Implicit tests of memory are those that measure retention indirectly, by transfer of prior experience ostensibly unrelated to ongoing behaviour. Performance on implicit memory tests is often dissociated from that on explicit memory tests, psychologists' traditional measure of conscious recollection, such as free recall, cued recall and recognition. For example, densely amnesic patients who recall very little on explicit tests perform at normal levels on implicit tests. Similarly, in normal populations, independent variables often affect performance on implicit and explicit tests in different ways. This chapter surveys some basic facts that have been discovered about priming on implicit memory tests and extensions of this work into other arenas. There are at least two types of implicit memory test—perceptual and conceptual. Perceptual implicit memory tests involve processes used in the recognition of words and objects and are greatly affected by specificity of perceptual operations, but little affected by manipulations of meaning. Conceptual memory tests are greatly affected by manipulations of meaning, but little affected by changes of perceptual operations.

INTRODUCTION
Implicit memory is a new term that refers to an old idea: the notion that people can demonstrate the after-effects of experiences in their behaviour without being able to consciously recollect the experiences themselves. Given this broad definition, the term could encompass such things as Ebbinghaus's measure of savings through relearning, or Freud's study of
slips. Indeed, any transfer that a person exhibits from a prior situation to a current one without awareness that the transfer is occurring could be labelled implicit memory (if the broadest definition is used). However, for present purposes, we will consider a relatively circumscribed area of research that has grown up around this term.

Schacter (1987, p. 501) stated that “Implicit memory is revealed when previous experiences facilitate performance on a task that does not require conscious or intentional recollection of these experiences”. Such facilitation is typically referred to as priming. This form of memory is contrasted with explicit memory, which “is revealed when performance on a task requires conscious recollection of previous experiences” (ibid.). Others have preferred the terms indirect and direct memory tests to refer to what here will be called implicit and explicit tests, respectively (Johnson & Hasher, 1987; Richardson-Klavehn & Bjork, 1988; Segal, 1966). These alternate terms are used because explicit tests measure subjects’ retention directly, whereas implicit tests do so only indirectly, by measuring transfer.

In this brief review, we try to accomplish several goals. First, we consider the origins of implicit memory research; second, we review some of the basic phenomena that have been discovered; and, third, we briefly sketch in theoretical concepts required to explain these new phenomena. Fuller reviews of this literature can be found elsewhere: Schacter (1987) and Richardson-Klavehn and Bjork (1988) provided the first comprehensive reviews; Shimamura (1986) and Moscovitch, Vriezen and Gottstein (1993) have examined neuropsychological evidence; and Roediger and McDermott (1993) have reviewed implicit memory in normal human subjects.

ORIGINS OF IMPLICIT MEMORY RESEARCH

The current fascination with implicit memory originated in neuropsychological work. Damage to certain parts of the brain causes profound losses of memory (Squire, 1987). Patients suffering from such amnesia often fail to consciously recollect virtually any new information, including their doctors’ names after hundreds of trials, and current events despite watching television. Patient H.M. was the first case studied in great detail (Milner, Corkin, & Teuber, 1968), although many others have been studied more recently. These patients typically display intact short-term or primary memory, showing relatively preserved digit span, but long-term memory, especially for new verbal material, is greatly impaired. Therefore, one idea prevalent in the 1960s and early 1970s was that the patients’ brain damage

1 “Priming” is a term used in several ways by cognitive psychologists. The semantic priming paradigm using the lexical decision or word naming task—in which a prime and target occur temporally close together—is probably the dominant use of the term priming (e.g., Neely, 1991). Priming on implicit memory tests occurs over much longer intervals.
affected their ability to consolidate information, or to transfer it from a short-term temporary store to more permanent long-term memory. Most researchers were quite impressed by the profound amnesia for any information that had occurred more than a few moments earlier.

More recently, however, Warrington and Weiskrantz (1968; 1970) have demonstrated that, under the right conditions, even profoundly amnesic patients can show intact retention beyond just a few moments. The basic paradigm was to show patients a series of words or pictures and then to test their memories in various ways. If patients were given tests of recall or recognition, they performed very poorly relative to control subjects. This outcome is no surprise, but simply a defining criterion of an amnesic patient. More interestingly, Warrington and Weiskrantz showed that if these patients were given fragmented forms of pictures and words and asked to guess their identity, they benefited from the past experiences. That is, the patients showed greater ability to name a fragmented picture or word if its intact form had recently been presented in a list, even under conditions in which they displayed no conscious recollection for the event's occurrence. This outcome led to the contemporary interest in implicit memory. In retrospect, one critical ingredient in such tests is the instructions that subjects are given prior to the test. On implicit memory tests, subjects are not told to recollect the words or pictures they have studied, but rather they are told to say the first name that comes to mind when the test stimulus is presented. Many implicit memory tests are presented as guessing games; subjects are told to complete the task by guessing the names of the fragmented words or pictures.

