challis, 1989), and the bias view (Ratcliff & McKoon, 1996).

The Activation View

This account, perhaps the least popular of the four today, holds that the priming seen on indirect tests is attributable to the temporary activation of preexisting representations. This activation occurs automatically, without the need for extensive or intentional processing on the part of the subject. Because the activation is automatic and occurs without elaborative processing, no contextual information is available that would make the item appear as part of an episode. This view readily explains certain aspects of performance on indirect tests. For example, it predicts priming in the absence of elaborative processing (see Jacoby & Dallas, 1981). Furthermore, in amnesics, it predicts normal priming of information that is already known, but no such priming of novel word pairs (see Cermak, Talbot, Chandler, & Wolbarst, 1985). As we will see in Chapter 8, amnesics often show impairment on tasks that require processing contextual information; according to the activation view, however, context is not important, so amnesics should still show priming for information they already know.

Several types of findings pose serious problems for the activation view, however. First is the finding that some indirect tests show priming after a delay of as long as 16 months in college students (Sloman, Hayman, Ohta, Law, & Tulving, 1988) and 12 months in amnesics (Tulving, Hayman, & MacDonald, 1991). If priming is automatic temporary activation, the time frame involved should be seconds or minutes, not months or years. Second, under certain circumstances, amnesics demonstrate priming of newly acquired information (see Graf & Schacter, 1985). This finding poses a problem because the activation view assumes that the primary cause of priming is temporary activation of preexisting representations. If newly acquired information can be primed, it calls this assumption into question. The activation explanation has not fared well of late, and it has been eclipsed by other theoretical views.

Multiple Memory Systems

The multiple memory systems view is put forward most strongly by Tulving and Schacter (1990; Schacter & Tulving, 1994; Schacter, Wagner, & Buckner, 2000). In its simplest form, it holds that many dissociations between direct and indirect tests of memory arise because the tests tap different underlying memory systems. In particular, Schacter et al. (2000) identify the *perceptual representation system (PRS)* as a separate memory system responsible for many of the effects seen on indirect tests. The PRS is a collection of nondeclarative, domain-specific modules that operate on perceptual information about the form and structure of words and objects; it is responsible for "the facilitated identification of perceptual objects from reduced cues as a consequence of a specific prior exposure to an object" (Schacter, 1994, p. 234). Before describing this proposed system more completely, we first need to define what is meant by a memory system. By necessity, the discussion begins with the assumption that there are multiple memory systems, although not all researchers agree on this point. For example, the following discussion uses a distinction between episodic and semantic memory to illustrate the requirements for proposing different systems, but many researchers question whether there is sufficient evidence to differentiate these systems (see below).

What is a system? Schacter and Tulving (1994) define a memory system by describing what it is not. First, a memory system is not a memory process: "A memory process refers to a specific operation carried out in the service of memory performance" (Schacter & Tulving, 1994, p. 12). This definition includes encoding, rehearsal, retrieval, and so forth. Second, a memory system is not a memory task. A recognition task does not imply a recognition memory system distinct from other memory systems. There is often an implicit isomorphism between certain tasks, such that most free recall tasks tap episodic memory, but this need not be the case. Except in highly unusual circumstances, a given memory task is not a pure measure of a particular memory process, let alone a particular memory system (Jacoby, 1991). Finally, implicit memory and explicit memory are not memory systems (Schacter & Tulving, 1994). Rather, these terms refer to situations in which memory is expressed without awareness (implicit) or with awareness (explicit) of the original learning episode.

Different researchers have offered different definitions of a memory system, and at least some of the confusion about what is and what is not a system is due to inconsistent or contradictory definitions. Part of the problem is that experimental research into different memory systems is relatively recent; as experimental evidence accumulates, the definitions are continually being refined and made more precise.

The most clearly defined set of criteria for what constitutes a separate memory system was offered by Sherry and Schacter (1987). In order to establish whether two memory systems, A and B, are separate, the following four properties must hold:

1. *Functional dissociations*. An independent variable that has one effect on a task thought to tap System A must have either no effect or a different effect on a task thought to tap System B.

2. *Different neural substrates*. System A must depend on different brain regions from System B.
3. *Stochastic independence*. Performance on a task that taps System A should be uncorrelated with performance on a task that taps System B.
4. *Functional incompatibility*. A function carried out by System A cannot be performed by System B.

A slightly revised set of criteria, described in the following paragraphs, was proposed by Schacter and Tulving (1994, pp. 14–20).

