Priming of novel information in amnesic patients: Issues and data

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Dissociations between implicit and explicit memory have been observed across a wide variety of tasks and conditions, as documented by recent review articles (cf., Richardson-Klavehn & Bjork, 1988; Roediger, 1990; Schacter, 1987) and by other chapters in this volume. Despite the apparent ubiquity of such dissociations, it is probably safe to say that the most striking separation between implicit and explicit memory is observed in the amnesic syndrome: Densely amnesic patients perform poorly on explicit tests of memory, but they perform remarkably well, and frequently normally, on numerous implicit tests (e.g., Cohen & Squire, 1980; Graf, Squire, & Mandler, 1984; Milner, Corkin, & Teuber, 1968; Moscovitch, 1982; Schacter, 1985; Shimamura & Squire, 1984; Warrington & Weiskrantz, 1974). In addition to providing some of the strongest empirical grounds for distinguishing between implicit and explicit memory, these dissociations can provide potentially important insights for both cognitive and neurobiological theories of mnemonic processes. On the one hand, observations of preserved implicit memory in amnesia provide important constraints for cognitive theories: If a theory does not speak to or cannot accommodate the amnesia data, then it fails to explain a critical aspect of implicit memory. On the other hand, data concerning implicit memory in amnesic patients can aid neurobiological formulations by providing insights into the function of the hippocampus and related limbic structures that are typically damaged in amnesia (e.g., Milner et.al., 1968; O'Keefe & Nadel, 1978; Squire, in press), and can also be informative regarding the cortical structures that are typically preserved in amnesia (cf., Schacter, 1990, 1992a; Squire, in press). Indeed, attempts to fully characterize the computations that these structures perform should be informed by, and must be consistent with, the known implicit memory abilities of amnesic patients.

In the present chapter, we focus on one particular type of implicit memory: the phenomenon of priming, or facilitated identification of words and objects from reduced cues as a consequence of recent exposure to them (e.g., Tulving & Schacter, 1990). More specifically, we consider the question of whether amnesic patients show intact priming of newly-acquired or novel information. When we use the terms "implicit memory for novel information" or "priming of novel information", we refer to memory for various kinds of materials that are not represented as a unit in memory prior to an experimental encounter with them -- unrelated paired associates, nonwords, unfamiliar objects, novel dot patterns, and the like. Novel materials of this kind can be contrasted with familiar materials that are represented as a unit in memory prior to the experiment, such as real words or pictures of common objects. Although we shall have more to say later about conceptualizing the notion of "novel information", the key point to note for introductory purposes is that a number of important cognitive and neurobiological issues turn on the question of whether amnesic patients show normal priming of novel information in various experimental paradigms.

The chapter is divided into four main sections. In the first, several neuropsychological and cognitive theories of implicit and explicit memory are

briefly reviewed in order to set the stage for thinking about priming of novel information. This review highlights the idea that different theories can be divided into two groups: Those that predict that priming should be limited to materials with preexisting memory representations, and those that predict that priming should extend to novel materials without preexisting memory representations. The second section considers conceptual issues surrounding the question of what constitutes "novel information". Although the meaning of the phrase "novel information" has often been treated as self evident in memory research, the matter is complex and we make use of recent discussions in the psycholinguistic literature to illuminate it. In the third section, we review priming of novel information in both amnesic patients and normal subjects. The fourth and final section evaluates theories of implicit memory in light of previous discussions.

Cognitive and Neuropsychological Theories of Amnesia and Implicit Memory

Early reports that amnesic patients show some preservation of what we would now call implicit memory can be traced to late 19th- and early 20th-century observations (cf., Parkin, 1982; Schacter, 1987). However, the critical data for contemporary researchers were reported in two influential sets of experiments dating to the 1960s. The first were studies by Milner and colleagues showing that the famous patient H.M., who became amnesic following bilateral medial temporal lobe resection (Scoville & Milner, 1957), could acquire new motor skills despite lack of recollection for the episodes in which the skills were acquired (e.g., Milner etal., 1968). Thus, although it had been known for years that H.M. possesses intact immediate or short-term memory (Scoville & Milner, 1957), the data on motor skill acquisition suggested that some aspects of H.M.'s long-term memory are spared.