One experiment that compellingly documents intact priming with amnesic patients was reported by Graf, Shimamura and Squire (1985, experiment 1). They tested 10 amnesic patients, 8 of whom suffered from Korsakoff's syndrome. (In this disease, chronic alcoholism combined with a vitamin deficiency damages certain parts of the limbic system and the frontal lobes.) The other two amnesic patients were rendered so by brain damage caused by hypotensive episodes in which the blood supply to the brain was briefly shut off. The memory abilities of these 10 amnesic patients were compared to those of two control groups, one composed of alcoholic subjects who did not suffer from Korsakoff's syndrome and another of medical in-patients in the same facility.

All the subjects were tested individually on four word lists. As they studied each word on the list, they judged (on a scale of 1–5) how much they liked the named object. For two of the lists the words were presented visually, and for the other two they were presented auditorily. Similarly, after one list of each type the subjects were given a free recall test (an explicit test): they were given a blank sheet of paper and were simply asked to write down as many words as possible from the list. After the other two lists, the
subjects were given a word-stem completion test: they were given the first three letters of many words (half had been recently studied and half had not) and were told that each of the cues was "the beginning of an English word"; they were instructed to write a "few letters to make each into a word. You can write any English word—but please write the first word that comes to mind" (Graf et al., 1985, p. 389). This word-stem completion test is an implicit test of memory because subjects are not asked to use the cues to consciously recollect words from the list, but instead are instructed to generate the first word that comes to mind.

The results from this experiment are shown in Figs 4.1 (free recall) and 4.2 (word-stem completion). Considering the free recall results first, the inpatient and alcoholic controls showed better recall than did the amnesic patients after both visual and auditory presentations of the list. In addition, mode of presentation did not affect free recall. However, a very different pattern of results occurred on the word-stem completion test. What is shown in Fig. 4.2 is that amnesic patients showed just as much priming (i.e. benefit from recently studying the words in completing the word stems, beyond the baseline level of performance) on this implicit memory test as did the two control groups. Indeed, for visually presented words, the amnesic subjects actually showed equivalent or slightly greater priming than did the control

![Graph showing recall results](image-url)

**Fig 4.1** Results of Graf et al. (1985, experiment 1). Free recall by amnesic patients (AMN), medical in-patients (INPT) and alcoholic controls (ALC).
FIG. 4.2 Results of Graf et al. (1985, experiment 1). Word-stem completion by amnesic patients (AMN), medical in-patients (INPT) and alcoholic controls (ALC). Test cues in the word-stem completion test were always presented visually. Thus, test cues were either in the same sensory modality as the study list items (visual presentation) or in a different sensory modality (auditory presentation).

groups. The other feature to note is that visual presentation produced greater priming than did auditory presentation for all three groups, unlike the case in free recall where modality did not matter.

The conclusion to be drawn from Graf and co-workers' (1985) experiment and many others is that the studied words were encoded by amnesic patients; there seemed to be no impairment in transferring the words from a short-term state to a long-term state. Rather, the difficulty was in conscious recollection of the words for free recall. Using Tulving and Pearlstone's (1966) terms, even for the amnesics the words seemed available (because they could be displayed on another form of test) but not accessible to conscious recollection. The amnesic subjects could not consciously recollect the words, but nonetheless showed as much benefit from their recent presentation in the implicit memory test as did control subjects.

Experiments such as those by Warrington and Weiskrantz (1968; 1970) and Graf et al. (1985), among many others, helped create interest both in neuropsychology and in cognitive psychology as to the causes of preserved priming in amnesic patients. Interest was heightened when studies began showing the same sorts of dissociations in normal subjects. Researchers
manipulated independent variables that had powerful effects on measures of explicit memory, but had little or no effect on measures of implicit memory (e.g. Graf, Mandler, & Haden, 1982; Jacoby, 1983; Jacoby & Dallas, 1981; Tulving, Schacter, & Stark, 1982). In each of these experiments, some variable was shown to have a large effect on explicit measures of memory, recall or recognition, but either no effect on priming on an implicit test (such as word completion) or even an opposite effect (Jacoby, 1983). These dissociations suggested that different factors operate in tests of explicit and implicit memory. The remainder of this tutorial review will illustrate what we know about these other factors and, more generally, about implicit memory.

TWO TYPES OF IMPLICIT MEMORY TEST

A wide variety of implicit memory tests has been developed. Roediger and McDermott (1993) listed 13 tests in common use, but this number could easily be extended by a factor of two if all the variations are considered. Indeed, we suspect that many other forms of test will be devised in the future, as virtually any cognitive task can be converted into an implicit memory test. The requirements are simply that (1) relevant information be exposed to subjects in a first phase, and (2) subjects' transfer of these experiences to some new task be examined in a second phase, under instructions that emphasise immediate responding and not conscious recollection. Of course, these requirements satisfy the operational definition for studying implicit memory, but the thorny problem of whether subjects will occasionally invoke conscious recollection of the first phase to solve the problems of the second phase must be faced. We consider this problem below.