Class-Inclusion Operations A memory system enables the organism to perform a very large number of tasks of a particular class or category, regardless of the specific details of the tasks. For example, one proposed memory system is episodic memory, which is the conscious recollection of personally experienced episodes. It does not matter what the personally experienced episode is; it could be a birthday party, the time your dog was nearly hit by a car, your first day at college, or any other event. All operations dealing with these types of memories occur within the episodic memory system. If there is damage to the system, then all kinds of personally experienced memories will be affected, but other cognitive operations should remain intact. Thus, certain forms of amnesia can interfere with episodic memory but not with recollection of historical facts, which are assumed to be in a different system (semantic memory).

Properties and Relations The second criterion proposed by Schacter and Tulving (1994) is that a memory system must be described in terms of a property list: an enumeration of features and aspects by which its identity can be determined and its relation to other systems specified. These properties include the rules of operation, the kind of information that is processed, the neural substrate, and a statement about the system's evolutionary purpose. In addition to these properties, the proposed system must have a definite relationship to other systems. For example, episodic memory relies on parts of semantic memory, but semantic memory does not depend on episodic memory in any way.

Convergent Dissociations As we have already noted, *single dissociations* occur when a particular independent variable, such as word frequency, has two different effects depending on the test—recall versus recognition. Weaker forms of dissociation occur when the independent variable has a larger effect on one test than on another, or has an effect only on one test and not on the other. Single dissociations provide no evidence for postulating a new memory system, according to Schacter and Tulving (1994). However, *convergent dissociations* are multiple single, or double, dissociations that use a variety of tasks, a variety of materials, a variety of populations, and a variety of techniques. If a proposed memory system is indeed a memory system, then these multiple dissociations will all converge on the same conclusion.

On the basis of the criteria outlined above, Schacter and Tulving (1994) propose five memory systems and nearly a dozen subsystems (see Table 7.4). The main division is between procedural and declarative memory. *Procedural memory* is involved with learning behavioral and cognitive skills and algorithms. A rule of thumb is that if you can say you know how to do something, it is a good candidate for a form of procedural memory. Sample tasks include riding a bicycle, typing (if you are a touch typist), and even performing complex skills such as solving puzzles. In contrast, *declarative memory* is involved with

Table 7.4 Major memory systems and their subsystems

System	*Other Name(s)*	*Subsystems*
Procedural	Nondeclarative	Motor skills Cognitive skills Simple conditioning Simple associative learning
Perceptual representation	Nondeclarative	Visual word form Auditory word form Structural description
Primary memory	Working memory	Visual Auditory
Semantic	Generic Factual Knowledge	Spatial Relational
Episodic	Personal Autobiographical Event memory	

SOURCE: Based on Schacter & Tulving (1994).

knowing "that" rather than knowing "how." For example, if you know that 2 plus 2 equals 4, the information is said to be declarative.

The subsystems of procedural memory include those responsible for learning motor skills, simple conditioning, and simple associative learning (Schacter & Tulving, 1994). Procedural memory is also thought to be responsible for learning about patterns and regularities in the environment that unfold over time, even quite complex ones (Reber, 1993). For example, many attributions of cause and effect have their basis, according to Reber, in implicit learning.

The perceptual representation system (PRS) mentioned before is another form of nondeclarative memory, and Schacter et al. (2000) view it as a separate memory system. This system is important in identifying words and objects but is nondeclarative in the sense that it is typically involved in nonconscious operations. The PRS encompasses three subsystems: one that handles visual input, one that handles auditory input, and one that handles descriptions of objects.

The three remaining systems belong on the declarative side, and all three involve conscious awareness. Primary memory, as we saw in Chapters 3 and 4, has had a long history, at times being called short-term store, short-term memory, or working memory. The system listed in Table 7.4 follows Baddeley's (1986) general description of two subsystems—one for visual-spatial information and another for auditory-verbal information (see Chapter 4).