The second set of crucial experiments, which are more directly relevant to priming, were reported by Warrington & Weiskrantz (1968, 1970, 1974). These investigators demonstrated that densely amnesic patients can show relatively intact retention of information acquired from a single study episode, but only when memory is assessed with specific types of tests -- perceptual fragments of words or pictures (see also Milner etal., 1968). For example, when amnesic patients viewed fragments of previously studied pictures, or viewed fragments of recently studied words, they often responded to the cues by providing the previously studied items -- even though they could not explicitly remember the items on standard free recall or recognition tests. Although a variety of interpretations of the initial Warrington and Weiskrantz data were considered, subsequent research established that amnesic patients exhibit normal memory performance with fragment cues only when they are given implicit memory instructions to respond with the first word that comes to mind; when given the same fragment cues together with instructions to try to remember study list items, impaired performance is observed (Graf etal., 1984). A number of other studies have shown normal priming and impaired explicit memory in amnesic patients under conditions in which test cues are held constant and only retrieval instructions are varied (e.g., Cermak etal., 1985; Graf, Shimamura, & Squire, 1985; Schacter, 1985; Shimamura & Squire, 1984).

In the foregoing studies, intact priming was observed for familiar materials,

such as common words or highly-related associates, that have preexisting memory representations. To understand the theoretical importance of the distinction between priming of familiar vs. novel materials, it is useful to consider the data on spared priming in relation to ideas that have been put forward regarding other spared memory abilities in amnesic patients. For instance, the early observations on preserved short term memory and motor skill learning in H.M. and other amnesic patients have typically been explained by appealing to impaired consolidation processes (for an historical overview, see Polster, Nadel, & Schacter, 1991). The specific nature of these consolidation processes are not well understood, but the idea that amnesia impairs processes that convert short- into long-term memories is consistent with data on spared short-term memory in amnesia and has been accepted by many neuropsychologists (Squire, Cohen & Nadel, 1984) and connectionist modelers (cf., McClelland & Rumelhart, 1986; Carpenter & Grossberg, 1987; Wolters & Phaf, 1990). Similarly, the preserved motor learning skills of amnesic patients have also been interpreted in terms of consolidation theory. The basic idea is that long-term memory, as expressed on standard recall or recognition tests, and motor learning, as expressed on pursuit rotor and similar tasks, are mediated by separate systems: Impaired long-term recall and recognition is thought to reflect defective consolidation in a system involving the hippocampus and related structures, whereas spared motor learning is thought to depend on a separate system involving basal ganglia and related structures (e.g., Milner etal., 1968; Mishkin & Petri, 1984; O'Keefe & Nadel, 1978; Squire, 1987).

While many if not all amnesia researchers would agree with this general approach to explaining preserved short-term memory and motor learning, attempts to apply consolidation theory to priming phenomena in amnesic patients are less clear-cut. Two different approaches to the issue can be distinguished. One approach holds that amnesia is attributable to a consolidation failure that impairs the acquisition of all new memory representations that are usually acquired in a single episode. Accordingly, it is argued that priming effects do not reflect the establishment of new memory traces within a long term memory system, but instead are the result of spared activation processes that act on preexisting memory traces (e.g., Diamond & Rozin, 1984; Rozin, 1976; Wicklegren, 1979). For example, when a subject studies the word WINDOW, the preexisting representation for WINDOW is assumed to be activated automatically as a consequence of encountering the word, and to remain activated beyond the span of short-term memory. This activated representation is thought to be more readily accessible to the subject than is a non-activated representation and hence provides the basis for priming on various implicit memory tests. A related idea was advanced by Graf and Mandler (1984; Mandler, 1980), who distinguished between an <u>integration</u> process that strengthens the code of preexisting memory representations and an <u>elaboration</u> process that constructs new memory representations by building novel connections among previously unrelated representations. Integration promotes the accessibility of preexisting representations, supports priming, and is spared in amnesic patients; elaboration establishes new episodic memories, supports explicit

retrieval, and is impaired in amnesic patients (e.g., Graf etal., 1984).