There seem to be two different types of implicit memory tests (Jacoby, 1983; Roediger & Blaxton, 1987). These two types have been called perceptual (or data-driven) and conceptual (or conceptually driven). In perceptual implicit memory tests, subjects are given impoverished renditions of pictures or words and asked to guess their identity. The subjects' job is to resolve the data-limited display. The hallmark of a perceptual implicit memory test is that the test cue bears some perceptual resemblance to the target item, such as being a fragmented form of the target. On the other hand, conceptual implicit memory tests provide a cue that is related to the target on a conceptual basis but does not share perceptual features with the target. For example, if subjects studied a target word such as cologne for a perceptual implicit memory test, they might be given a word stem or word fragment such as col______ or c____g n and asked to write down the first word that comes to mind to complete the stem or fragment. For a conceptual implicit memory test, subjects might be given a general
knowledge question ("What German city is famous for the scent it produces?") and be asked to answer as quickly and as accurately as possible.

The study by Graf et al. (1985, experiment 1) provided an example of a perceptual implicit memory test, as they showed normal priming in amnesics on a word-stem completion test. Let us consider another study by Graf et al. (1985, experiment 2) to illustrate the use of conceptual tests. They used 10 amnesic subjects (8 with Korsakoff's syndrome and 2 who became amnesic as a result of hypotensive episodes) and two new control groups (alcoholic patients without Korsakoff's syndrome and healthy volunteers). The subjects studied lists of words that were taken from various conceptual categories (e.g. fruits, sports, parts of the body, etc.). The lists were presented twice in a different random order, with subjects performing the liking judgement task each time. After the second presentation, the subjects were given category names as cues and told to generate eight items belonging to each category. They were told that this was a word production test and that "I'm going to give you a title—the name of a category—and I want you to say eight things that belong to that category as fast as you can" (Graf et al., 1985, p. 392). The subjects did this for six categories, three of which had been studied and three of which had not been studied. (The latter three were control categories for which base rates for priming were taken; the categories were counterbalanced across studied and non-studied conditions over subjects.) Following the word production test, the subjects were given a free recall test in which they were given a blank sheet of paper and asked to recall as many of the words as they could from the studied list.

The results are shown in Figs 4.3 (free recall) and 4.4 (category instance production). It is clear that amnesic patients recalled virtually nothing, whereas control groups recalled 40–50% of the words. However, reliable and equivalent priming effects were found for all three subject groups. Therefore, we see that amnesic patients are severely impaired on an explicit test (free recall) but are unimpaired on an implicit test (generating exemplars to category names as fast as possible). The results in Fig. 4.4 also suggest that the control subjects did not invoke processes of conscious recollection when using the category name cues to produce words, because their results were equivalent to those of the amnesic patients (who would not be able to recall words to any great degree).

Although Graf et al. (1985) found similar results with perceptual and conceptual implicit tests—normal levels of priming in amnesics—more recently, dissociations have been obtained between these tests. For example, Srinivas and Roediger (1990, experiment 1) had subjects either read words presented in isolation (donkey) or generate them from a sentence cue and the first letter of the word (a mule is similar to a d_____) in a study phase. In both study conditions, the subjects said the word aloud. After studying many items in these conditions, the subjects took one of several implicit
Fig. 4.3 Results of Graf et al. (1985, experiment 2). Free recall by amnesic patients (AMN), healthy controls (HC) and alcoholic controls (ALC).

memory tests. For our purposes here, the critical tests were (1) a perceptual implicit memory test in which subjects completed fragmented words (d–n–...–) with the first item that came to mind, and (2) a conceptual implicit memory test in which subjects spontaneously produced items of a given category (animal– ... ). Of course, items were counterbalanced across conditions and so served equally often (over subjects) in the read, generate and non-studied conditions. The non-studied condition provides the baseline for performance.

Srinivas and Roediger's (1990) results are shown in Fig. 4.5, where it can be seen that a strong dissociation occurs on these two implicit tests. In the word-fragment completion test, reading words produced greater priming than did generating them, whereas in the category instance production test the opposite was true. Thus, even though priming on both perceptual and conceptual implicit memory tests is preserved in amnesic patients (as seen in Figs 4.2 and 4.4), these tests can themselves be dissociated from one another by manipulation of other variables.

Many other experiments have revealed similar dissociations between perceptual and conceptual implicit memory tests. For example, Challis and Sidhu (1993) have reported a series of experiments in which they examined the effect of massed repetition on these two kinds of implicit tests, as well as
explicit tests. They presented words 1, 4 or 16 times successively and showed that this variable had powerful effects on free recall and on recognition. Repetition had a similar effect on a conceptual implicit test (answering general knowledge questions) but no effect on the perceptual implicit test of fragment completion. Priming occurred on the fragment completion test but was no greater after 16 presentations of the target word than after a single presentation. Massed repetition priming therefore affected a conceptual implicit test but had no effect on a perceptual implicit test. There are a number of other reports of dissociations between perceptual and conceptual implicit memory tests (e.g. Blaxton, 1989; Hamann, 1990; Rappold & Hashtroudi, 1991). These findings reinforce the conclusion that at least two types of implicit tests exist. A review of this literature is provided in Roediger, Srinivas and Weldon (1989a).