The final two systems—episodic and semantic memory—take their names and general characteristics from Tulving (1972, 1983). The *semantic memory* system (also known as knowledge or generic memory) processes factual information. If you can recollect that George Washington was the first president of the United States, that information comes from your semantic memory system. *Episodic memory* (also known as autobiographical memory) differs from semantic memory in that it includes recollection of personal involvement and enables the individual to mentally "travel back" into his or her personal past (Tulving, 1998). An example will help illustrate the difference. Suppose that you know nothing about the vice presidents of the United States. One day, while waiting for an appointment, you read in an old magazine about Maine's commemoration of the 100th anniversary of the death of Hannibal Hamlin (1809–1891), Abraham Lincoln's first vice president. You immediately think of elephants crossing the Alps to fight Romans, confusing the more famous Carthaginian with the less famous Granite State native son. A few days later, you happen to watch a television quiz show and Hamlin's name occurs again. Although the bare fact that he was Lincoln's first vice president may be in semantic memory, all of the details that you recollect about the learning episode—such as the fact that you were reading an old magazine, that you thought of the more famous Hannibal, that you were so bored you were reading a magazine that was several years old, that the room was stuffy and hot—are due to episodic information. Finally, suppose that several years later, you again recollect Hamlin's name, but this time you are unaware of the source. In one sense, Hamlin has become Washington's equal; you cannot recall anything about the learning episode.

If there is some uncertainty about what constitutes a system, there is even less agreement about what distinguishes a subsystem from a system. Schacter and Tulving (1994, p. 19) define the difference as follows:

> Whereas systems are characterized by different rules of operation, as embodied in property lists and relations, subsystems, we suggest, are distinguished primarily by different kinds of information (subsystems share the principal rules of operations of their superordinate system, but they differ from one another with respect to the kinds of information each one processes) and different brain loci (although subsystems are all instantiated in the neural circuitry that defines their superordinate system, they can occupy distinct loci within the broader network). . . . Whereas postulating of full-blown systems requires satisfaction of all three of our major criteria, postulating of subsystems requires satisfaction of the first (class inclusion operations) and third (converging dissociations) but not the second (property lists and relations, with the corresponding emphasis on different rules of operation).

Despite these attempts at clarification, a major weakness of the multiple systems view is a lack of consensus among its proponents as to what the systems are, and even on what the criteria should be. For example, some researchers think of episodic and semantic memory as subsystems rather than as two distinct systems (Johnson & Chalfonte, 1994; Squire, 1994). Others propose systems not included in the Schacter and Tulving hierarchy, such as the sensory memory systems proposed by Cowan (1995). Indeed, according to some criteria, there could be as many as 25 different memory systems (Roediger, 1990b).

Transfer Appropriate Processing

The explanation of dissociations between direct and indirect tests of memory in terms of transfer appropriate processing (TAP) (see Chapter 5) has been most fully articulated by Roediger and his colleagues (see Blaxton, 1989; Roediger, Weldon, & Challis, 1989). This account proceeds from four assumptions. First, a given type of processing will lead to better memory performance if it is appropriate for the particular test (see Morris, Bransford, & Franks, 1977; Tulving & Thomson, 1973). The important point here is that different types of processing lead to good performance on different types of tests; there is no one type of processing that will lead to optimal performance on all tests. Second, direct and indirect tests of memory typically require different retrieval operations. In particular, the tasks typically chosen for direct and indirect tests differ not only in the presumed underlying memory being tapped (explicit versus implicit) but also in the type of information required. Third, most indirect tests rely primarily on perceptual processing. For example, a fragment completion task requires processing the individual letters rather than focusing on an item's meaning. Roediger calls this kind of processing *data driven*, a term introduced by Jacoby (1983). Finally, most direct tests rely primarily on the encoded meaning of concepts. For example, most subjects will focus on word meanings and relationships between the words on recall and recognition tasks. Roediger calls this kind of processing *conceptually driven* (Jacoby, 1983).

To be clear, not all indirect tests are data driven and not all direct tests are conceptually driven. Indeed, the key experiments that support the transfer appropriate processing view compare data-driven indirect tests to conceptually driven indirect tests. Another point of clarification concerns the terms *data driven* and *conceptually driven*, which represent not a dichotomy, but rather two endpoints on a continuum. In practice, most tasks will involve both data-driven and conceptually driven processes; what concerns Roediger and his colleagues is which type of processing predominates.

A study by Blaxton (1989) examined two types of indirect tests and two types of direct tests. One indirect and one direct test were predominantly data driven, and one indirect and one direct test were predominantly conceptually driven. Blaxton chose presentation modality as the key independent variable. According to dissociation logic, if indirect tests are tapping a separate system, then presentation modality should affect both indirect tests in the same way. However, if the transfer appropriate processing view is correct, then it should not matter whether the test is direct or indirect. According to this view, data-driven tasks should show one pattern of results, and conceptually driven tasks should show a different pattern.