A distinction between processes that activate or strengthen preexisting memories, and processes that establish novel memory representations is also found in various connectionist theories (cf., Carpenter & Grossberg, 1987; Wolters & Phaf, 1990). In these theories, amnesia can be modelled by selectively impairing the processes that mediate the establishment of new memories in the network.

A second general class of theories assumes that priming phenomena are mediated by memory systems that operate independently of the episodic or declarative system that depends on the hippocampus and related structures. While these theories often assume that amnesic patients' explicit memory deficit is attributable to consolidation failure within the episodic/declarative system, they do not necessarily imply that consolidation of <u>all</u> new representations is blocked. For example, Cohen (1984) and Squire (1987) suggested that priming effects are mediated by a procedural memory system that becomes more efficient at processing information as a consequence of past experience. The system depends on cortical structures and is spared in amnesic patients (see Squire, in press, for a revised and expanded version of this idea). According to this view, reading the word WINDOW on a study list produces a direct on-line change to the system responsible for processing words, and as consequence of this change, the system may process the word WINDOW more effectively on subsequent exposures, or may require less information to identify this word than a nonstudied word on a subsequent test. A related idea is that many priming effects depend on a perceptual representation system (PRS) that is spared in amnesic patients (Schacter, 1990, 1992a, 1992b; Tulving & Schacter, 1990; see also Gabrieli etal., 1990). According to this theory, priming effects are mediated by various cortical regions that represent the form and structure, but not the meaning and associative properties, of words and objects. Processing a word or object on a study list produces a perceptual representation of relevant form/structure information, and this representation provides the basis for facilitated performance -- priming -- on identification, completion, and similar implicit tests.

Although this thumbnail sketch of theoretical views touches on only a few main points, its main purpose is to highlight a key contrast between the two general approaches that were considered. According to activation/integration views, new memories are not consolidated normally in amnesic patients and priming depends on activation of preexisting memory representations; hence, priming should not be observed for novel materials that require the establishment of new memory traces. According to the memory systems accounts, only certain kinds of new memories -- those that depend on an episodic or declarative memory system -- are subject to consolidation failure in amnesic patients. Priming depends on a separate, spared memory system and hence should be observed for both familiar and novel information: if a memory system is truly spared by amnesia, then it should operate normally.

One further account of priming, espoused by Jacoby (1983), Masson (1989), and Roediger and colleagues (e.g., Roediger & Blaxton, 1987; Roediger, Weldon, &

Challis, 1989; see also, Roediger & Srinivas, Chapter X), should be noted briefly before proceeding further. These authors have argued that a single memory system mediates both implicit and explicit memory. Implicit/explicit dissociations are thought to reflect differences in retrieval operations that are required by implicit and explicit tasks and, in conformity with the principle of transfer appropriate processing, depend on the degree of match between such retrieval operations and the processing activities engaged during a study task. Proponents of this general viewpoint have focussed on explaining various implicit/explicit dissociations that have been observed in studies of normal subjects. Unlike the theories discussed earlier, the processing approach has not been systematically related to the amnesia literature; indeed, key proponents of this view concede that the theory does not provide a straightforward explanation of intact priming effects in amnesia (Roediger et al., 1989). Nevertheless, the processing approach would appear to predict that priming should occur for both familiar and novel information. According to this view, all implicit memory effects are mediated by an episodic memory system that can store new information from a single episode.

Defining "Novel" Information

Studies that purport to assess priming of novel information have generally used nonwords, unrelated paired associates, and unfamiliar objects as target materials, and have examined whether study-list exposure to these materials produces priming on a subsequent implicit test. The general assumption has been that because nonwords, unrelated paired associates, and unfamiliar objects do not have preexisting representations as units in memory (in the sense that words, highly related associates, and familiar objects do), we are justified in assuming that they constitute "novel" materials that enter memory for the first time during a study episode. While these stimuli may in fact be examples of novel information, further consideration suggests that the distinction between a "novel" and "preexisting" representation is not entirely straightforward.