SPECIFICITY OF PRIMING ON PERCEPTUAL
IMPLICIT TESTS

One hallmark of perceptual implicit tests is that priming increases with the similarity of the perceptual display between study and test. This is as it should be, if the basis of transfer in such tests is due to perceptual
FIG 4.5 Results of Srinivas and Roediger (1990, experiment 1). Read words produced greater priming than generated words on the word-fragment completion test, whereas the opposite occurred on the category production test. The bars indicate priming above non-studied baseline levels of 0.21 for word-fragment completion and 0.16 for category production.

operations. Roediger and Srinivas (1993) have argued that the processes involved in such implicit memory tests are the same as those used in recognising words and objects. The more similar the perceptual operations in recognising objects between study and test, the greater priming ought to be. Some evidence for specificity of priming has already been seen in the results of Graf and co-workers' (1985) experiment 1 (see Fig. 4.2). Priming in the word-stem completion test was greater following visual presentation of words than following auditory presentation. This outcome has been replicated many times and indicates that priming is partly due to modality-specific processes and partly due to some more general process (see Kirsner, Dunn, & Standen, 1989).

Another example of such specificity of priming is found in an experiment reported by Weldon and Roediger (1987, experiment 4), in which subjects studied a long series of words and pictures. Of course, the picture-word comparison is a much-studied variable and the general finding on explicit memory tests is that pictures are better remembered than are words (even when the test is verbal, such as recall or recognition for the names of the
pictures and words). Weldon and Roediger showed that, with their stimulus set too, pictures were indeed better recalled than words. However, their primary interest was in how pictures and words would affect two perceptual implicit memory tests, completing fragmented words and naming fragmented pictures. At test, different groups of subjects were given a long series of word fragments or picture fragments, which corresponded either to studied words, studied pictures, or to non-studied items. The results are shown here in Fig. 4.6. Priming on the word-fragment completion test is seen on the left, where it is apparent that words produced greater priming than did pictures. This stands to reason if one assumes that the perceptual operations used in decoding the word fragments were more similar to those originally used in reading the words than in analysing the pictures. Similarly, priming on the picture-fragment naming test was greater if subjects had studied pictures than if they had studied their verbal counterparts, the names of the pictures. Again, we can assume that the similarity in processes of studying a picture and decoding its fragment is greater than of studying a word and decoding a picture fragment.
The experiments cited above provided radical transformations between study and test, such as presenting words at study and then testing with picture fragments. Evidence for perceptual specificity can also be obtained within either the verbal or pictorial domain by varying qualities of the stimuli. In Roediger and Blaxton's (1987) experiment 3, subjects studied words that were either presented in clear focus or blurred. The blurring manipulation was effected by changing the focus of the slide projector to the point that the words could be read only with considerable difficulty. Later, the subjects received a word-fragment completion test in which the fragments were presented either clearly or blurred. The results are presented in Fig. 4.7. Words studied in the clearly focused condition produced more priming when the test fragments were clearly focused than when they were blurred. Conversely, words studied in the blurred condition produced more priming when the test fragments were blurred than when they were clearly focused. Presumably, this differential priming in the two conditions was due to matching of perceptual operations in analysing blurred and focused words between study and test.

![Graph showing priming effects](image)

**Fig 4.7** Results of Roediger and Blaxton (1987, experiment 3). More priming occurred when the condition of presentation of intact words during study (focused or blurred) matched the condition of the fragment at test (focused or blurred). Non-studied base rates were 0.29 for focused fragments and 0.27 for blurred fragments.
The points made by the experiments described above show that priming on perceptual implicit memory tests that involve degraded stimuli is greatest when the studied item is presented in the same modality (visual or auditory), in the same symbol form (picture or word), and with similar visual features (clear or blurred) as the test item. The interpretation is that the specificity of perceptual operations provides greater transfer in the case where the studied item and the test stimulus match. Carrying this transfer-appropriate processing logic one step further, there should exist situations in which priming is increased above that in which the study item matches the test item only on features such as modality and symbol form. For instance, if the study phase involved subjects decoding a fragment, then one might expect priming on a fragment completion test to be enhanced above the level observed in the case of simply presenting the intact word or picture at study. In general, according to the transfer-appropriate processing logic, the more the operations at test match those at study, the greater priming should be.

Two different lines of evidence show that this prediction is indeed borne out. Gardiner (1988; 1989; Gardiner, Dawson, & Sutton, 1989) has conducted a series of experiments showing that this is the case with verbal material. For example, Gardiner et al. (1989) had subjects generate words from conceptual and fragment cues such as single unmarried man, B____E____OR. In another condition, subjects read the intact version of BACHELOR at the end of the phrase. Relative to a condition in which the word BACHELOR had not been studied at all, both conditions produced priming of the target words on a standard word-fragment completion test. However, priming was 10–15% greater across experiments if the subjects had generated the word from the same fragment that they later received at test. The priming was highly specific, because the advantage occurred both relative to the condition in which subjects read the intact word, and also relative to a case in which subjects generated the word from a fragment that differed by only one letter from the test fragment. That is, in order to obtain the enhanced positive transfer (relative to the condition in which they read an intact word), the subjects had to receive exactly the same fragment at study and at test. Gardiner and co-workers' (1989) results are presented in Fig. 4.8. It seems unlikely that the result is due to subjects using the fragments as retrieval cues and invoking conscious recollection, because Gardiner (1989) reported that the phenomenon occurred even in a sub-group of subjects who did not realise that any items in the test phase were the same as those in the study phase. Srinivas (1993) has obtained results quite similar to Gardiner's in the non-verbal domain by employing a picture-fragment naming test.