First, all subjects saw (visual condition) or heard (auditory) a list of words; then, several different kinds of tests were administered. To illustrate the different test types, consider the target word *bashful*. The direct, data-driven test was graphemic cued recall. A grapheme, for this test, was a word that had similar letters in similar locations, such as *bushel*; subjects were instructed to recall a word from the list that had similar letters. This test is both direct (subjects are instructed to recall words from the list) and data driven (processing needs to focus on physical features rather than on meaning). The indirect, data-driven test was word-fragment completion; given the word fragment *b_sh_u_*, subjects were asked to complete the fragment with the first word that came to mind. This is an indirect test because no mention was made of the study items. The direct, conceptually driven test was free recall; subjects were simply asked to recall as many of the words as they could. The indirect, conceptually driven test was a test of general knowledge. The question was "Which of the seven dwarves comes first alphabetically?" This test is both indirect (subjects need not refer back to the learning episode) and conceptually driven (the test requires processing of meaning rather than of physical features).

The results are shown in Figure 7.4: Consistent with the transfer appropriate processing view and contrary to the multiple systems view, performance was better on data-driven tasks (the upper- and lower-left graphs) with visual presentation, and performance was equivalent or slightly better on conceptually driven tasks (upper- and lower-right graphs) with auditory presentation. The multiple systems view predicted that the two direct tasks would be similar, whereas the results showed that the two data-driven tasks were