The complexity of the issue is highlighted by a recent debate in psycholinguistic research concerning the representational format of words. On the one hand, a number of theorists have adopted a "lexical" stance. According to these authors, separate and discrete representations exist for each word in our vocabulary (e.g., Morton, 1979; Forster, 1976), and the first stage of word recognition is to gain access to the appropriate lexical entry. These lexical entries are thought to specify the meaning, pronunciation, and other relevant features of previously encountered words. The critical point for our discussion, however, is that this approach assumes that words have preexisting representations and nonwords do not. By contrast, various connectionist theorists have argued that word recognition processes proceed in the absence of any "lexical" representations (e.g., Seidenberg & McClelland, 1989; Van Orden et al., 1990). On this view, a connectionist network can learn to associate orthographic features of words with phonological and semantic features. These associations are thought to be acquired at a sublexical level -- that is, representations of words do not exist as discrete memory traces, but instead are emergent properties of associations between subword representations.

An important consequence of the connectionist approach is that words and nonwords have a similar representational status: The network processes information on the basis subword features, and both words and (pronounceable) nonwords possess similar subcomponents. As a simple (and perhaps simplistic) example, the items "numby" and "number" share many orthographic features in common (i.e., the letters "n","u", "m", and "b"), so they are processed similarly by the network. The critical difference between words and nonwords is not that words have preexisting lexical representations and nonwords do not; rather, the orthographic processes that are invoked by words access semantic codes, whereas the orthographic processes that are invoked by nonwords do not. In support of this general framework, various empirical results suggest that words and nonwords are processed similarly (e.g., Glushko, 1979; Rosson, 1985). Furthermore, several models of word recognition and naming can explain a variety of linguistic data without including lexical units in the model (e.g., Seidenberg & McClelland, 1989).

The debate regarding the nature of lexical representation is far from settled. For example, some data do suggest the need for discrete lexical entries (e.g., Besner etal., 1990). The reason for taking note of this debate is that its resolution has implications for theories of priming in amnesia. For example, if one adopts an activation account, and assumes that priming in amnesia is restricted to preexisting representations, then predictions regarding nonword priming effects depend on whether a lexical or sublexical view of word recognition processes is adopted. On the lexical view, words have preexisting memory representations and nonwords do not; accordingly, amnesic patients should show intact priming effects for words only. On the sublexical view, however, words and pronounceable nonwords share the same representational status in the orthographic domain. Consequently, the observation of spared nonword priming in amnesia might be consistent with some form of nonlexical activation theory -- that is, rather than necessarily indicating the formation of a novel lexical representation, intact priming of nonwords in amnesics might simply reflect activation of preexisting sublexical units.

Similar issues may be raised in the domain of nonverbal or visual object priming. The question here is whether discrete visual representations exist for each object that are analogous to lexical entries for words, or whether object representations are the emergent property of what we might call "subobject" codes -- primitive parts such as "geons" (e.g., Biederman, 1987) -- that are active at the same time. If we adopt a position analogous to the lexical view of word representation, where each object is represented by a discrete entry, we would conclude that novel objects (e.g., unfamiliar shapes or patterns) do not have preexisting memory representations. Thus, if priming in amnesia involves only activation of preexisting representations, intact priming of unfamiliar objects should not be observed. If on the other hand, we adopt a position analogous to the "sublexical" account of word representation, then we might well conclude that unfamiliar objects are represented similarly to familiar objects -- i.e., in terms of relations among shape primitives. By this view, exposure to an unfamiliar object on a study list would produce activation of the preexisting shape primitives and,

hence, even an activation account would predict intact priming in amnesic patients.

It seems clear that this lexical/sublexical debate complicates the task of using data on priming of novel information to distinguish between theories of implicit memory in amnesia. If we assume that words and objects are represented in the manner indicated by the lexical account, then an activation theory can be falsified by observing intact priming of nonword or nonobject in amnesia. And conversely, the idea that priming phenomena are mediated by novel representations in a system that is separate from episodic memory can be falsified if implicit memory effects in amnesics are restricted to familiar information that has a preexisting memory representation. However, if we adopt the sublexical approach, and thus assume that legal nonwords and unfamiliar objects do have preexisting orthographic or shape representations, respectively, then virtually all theories can accommodate nonword and nonobject priming effects in amnesia. Thus, an activation theory that assumes sublexical representations mediate priming effects may be difficult to distinguish from alternative theories that assume that novel representations mediate priming phenomena. We shall return to this general issue after considering pertinent data.