To sum up this section, perceptual priming tests generally show remarkable specificity. When the conditions of original presentation engage perceptual operations that will later be required to decode the test fragment, transfer or priming is maximised (see Roediger and Srinivas,
FIG. 4.8 Results of Gardiner et al. (1989, experiment 1). During a study phase, subjects either read words at the end of a phrase (political killer = ASSASSIN) or generated them from a fragment after reading the phrase (political killer = A--A--IN). The fragment for generation during study was either the same as the fragment at test or differed by one letter (added or subtracted). (The test fragment was always presented out of context: A--A--IN.) Priming occurred in all four conditions (relative to a 0.33 baseline), but was greatest when the test fragment exactly matched the study fragment.

1993; Tulving & Schacter, 1990). Although there is less evidence about conceptual implicit memory tests, the general conclusion is that alteration in perceptual features at study have little or no effect on priming on these tests. For example, Blaxton (1989), Srinivas and Roediger (1990) and Challis and Sidhu (1993) have all shown that modality of presentation has no effect on priming on conceptual implicit memory tests, although all these studies showed large effects of this variable on perceptual priming tests.

MANIPULATIONS OF MEANING

If manipulation of perceptual operations during study affects perceptual implicit tests but not conceptual tests, then a reasonable expectation is that manipulations of meaning ought to affect priming on conceptual implicit tests, but not perceptual tests. Although the evidence is not wholly consistent on this point, the bulk of it falls in line with this prediction. However, most evidence has been derived from perceptual implicit tests.
Conceptual implicit memory tests have been less studied, but thus far the evidence is consistent with the proposition that elaboration of meaning affects these tests. For example, Hamann (1990) showed that varying meaningful analysis of studied words affected priming on a conceptual implicit test. Rappold and Hashtroudi (1991) and Srinivas and Roediger (1990) provided converging evidence for the conclusion that conceptual implicit tests are affected by manipulations of meaning.

Most of the remainder of this section examines the prediction that manipulation of conceptual factors has little effect on perceptual implicit tests. Let us first consider a striking experiment by Denny and Hunt (1992). They compared memory performance for subjects who were diagnosed as being clinically depressed with that for the control group of non-depressed subjects by presenting them with words that had different affective valences. Some words had a quite positive connotation (affectionate, energetic, helpful, etc.), whereas others had a negative connotation (depressed, gloomy, hopeless, etc.). The subjects saw a list of 24 words and, for each word, rated on a 6-point scale how well the word described them. Later they took a free recall test and a word-fragment completion test (i.e. _E A _ E F_, for peaceful). On the word-fragment completion test, the subjects received fragments from the 24 studied words intermixed with 24 other fragments from a different list (the two lists were counterbalanced across subjects).

![Graph showing the proportion recalled for positive and negative words for non-depressed and depressed subjects.](image)

**Fig 4.9** Free recall results of Denny and Hunt (1992). Recall by depressed subjects was greater for negative than for positive words, whereas the reverse outcome occurred for normal subjects.
The free recall results from this experiment are shown in Fig. 4.9. Denny and Hunt (1992) replicated a standard finding in the literature: Non-depressed people recall positive words better than negative words, whereas depressed people recall negative words better. Thus, the meaning of the stimuli plays a large role in their recallability and the effects of meaning are opposite for the two groups of subjects. The results of the word-fragment completion test in Fig. 4.10 show a quite different pattern. The amount of priming for both positive and negative words was equivalent for the depressed subjects and the non-depressed control subjects. Despite the fact that the meaning of the stimuli significantly affected the (conceptual) free recall test, no reliable effect occurred on priming for the perceptual implicit test.

Another experimental result leading to the same conclusion has already been cited above (see Fig. 4.5). Generating words from conceptual clues is believed to involve elaboration of meaning, relative to reading words out of context. This elaboration typically produces a greater recall for generated than for read words (Jacoby, 1978; Slamecka & Graf, 1978). Generating also produces more priming on conceptual implicit memory tests, as seen in Fig. 4.5. However, on perceptual implicit memory tests, reading words out of context usually leads to greater priming than does generating them (e.g.
 Jacoby, 1983; see also Blaxton, 1989; Srinivas & . . diger, 1990; Weldon, 1991). Despite the fact that generated words seem “well encoded” by measures of recall and recognition, they typically produce less priming on perceptual implicit memory tests. Indeed, in some experiments, there is no reliable priming from generated items (Jacoby, 1983; Smith & Branscombe, 1988). However, not all researchers have obtained the result of read items producing more priming than generated items on perceptual implicit memory tests. In particular, Masson and MacLeod (1992) reported several experiments in which generating words at study produced priming equivalent to reading words. This outcome is something of a mystery, because most of the literature shows that reading a word produces more priming than generating a word (see Roediger & McDermott, 1993). Because this result is in some doubt, we report here an experiment conducted by the third author as preliminary work testing our experimental procedures in a new location. These results will not be reported elsewhere, so we include some relevant experimental details.