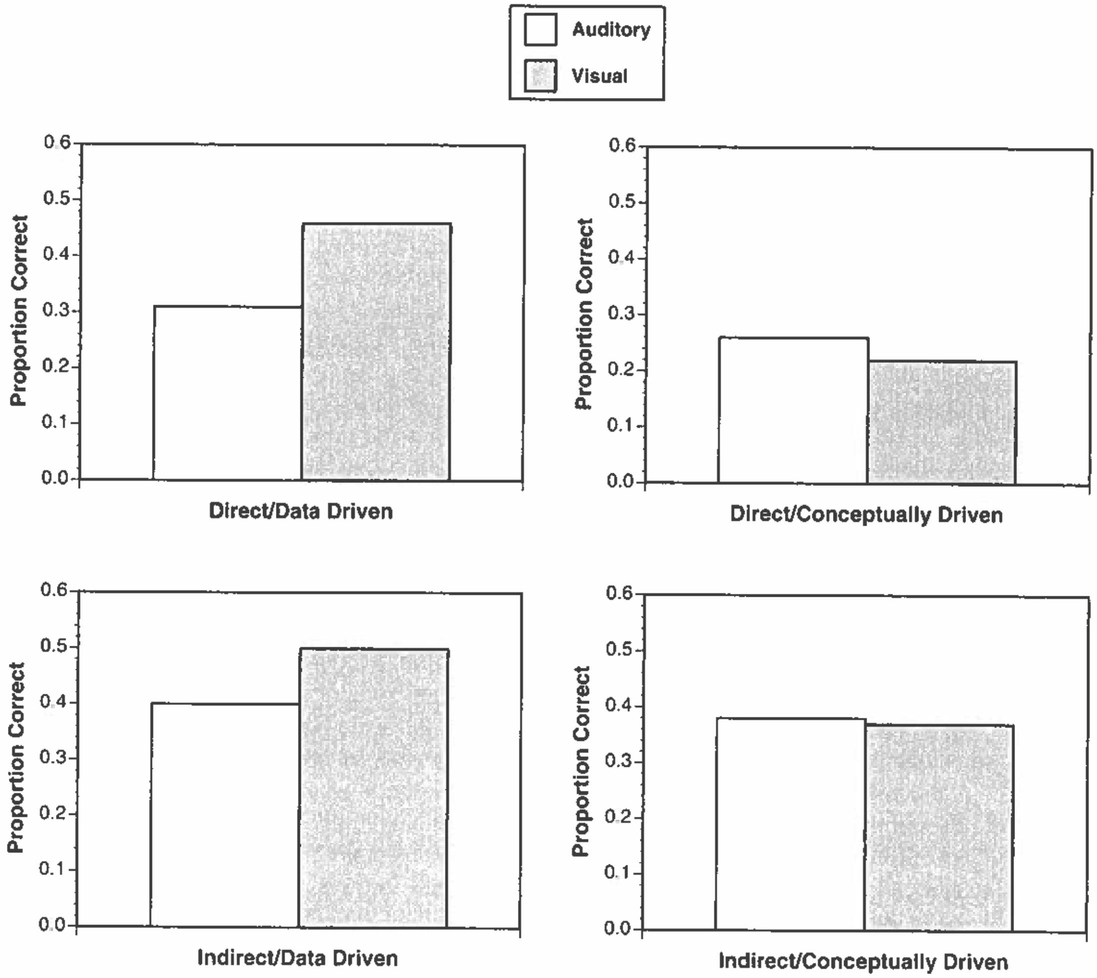

Figure 7.4 Proportion correct as a function of test type (direct or indirect), task type (data driven or conceptually driven), and presentation modality. Transfer appropriate processing predicts that type of processing is most important, whereas the multiple systems view predicts that type of test is most important. SOURCE: From "Investigating Dissociations Among Memory Measures: Support for a Transfer-Appropriate Processing Framework," by T. A. Blaxton, 1989, *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *15*, 657–668. Copyright © 1989 American Psychological Association. Reprinted with permission.

similar. According to Blaxton's (1989) interpretation, the type of test (direct or indirect) did not matter as much as the predominant type of processing (data driven or conceptually driven).

The Bias View

The bias view (Ratcliff & McKoon, 1996) begins with the observation that none of the preceding views actually explains the phenomenon. In a repetition priming task, there is an increase in the probability of responding (or a decrease in the time needed to respond)

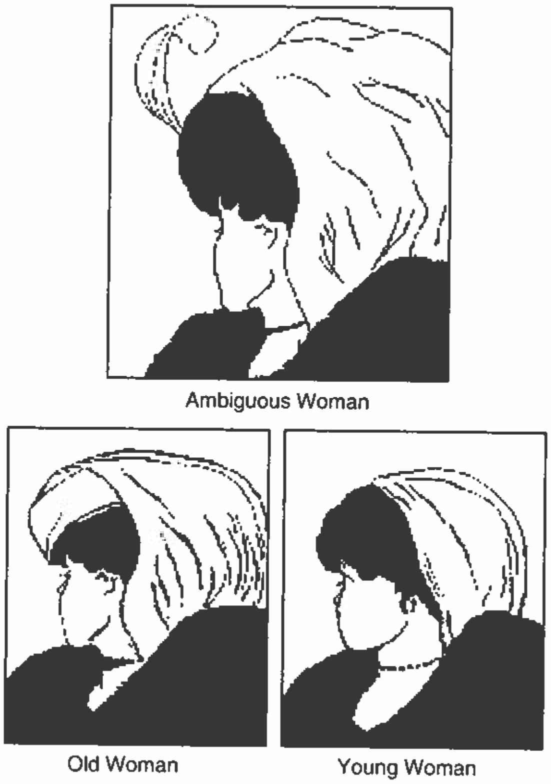

Figure 7.5 The ambiguous and unambiguous figures used by Leeper (1935). SOURCE: Adapted from Boring (1930), Leeper (1935).

when an item has been seen recently. The multiple systems view (Schacter & Tulving, 1994) explains these results by postulating three separate memory systems: one system for auditory words, one for visual words, and one for structural descriptions. However, saying that these effects occur because of the memory system responsible does not really explain them. The transfer appropriate processing view (Roediger, 1990a) also has difficulty explaining these results because of the possibility of circularity. Repetition priming will be observed when there is appropriate transfer of the study and test processing, but evidence for appropriate transfer of processing comes from observing priming.

The bias view proposes that prior presentation of an item can bias subsequent processing of the item on later presentations. Bias is seen as the result of modifications to the processes that will be used in the task, including perceptual and decision processes (Ratcliff & McKoon, 1996). At its simplest, the bias view says that, other things being equal, you are likely to interpret a stimulus in the same way as you have interpreted it in the past.

Consider an example of how an ambiguous picture might be interpreted. Leeper (1935) used a set of figures, derived from Boring (1930) and shown in Figure 7.5, known as "the wife and the mother-in-law." (Another version of this illusion, created by Botwinick, 1961, is called "the husband and the father-in-law.") First, one of the unambiguous versions was shown; two weeks later, the ambiguous version was shown. Subjects were far more likely to interpret the ambiguous picture as representing the same person as the unambiguous picture. That is, if they first saw the unambiguous old woman, they would then interpret the ambiguous picture as representing an old woman. The idea is that a person's processing becomes biased as a result of the way in which the unambiguous item was originally processed.