Priming of Novel Information: A Review

In this section of the chapter, experiments that assess priming of novel information in amnesic patients are reviewed; also, we will consider briefly pertinent studies on priming of novel information in normal subjects. In light of the foregoing discussion, it is important to note that when we use the phrase "novel information", we do not make any assumptions about an item's representational status; rather, we use the term in an atheoretical sense to indicate that a nonword or nonobject is subjectively unfamiliar to the subject. Indeed, we will use the phrases "novel information" and "unfamiliar information" interchangeably.

Priming of novel verbal information

Experiments concerning priming of novel verbal information have focussed on two main types of materials: nonwords and unrelated paired associates. We consider in turn studies that have made use of each type of novel material.

Nonword priming The question of whether priming effects can be observed for nonwords was addressed in some of the earliest studies of priming in normal subjects (e.g., Forbach, Stanners, & Hochhaus, 1974). Taken as a whole, however, the literature on nonword priming in normal subjects is rather mixed. Studies that have employed lexical decision as a priming task have generally failed to observe nonword repetition effects (e.g., Forbach etal., 1974; Fowler etal., 1985; Bentin & Moscovitch, 1988), whereas studies using identification or a naming latency tasks have yielded evidence of significant priming (Kirsner & Smith, 1974; Feustel, Shiffrin & Salasoo, 1983; Salasoo, Shiffrin, & Feustel, 1985; Whittlesea & Cantwell, 1987; Carr, Brown, & Charalambous, 1989; Rueckl, 1990). Note, however, that questions have been raised regarding the suitability of the lexical decision task for assessing nonword priming effects (Feustel et al., 1983), and if these results are set aside, then priming of nonwords is consistently observed in normal subjects. Nevertheless, theoretical interpretation of these results with respect to the

implicit/explicit memory distinction is not straightforward, because studies that reported significant effects with normal subjects have not dissociated priming from explicit memory. Consequently, it is possible that the observed priming effects were mediated partly or perhaps entirely by explicit memory strategies (see Schacter, Bowers, & Booker, 1989 for general discussion).

In view of the uncertain status of nonword priming effects in normal subjects, it is perhaps not surprising that the data from amnesic patients are also rather mixed, with both positive and negative results reported (cf., Cermak etal., 1985; Diamond & Rozin, 1984; Gabrieli & Keane, 1988; Haist, Musen & Squire, 1991; Musen & Squire, 1991a; Smith & Oscar-Berman, 1990) . We now consider each of these studies individually.

The first study to provide evidence on nonword priming in amnesia was described by Rozin (1976; see Diamond & Rozin, 1984, for a full report). Six memory-disordered patients of varied etiologies and six control subjects were tested in two separate sessions; within each session, subjects studied a list of six words and six nonwords. Each of the lists was studied six times, and following each study trial, subjects were asked to complete a short distractor task and perform a free recall test. In addition, subjects were presented on several trials with the first few letters of the target item, and they were asked to complete the cues with studied items. Subjects were encouraged to guess on this cued- recall test when they did not remember the study items, so performance could be mediated in part by an implicit form of memory.

The first key result of the experiment was that although the amnesic patients showed little evidence of memory on the free recall test, they showed robust facilitation on the cued-recall test, thus replicating the earlier results of Warrington and Weiskrantz (1970). The second key result was that the patients were quite impaired on the cued-recall test for nonwords; indeed, they did not show any facilitation in cued recall relative to free recall. Thus, these results suggest that for amnesic patients, priming effects require preexisting memory representations of words. However, there are three aspects of this study that limit the force of this conclusion. First, the normal subjects did not show any facilitation for nonwords in cued recall relative to free recall, because both cued and free recall of nonwords were at or near the ceiling. Thus, it is difficult to interpret the absence of nonword facilitation in the patient group. Second, as noted earlier, Diamond and Rozin used explicit rather than implicit memory instructions, so it is not clear whether these data bear directly on priming in amnesic patients. Third, a number of the patients in this study exhibited dementia in addition to amnesia.