Jones (1992) tested 48 US Air Force recruits (43 males) at Lackland Air Force Base, all of whom were in their second week of basic training. They were tested at the Air Force Human Resources Laboratories on 40 IBM-compatible computers. The subjects were presented with three lists of 20 items in three presentation conditions. In one condition, the subjects read isolated words; in a second condition, they silently generated the words from a conceptual clue and the target’s initial letter (e.g. an animal with eight legs that makes a silky web: s____); in a third condition, they viewed line drawings from Snodgrass and Vanderwart’s (1980) norms and silently named the drawings. (The items were normed to be readily generated from the pictures and conceptual clues. After the test phase was over, the subjects were presented with the conceptual cues and pictures for all of the lists. They were able to produce the targets 95 and 94% of the time for the generate and picture conditions, respectively.)

In short, the subjects studied 60 items with a third each in the read, generate and picture conditions. In addition, another set of items was not studied to serve as baseline items in the later implicit memory test. The items were rotated through conditions over subjects. The rate of presentation was one item per 5.5 sec, and the entire study phase lasted about 10 min. After the subjects saw or generated each item, they rated its pleasantness on a scale from 1 to 7, where 1 was very unpleasant and 7 was very pleasant.

Following this study phase, the subjects engaged in a distractor task and after 5 min received a word-fragment completion test. For this test, the subjects were told that they would see words with letters left out and that their task was simply to provide an English word that fit the word frame. They were instructed to write down the first word that came to mind. Several examples were given. The subjects were told that the task was quite
difficult and they should not worry if they could not complete many items. They were encouraged to try hard. No mention was made of the relation between the word-fragment test and the prior study phase.

The results of Jones's (1992) experiment are quite straightforward. Subjects completed 0.47 fragments in the non-studied baseline condition and 0.63, 0.52 and 0.50 in the read, generate and picture conditions, respectively. A one-way ANOVA indicated at least one significant difference between the four conditions [$F(3,141) = 18.14, P < 0.001; MSe = 135.47$]. A Tukey test (critical difference $0.06, P = 0.05$) was used to investigate statistically all pair-wise comparisons. The subjects exhibited significant priming (0.16) in the read condition, but little priming occurred in either the generate or picture conditions (0.05 and 0.03, respectively), and it was not statistically different from the baseline in either case. Priming in the read condition was significantly greater than priming in both the generate and picture conditions.

Therefore, Jones replicated the results of many others (e.g. Jacoby, 1983; see also Blaxton, 1989; Srinivas & Roediger, 1990; Weldon, 1991) in showing that reading words out of context produced more priming than did generating them from conceptual cues on a perceptual implicit test. Like Winnick and Daniel (1970), Jones found no statistically reliable priming after subjects generated words from conceptual cues or from pictures. Because the manipulation of generating words virtually always produces greater explicit retention than does reading them, at least in within-subjects designs, the reverse finding on perceptual implicit memory tests indicates that different processes are involved in the two types of test.

A number of other experiments could be cited that show relative indifference of perceptual implicit memory tests to manipulations of conceptual factors that produce huge effects on explicit tests of recall and recognition (see Roediger & McDermott, 1993, for a review). Although the bulk of the evidence favours this conclusion, there are clear exceptions in the literature that are as yet not well understood. Smith (1991) and Masson and MacLeod (1992) have conducted experiments with manipulations of meaning that do show effects on implicit memory tests. Toth, Reingold and Jacoby (in press) argue that these exceptions are due to contamination of implicit memory tests by conscious recollection. When they used a technique that estimated and removed the contribution of conscious recollection, priming from generated words fell to baseline levels. This raises a fundamental issue: How can one be sure that an implicit memory test is really measuring incidental retrieval and that subjects are not applying intentional retrieval processes and converting the test into one of cued recall? We consider one solution to this problem in the next section.
THE RETRIEVAL INTENTIONALITY CRITERION

The problem of distinguishing explicit from implicit memory tests is currently occupying many researchers. Operationally, the tests are distinguished by the instructions given to subjects: In explicit tests subjects are told to recollect recent experiences, whereas in implicit tests they are simply told to respond to test stimuli as rapidly and as accurately as possible with the first answers that come to mind. However, some researchers worry that in the course of taking implicit tests, subjects may invoke conscious recollection. To us, this seems unlikely in most situations, because the task can usually be more easily solved simply by responding with the first word that comes to mind rather than the more effortful process of recollecting what study stimulus corresponds to the test cue. We suggest that subjects usually obey the law of least effort and follow the experimenter’s instructions. Nonetheless, other researchers are quite vexed by the potential problem of intentional retrieval processes affecting implicit memory tests. As yet, there is no consensus on a single solution to this problem (or even that this problem might exist). Roediger and McDermott (1993) review a handful of methods that have been devised to deal with this potential problem, but most are quite new and not yet carefully analyzed. Here we sketch one potential solution that we think is promising.

The solution is what Schacter, Bowers and Booker (1989) have called the retrieval intentionality criterion. This rather cumbersome name refers to an idea embodying a straightforward logic: In comparing performance on explicit and implicit memory tests, researchers should attempt to keep all overt study conditions and test conditions constant and vary only the instructions that subjects are given at test. If dissociations can be produced between explicit and implicit tests with all conditions held constant except test instructions, then one has better evidence than in the typical case (where other conditions are confounded) that the two types of test are invoking two different modes of retrieval (intentional and incidental).