A central feature of the bias view is that bias entails both costs and benefits. The modifications to processing caused by the first presentation will sometimes facilitate subsequent processing and sometimes impede subsequent processing. More generally, there will be an advantage if prior processing is appropriate for the current task, but a disadvantage if prior processing is inappropriate for the current task. Many studies of repetition priming have been set up to see only benefits (such as better performance or reduced response times) because the systems view predicts only benefits. Ratcliff and McKoon (1996) surveyed several studies and reported new data that illustrate both costs and benefits in three different repetition priming paradigms, each of which had previously been attributed to separate memory systems.

Bias with Auditory Words Ratcliff, Allbritton, and McKoon (1997) had subjects listen to two lists of words, the second of which was presented in noise to make the task difficult. Each word on the second list fell into one of three conditions: (1) It was a new word (novel); (2) it was a word that was also in the first list (repeated); or (3) it was a word that was similar to a word on the first list (similar). The measure of interest was the probability of identifying items in the second list. Novel words (the control condition) were identified correctly about 60% of the time. A repetition priming effect was seen for the repeated items, with more items identified correctly—65%—than in the control condition. Most important, there was a cost for similar items, with only 55% identified correctly. The idea is that there is no experimentally induced bias to process the control items, so they serve as a baseline. According to the bias view, the repeated items showed a benefit because the type of identification processing required had been used previously within the session. The similar items showed a cost because the processing of the similar items in the first list was inappropriate.

Bias with Visual Words Ratcliff and McKoon (1996) reported an experiment that examined bias effects with a stem completion task. In the first phase, 32 words were presented on a computer screen, and subjects were asked to make a rating of how pleasant these words were. In the second phase, four letters appeared in the center of the screen, and subjects were asked to say, as quickly as they could, a word that began with those letters. As before, there were novel, repeated, and similar conditions. The mean response time to say a word to a novel four-letter stem was 1363 ms. Repetition priming was observed in the repeated condition, with response time decreasing to 1156 ms. In the similar condition, performance was slowest, with a mean response time of 1561 ms. Items that could take advantage of previous processing showed a decrease in response time, whereas items that could not showed an increase.

Bias with Objects In a typical object decision experiment, subjects see a series of line drawings of possible and impossible objects (see Figure 7.6). There are two lists, and for each object, subjects are asked to decide as quickly as they can whether the object is possible. The typical finding is that only possible objects show repetition priming; there appears to be no advantage of being exposed to an impossible object during an earlier phase

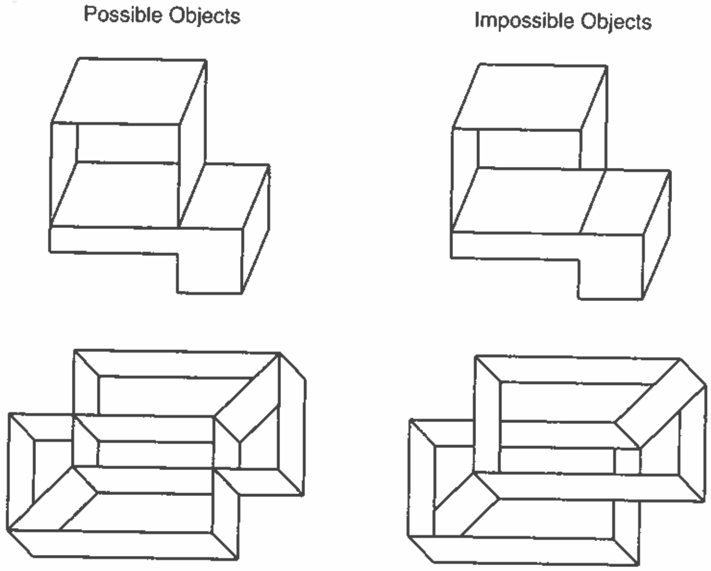

Figure 7.6 An example of possible (left) and impossible (right) objects, of the sort used in object decision experiments. SOURCE: Adapted from "Bias in the Priming of Object Decisions," by R. Ratcliff and G. McKoon, 1995, *Journal of Experimental Psychology: Learning, Memory, and Cognition, 21*, 754–767. Copyright © 1995 American Psychological Association. Adapted with permission.

of the experiment (Schacter, Cooper, & Delaney, 1990; Schacter, Cooper, Delaney, Peterson, & Tharan, 1991). This finding of repetition priming for possible objects and no repetition priming for impossible objects is consistent with the idea of separate memory systems, one of which is devoted to processing objects.