In a later study, Cermak etal. (1985) used a perceptual identification task to assess implicit memory for words and nonwords in Korsakoff amnesics. In Experiment 1, amnesic patients and control subjects studied a series of lists, each composed of 10 words; following each study list, subjects completed an identification and a recognition task. For the identification task, subjects were given as much exposure time as required to identify an item; if they failed to identify an item at one exposure rate, additional, longer exposures were given until identification was achieved.

Priming on this task is indicated when less time is required to identify previously studied items relative to nonstudied items. For familiar words, normal subjects and amnesic patients demonstrated priming effects of 17 ms and 10 ms, respectively. Statistical analysis revealed a main effect of prior exposure on perceptual identification performance (i.e., priming), together with a nonsignificant interaction between prior exposure and subject group (i.e., amnesics vs. controls). On the basis of these analyses, it was concluded that amnesic patients showed intact word priming effects. In Experiment 2, amnesic patients and control subjects studied a series of lists, each composed of 10 nonwords, and following each study list, they performed an identification and a recognition task. On the identification test, normal subjects and amnesic patients demonstrated 55 ms and 18 ms priming effects, respectively. Statistical analysis revealed a significant interaction between prior exposure and subject group, thus indicating that the amnesic patients showed impaired nonword priming relative to controls. The existence of the prior exposure x subject group interaction for nonwords, together with the lack of such an interaction for words, led the authors to conclude that priming in amnesic patients, but not normal subjects, requires the existence of preexisting memory representations. However, the data from the amnesic patients are rather ambiguous: the 10 ms priming effect for words was actually smaller than the 18 ms effect for nonwords, and the authors did not report simple tests for the significance of either of these effects. The fact that normal subjects showed much greater facilitation than amnesic patients for nonwords could be attributable to the use of explicit memory by normal subjects to aid nonword identification; the use of multiple trials on the identification task could well promote the use of intentional retrieval strategies by intact subjects (cf., Haist etal., 1991; Schacter etal., 1989; Schacter, Delaney, & Merikle, 1990).

In a later study using a similar paradigm, Cermak etal. (1988) reported significant nonword priming in S.S., a patient with dense amnesia attributable to encephalitis. In this study, S.S. and control subjects studied a series of words and nonwords; following each list, they were tested on an identification and a recognition task. In the nonword condition, S.S. and control subjects demonstrated priming effects of 39 ms and 59 ms, respectively. Their corresponding recognition scores were 73% and 86% correct, respectively. As Cermak etal. point out, these results indicate that S.S. showed significant nonword priming effects. However, it must be noted that there is no dissociation between implicit and explicit memory in this experiment -- larger priming scores in the control subjects were paralleled by higher levels of recognition performance, perhaps because of the use of explicit strategies by control subjects.

Gordon (1988) reported evidence for significant nonword priming effects in a group of amnesic patients. In this study, amnesic patients of various etiologies made lexical decisions about words and nonwords, and following 10-15 intervening items, words and nonwords were repeated. With words, amnesic patients demonstrated a 151 ms priming effect compared to a 122 ms effect for normal subjects. With nonwords, however, normal subjects showed a 73 ms priming effect

and the amnesic patients showed an nonsignificant 9 ms effect. Although this result seems to suggest a lack of nonword priming in amnesic patients, Gordon reported that nonwords that were responded to especially slowly during the first presentation were responded to significantly more quickly by amnesics during the second presentation. On the basis of this latter observation, Gordon concluded that certain nonwords can be primed in amnesic patients. By the standard criterion of priming, however, amnesic patients failed to show a significant effect.

Smith and Oscar-Berman (1990) also reported some evidence of nonword priming in amnesic patients. Eight Korsakoff patients completed a lexical decision task in which words and nonwords were repeated after an average lag of 15 items. Under these conditions, control subjects demonstrated a 56 ms priming effects for words and a 50 ms priming effect for nonwords. The amnesic subjects, however, demonstrated a 131 ms priming effects for words and a nonsignificant 26 ms priming effect for nonwords. These reaction time measures clearly suggest that nonword priming is not normal in amnesic patients. However, when the accuracy of the lexical decisions was measured, the authors reported data suggesting robust priming of nonwords in amnesics. In this analysis, control subjects were equally accurate in judging items as words and nonwords on the first and second exposures, probably because of ceiling effects. Amnesic subjects, however, improved their lexical decision accuracy by 14.1 percent for words on the second trial relative to the first, whereas their performance for nonwords was 8.9 percent less accurate for second exposures relative to first exposures. According to the authors, this lowered accuracy on the repeated nonwords implies that some information about nonwords was acquired on the first lexical decision trial, information that made the lexical decision more difficult on the second trial. More specifically, the authors argued that the nonwords became more familiar to the subjects as a consequence of exposure on the first trial; this feeling of familiarity biased the patients to provide more frequent "word" responses to nonwords on the second trial than on the first, thus increasing their error rate. Once again, however, it is important to note that although these data do provide some evidence of nonword priming in amnesic patients, the amnesic patients failed to show intact nonword priming by a standard measure.