Graf and Mandler (1984, experiment 3) employed what later came to be known as the “retrieval intentionality criterion” to show that word-stem completion could function as an implicit memory test, unaffected by intentional retrieval. Graf and Mandler manipulated the level of processing that subjects accorded stimuli during study. “Level of processing” (Craik & Lockhart, 1972) refers to the type of analysis that subjects devote to words or other stimuli when they study them. Analyses involving meaning are said to be deep; these include such tasks as having subjects rate how much they like the word, how pleasant it is, or how meaningful it is. On the other hand, if words are rated as to how many vowels they have, or how many enclosed letters they contain, these are considered shallow or superficial analyses. The standard finding on explicit memory tests such as recall or recognition is
that level of processing has a powerful effect, with deeper levels of
processing producing better retention than shallow levels. However, the first
experiments examining the influence of this variable on perceptual implicit
memory tests showed surprisingly little effect (Graf et al., 1982; Jacoby &
Dallas, 1981). This variable therefore seems to be a suitable one for
attempting to show differences between explicit and implicit tests according
to the retrieval intentionality criterion. If subjects study words under
shallow and deep levels-of-processing conditions and then are given exactly
the same test cues (e.g. word stems), they should show a large levels-of-
processing effect when given explicit test instructions, but little or no levels-
of-processing effect when given implicit test instructions. Such an outcome
would satisfy the retrieval intentionality criterion for distinguishing implicit
and explicit tests.

Graf and Mandler (1984) conducted this experiment and produced exactly
this pattern of results. They manipulated level of processing of words at
study, and at test gave two groups of subjects word stems as cues, with either
explicit instructions (recall the word from the list that corresponded to this
word stem) or implicit instructions (write the first word that comes to mind
that begins with these three letters). In the explicit test condition, the subjects
recalled 41% of the words that had been processed semantically and 8% of
the words that had been processed non-semantically, showing the typical
levels-of-processing effect. However, this same manipulation that affected the
explicit test so powerfully had virtually no effect on the implicit word-stem
completion test. The subjects showed 20% priming for semantically
processed words and 18% priming for non-semantically processed words.
The 2% difference was not statistically significant, and at any rate was much
smaller than the 33% difference following explicit test instructions.

Roediger, Weldon, Stadler and Riegler (1992) replicated Graf and
Mandler’s (1984) results with word-stem completion, and extended them to
a word-fragment completion test. In their experiment, subjects were
presented with words that they processed either graphemically (they
counted the number of ascending and descending letters in each word,
with ascenders being letters like b and d that extend above the line of type,
and descenders being letters like j and y that extend below the line of type)
or semantically (they rated the pleasantness of each word). After a study
phase, the subjects were given either word fragments or word stems with
either explicit or implicit test instructions.

The explicit test results are shown in Fig. 4.11 for word stems on the left
and word fragments on the right. As can be seen, there was a large levels-of-
processing effect with the semantically processed words recalled much better
than the graphemically processed words. The difference was greater for
word-stem cues than for word-fragment cues, but the levels-of-processing
effect was robust for both types of test cue.
The situation was quite different for the implicit test, as the priming scores in Fig. 4.12 show. On the word-fragment completion test, there was actually slightly greater priming from the graphemically processed words than from the semantically processed words; for the word-stem completion test, the result was slightly greater priming from the semantically processed words. Obviously, however, these small differences were not statistically significant, and if an average was calculated across the two perceptual implicit memory tests, there would be absolutely no effect of the levels-of-processing variable. Levels of processing is considered largely a manipulation of meaning and therefore we see once again that perceptual implicit memory tests seem impervious to such manipulations. Not all experiments have shown such indifference of perceptual implicit memory tests to the levels-of-processing manipulation (see Challis & Brodbeck, 1992, for an analysis) and some researchers believe that when levels-of-processing effects are found on such tests, they reflect contamination by intentional recollection (Toth et al., in press).

The point we make here is that the pattern of results shown in Graf and Mandler’s (1984) experiment and in Roediger and co-workers’ (1992)
3.4.12 Implicit test results of Roediger et al. (1992). Level of processing had no effect on her implicit test. Bars represent priming on the tests above the base rates of 0.16 for word-stem completion and 0.28 for word-fragment completion. The contrast between results in Figs 1 and 4.12 satisfies the retrieval intentionality criterion.

Experiment provides strong support for the idea that implicit memory tests need be little affected by intentional recollection. With all relevant study and test conditions held constant, including the nature of test cues, we see that when intentional retrieval is invoked there is a large effect of the dependent variable, whereas when incidental retrieval is measured rough an implicit test, the manipulation of meaning has no effect. If subjects were using intentional retrieval strategies on the implicit test, then we should see a levels-of-processing effect (just as we do when subjects are directly instructed to use that strategy). The absence of levels-of-processing effects on perceptual implicit tests can be used as a barometer of whether the implicit test instructions were successful in invoking only incidental retrieval. On the other hand, if a levels-of-processing effect is obtained on such tests, it may indicate contamination of the implicit test by intentional retrieval strategies (although other interpretations are possible; see Challis & Rodrigo, 1992). However, the retrieval intentionality criterion seems to be relatively secure means of distinguishing explicit from implicit forms of
test. Others have used it successfully, too (e.g. Bowers & Schacter, 1990; Challis & Sidhu, 1993; Greene, 1986).