Ratcliff and McKoon (1995a) also presented subjects with line drawings of possible or impossible objects. In their standard condition, they replicated the finding of enhanced performance for possible objects on list 2 if they had been seen previously on list 1, and no enhancement for impossible objects. According to the bias view, however, one reason for this finding may be the contribution of episodic recollection. For example, recalling that you have seen an object before biases you to say that the object is possible. This recollective process could hide the effects of repetition priming on impossible objects by biasing subjects to respond with "possible." This idea was tested by using two different ways of minimizing conscious recollection. In one version, the subjects were given a memory load; that is, they were asked to keep seven digits in memory while making their decisions. The second version implemented a *deadline procedure*, in which subjects were required to respond more quickly than usual. The idea here is that the object decision response must be made before the episodic information becomes available. The results are shown in Table 7.5.

When recollective processes were allowed (the column labeled "Replication"), the results duplicated the finding of repetition priming only for possible objects (0.67 versus 0.58) and not for impossible objects (0.42 versus 0.41). However, when the influence of the recollective processes was minimized by a deadline procedure, the results were different:

Table 7.5 The proportion of possible and impossible objects labeled "possible" in three different experiments (replication, deadline, and memory load) as a function of prior exposure

		Proportion Labeled "Possible"		
Study Form	*Test Form*	*Replication*	*Deadline*	*Memory Load*
Possible	Possible	0.67	0.64	0.66
	Possible	0.58	0.54	0.61
Impossible	Impossible	0.42	0.48	0.42
	Impossible	0.41	0.33	0.34

SOURCE: From "Bias in the Priming of Object Decisions," by R. Ratcliff and G. McKoon, 1995, *Journal of Experimental Psychology: Learning, Memory, and Cognition, 21*, 754–767. Copyright © 1995 American Psychological Association. Reprinted with permission.

Repetition priming was seen for both possible (0.64 versus 0.54) and impossible (0.48 versus 0.33) objects. The results from the memory load condition, which should also minimize the contributions of recollection, were the same as those for the deadline condition. In other words, impossible objects also have an advantage when seen a second time. Ratcliff and McKoon (1996) extend this result to show both benefits (repetition priming) and costs (worse performance) for object identification.

Not only is the bias view able to account for all these results, but more important, it actually predicts them. That is, the bias view predicts that in all instances of repetition priming (which it views as a benefit of repetition), it should be possible to show a decrement in performance (which it views as a cost of repetition). A model that allows for both qualitative and quantitative predictions within the perceptual identification paradigm has been developed (see Ratcliff & McKoon, 1997), and it seems likely that similar approaches can be made for the other paradigms.

Comparing Bias, TAP, and the Multiple Systems Views

Both the bias and transfer appropriate processing (TAP) views hold that postulating multiple memory systems is not needed to explain the currently available data. Moreover, models developed from the bias view (Ratcliff & McKoon, 1997) specify at least some of the processes that are responsible for repetition priming, and so can be seen as complementing, rather than competing with, TAP.

The major strength of the transfer appropriate processing view is the emphasis on processing information and on viewing memory as a process (see Craik & Lockhart, 1972; Kolers & Roediger, 1984), especially a discrimination process (see Capaldi & Neath, 1995). Because of this emphasis, TAP predicts dissociations based on processing rather than on the underlying memory system. For example, Blaxton (1989) predicted that her data-driven tests would benefit from visual presentation regardless of whether the test was thought to tap implicit memory (the indirect test) or explicit memory (the direct test). Similarly, Balota and his colleagues demonstrated dissociations between two tasks thought to tap semantic memory (Balota & Neely, 1980) and between two tasks thought to tap episodic memory (Balota & Chumbley, 1984). The more similarities that are found between tasks that are thought to tap different systems, the more problematic the multiple systems view becomes. Another strength of TAP is its ability to account for age-related declines in memory (see Chapter 14).

One weakness of the TAP view is that it says relatively little about the phenomenon of conscious awareness in different types of tasks. A second problem is that, although it distinguishes between perceptual and conceptual processing, the TAP approach does not yet include more fine-grained distinctions (Roediger & McDermott, 1993). It is possible that Jacoby's (1991) process dissociation framework can remedy this weakness. Thus, the TAP view cannot currently explain certain dissociations between two conceptually driven tasks (McDermott & Roediger, 1996; Tenpenny & Shoben, 1992).

Much of the evidence for multiple memory systems comes from people with various forms of brain damage. According to proponents of the multiple systems view (Tulving, 1986), it is by studying the pattern of deficits in these patients that memory researchers will be able to specify the number and type of memory systems. In the next chapter, we examine the biological basis of memory and examine the extent to which those data support the systems view.