EXTENSIONS TO OTHER AREAS

The study of implicit memory has primarily occupied researchers in cognitive neuropsychology and in cognitive psychology, but their work is being extended into other areas. We considered above the issue of whether depressed patients show similar memory phenomena to non-depressed controls. The finding there, like the finding with amnesic patients, is that a powerful individual difference variable that affects explicit memory tests has little or no effect on perceptual priming (see Roediger & McDermott, 1992). Such implicit tests will doubtless be used to evaluate other unusual groups of subjects.

Developmental psychologists have also asked whether perceptual priming is affected by age. Although the results are not totally consistent, the general conclusion is that perceptual priming does not change much in young children over ages where performance on any explicit memory test is greatly increasing (e.g. Naito, 1990; Parkin & Street, 1988). Similarly, as explicit memory (especially recall) declines markedly in the aged, priming on perceptual implicit memory tests seems at least relatively preserved, although small declines are sometimes seen (e.g. Howard, 1991; Light & Singh, 1987; Russo & Parkin, 1993).

Implicit memory tests are also being used by researchers interested in social cognition, because the basic paradigm is quite similar to paradigms developed independently to study processes in person perception (e.g. Srull & Wyer, 1980). For example, Smith and Branscombe (1988) showed that generating words produced greater transfer than reading words on a trait attribution task used to examine social cognition, a test quite similar to conceptual implicit memory tests. However, they also showed that generating words produced almost no priming on the perceptual implicit memory test of word fragment completion.

Additionally, implicit memory tests are being used to ask if information learned under various abnormal states (such as under the influence of drugs, or while asleep, or under anaesthesia) can be detected on a later test. For example, Hashtroudi et al. (1984) showed that whereas alcohol greatly impaired performance on tests of explicit memory, priming on perceptual implicit memory tests was unaffected (relative to performance of subjects in a sober state). Some tests have even shown that priming can be found for material presented when subjects are under the influence of general anaesthetics (Jelicic, Bonke, Wolters, & Phaf, 1992; Kihlstrom et al., 1990), although explicit measures of memory typically fail to detect
any recollection of these events (Loftus, Schooler, Loftus, & Glauber, 1985).

These are just some samples of extensions of the implicit memory research into other domains. We fully expect to see additional explorations in the future.

THEORETICAL CONSTRUCTS

A variety of theories has been produced over the last 15 years to explain (1) dissociations between explicit and implicit memory tests and (2) phenomena of implicit memory tests themselves. We do not have the space here to review these developments, and so we refer readers to other, more comprehensive reviews (Richardson-Klavehn & Bjork, 1988; Roediger & McDermott, 1993; Schacter, 1987). Here we simply point to two theoretical constructs that we believe must be incorporated into any general theory of these phenomena.

First, any theorist must come to grips with the distinction between intentional retrieval and incidental retrieval. Intentional retrieval refers to conscious recollection, or more familiarly, remembering. It is this process that is severely damaged in amnesic patients—their conscious recollection is greatly impaired—and dissociations can also be created in normal subjects when they are told to remember (as in explicit tests) rather than simply to respond (as in implicit tests). The dissociations produced between tests that conform to the retrieval intentionality criterion described earlier show that the intentional/incidental retrieval distinction is as important in normal subjects as it is in amnesic patients (e.g. Graf & Mandler, 1984; Roediger et al., 1992).

The second crucial theoretical construct is the distinction between perceptually based tests and conceptually based tests, which has formed such an important part of this chapter. As described above, this distinction permits understanding of dissociations between both traditional implicit and explicit tests (where the type of test cue is often confounded with the study instruction) and can also permit understanding of dissociations between implicit tests themselves, as illustrated above in Fig. 4.5. Although the distinction between these two forms of test has attracted its critics (see Tenpenny & Shoben, 1992), we believe that much evidence demands that such a distinction be invoked. Further specification of this distinction can be found in Roediger (1990), Roediger et al. (1989a) and Roediger, Weldon and Challis (1989b). We suspect that the distinction between perceptual and conceptual tests is certainly not the only important contrast to be made in explaining these phenomena, but we think it will be numbered among the most important as research in this area develops.
CONCLUSIONS

The first 100 years of the experimental study of human memory, from publication of Ebbinghaus's (1885/1964) great book in 1885, to Graf and Schacter's proposition of the contrast between explicit and implicit memory in 1985, was dominated by the study of tests that are now called explicit memory tests. The traditional paradigms of free recall, cued recall, paired associate learning, serial recall and a host of others all deal with conscious recollection. The study of implicit memory has deep roots (Schacter, 1987) but has been an intense object of study only during the last 15 years. We believe that research for at least the next few decades will benefit from continued study of both explicit and implicit memory tests.

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