The systems view has three major problems. First, it provides no set of criteria for determining the number of memory systems that results in just the five proposed systems listed in Table 7.4. For example, Roediger, Buckner, and McDermott (1999) show how recall and recognition meet the Sherry and Schacter (1987) criteria for being separate systems: The variable word frequency produces functional dissociations between recall and recognition (Gregg, 1976; see also Chapter 9); neuropsychological dissociations between recall and recognition are observable in amnesic subjects (Hirst, Johnson, Phelps, & Volpe, 1988); and numerous studies have found essentially no correlation between performance on the two tests (Nilsson & Gardiner, 1993). The functional incompatibility is also easy to demonstrate: Memory for taste or odors is a function that is well supported by recognition (consider the case of Marcel Proust) but not very well supported by recall. However, no theorist actually suggests that they are different (see Chapter 9).

The second major problem is that the systems view fails to account for the decline in memory performance seen when healthy people get older. One would assume that if one system were affected, then most tasks that tap that system would show deficits. However, it turns out that some tasks thought to tap episodic memory are almost unaffected by aging, whereas other episodic tasks are greatly affected (see Chapter 14).

A third major problem concerns the role that dissociations play. Not only can one find dissociations between systems, but there are also findings of dissociations within a particular memory system. As mentioned previously, Balota and his colleagues demonstrated dissociations between two tasks thought to tap semantic memory (Balota & Neely, 1980) and between two tasks thought to tap episodic memory (Balota & Chumbley, 1984). Others have shown independence between two tasks thought to tap implicit memory (Witherspoon & Moscovitch, 1989).

Neuropsychological dissociations are also problematic. As Parkin (1999) notes, many studies show that retrieval in episodic tasks involves right prefrontal activation whereas retrieval of semantic information involves left prefrontal activation. This neuropsychological dissociation, however, reverses when the two tasks are equated for difficulty: Retrieval of semantic information produces larger amounts of right frontal activation than the episodic task. In one sense, then, semantic memory under one set of conditions has a different neural substrate than semantic memory under a second set of conditions.

A final problem with dissociations is that although the system view predicts differences, it does not make a priori predictions about the precise nature of the dissociation. Consider one example that involves the *fan effect*. After learning a set of sentences that contain a fact about a person and a location, subjects are given a recognition test. The *fan effect* is the finding that response times to say that a particular sentence has been seen previously increase when the number of facts in the sentence related to the person or the location also increases (Anderson, 1974). The important point, as McKoon, Ratcliff, and Dell (1986) point out, is that this fan effect is observed in episodic tasks but not in semantic tasks. There is nothing in the distinction between episodic memory and semantic memory that would lead anyone to predict this result. Although it is a dissociation, it is not predicted; if the result had been the reverse, the distinction would still be supported! As Hintzman (1984a, p. 241) put it, "If one wants to claim that a dissociation outcome supports the episodic-semantic distinction, one must show that the dissociation is predicted by theory that embodies the distinction."

Tulving and Schacter (1990) agree that there are many similarities between tasks thought to tap one memory system and tasks thought to tap a separate system. They argue that these "'parallel effects' are theoretically uninteresting, since some similarities would be expected of all forms of memory—otherwise it would be difficult to justify their general label" (p. 305). The goal facing multiple systems theorists is to develop a theoretical account that predicts which variables will show dissociations between different systems and which variables will behave in a parallel fashion.

hapter Summary

Implicit memory is concerned with situations in which subjects are unaware of various aspects of the learning and testing situation. Implicit serial learning examines whether people can learn structured information even though they have no awareness of what they are learning. In other implicit memory experiments, the learning instructions can be incidental (the subject is unaware that there will be a memory test) or intentional (the subject is fully aware that there will be a memory test), and the memory test can be indirect (the subject is unaware that the test is related to a particular learning episode) or direct (the subject is fully aware of the relationship between the learning episode and the test). Whereas early research found differences between implicit and explicit memory, more recent research has shown that principles of forgetting and interference apply to both. One explanation invokes separate memory systems, although there is no consensus on the exact number and type of systems. This view has difficulty accounting for the similarities between supposedly different systems and for dissociations within a single system. A second explanation is based on transfer appropriate processing and suggests that many differences arise from the relative contributions of data-driven and concept-driven processing. This view has difficulty in defining the types of processing precisely. A third view attributes the results from implicit memory tasks to bias: Prior presentation of something influences the way you process the same item a second time.