Several other studies, however, provide rather more convincing evidence of normal nonword priming effects in amnesic patients. In a briefly described study, Gabrieli and Keane (1988) reported evidence of normal nonword priming on a perceptual identification task in patient H.M., despite near-chance levels of recognition memory. Musen & Squire (1991a) reported repetition effects for nonwords on a reading task with a group of amnesic patients. In Experiment 1, control subjects and amnesic patients of various etiologies read lists of 100 items that were composed in four different ways: a) 100 unique words, b) 5 words repeated 20 times, with an average of 4 intervening items between repetitions, c) 100 unique nonwords, and d) 5 nonwords repeated 20 times each. The dependent measure was reading time, and this measure was obtained following each ten item sequence. The key result was that amnesic subjects performed similarly to the control subjects:

Reading times improved as a consequence of repetition, and the nonword reading times showed more improvement than did the words for both groups. In addition, it was found that the amnesic patients were significantly impaired on a recognition task relative to the control subjects, a result that suggests that performance of the reading task was not mediated by explicit memory. Experiment 2 was essentially a replication of Experiment 1, except that the target lists were re-exposed 10 min after the first presentation, so priming could be assessed with a 10 minute delay. Once again, amnesic subjects showed a normal facilitation of reading time for nonwords.

Although the Musen and Squire (1991) study used numerous repetitions of target items, evidence of intact implicit memory for nonwords in a more standard priming paradigm has been reported by Haist etal. (1991), who modified the perceptual identification task that had been used previously by Cermak etal. (1985). In the Haist etal. study, exposure duration on the perceptual identification task was calibrated individually for each patient so that baseline identification accuracy was approximately 50% correct for words and for nonwords. Subjects were then given four sets of study-test blocks; they made liking judgments about words and nonwords during the study phase and were then given perceptual identification and recognition tests. Amnesic patients showed normal priming for both words and nonwords. Haist etal. also assessed whether the observed priming of nonwords was attributable to items that were either phonologically or orthographically similar to real words. They failed to find evidence in support of this idea.

Evidence suggesting that phonological similarity to real words plays a role in nonword priming has been reported by Cermak, Verfaellie, Milberg, Letourneau, and Blackford (1991), using the same sort of perceptual identification procedure as employed previously by Cermak etal. (1985). In one experiment, amnesic patients and control subjects studied a list comprised of words, nonwords, and pseudohomophones (nonwords with the same pronunciation as a real word; e.g., phaire). Amnesics showed some, but impaired, priming for both nonwords and pseudohomophones. Although these data are inconclusive, in an additional experiment, a list consisting solely of pseudohomophones was studied, and amnesic patients now showed intact priming. Haist etal. (1991) have suggested that the differences between their data and those of Cermak etal. (1991) are attributable to the use of explicit memory by normal subjects in Cermak etal's mixed list condition.

In summary, although the literature on nonword priming in amnesic patients is rather unsettled, with both positive and negative findings reported, the message from recent work is that conditions do indeed exist in which amnesics show robust and even normal priming effects for nonwords. Note also that two of the studies that failed to observe significant nonword effects, at least by a standard criterion of priming (Gordon, 1988; Smith & Oscar-Berman, 1990) used a lexical decision task. This task has often failed to show nonword priming effects in normal subjects (e.g., Forbach etal., 1974; Fowler etal., 1985; Bentin & Moscovitch, 1988), so the noisy data obtained with amnesic patients are not entirely surprising. The possible use of explicit memory strategies by control subjects under certain experimental conditions has also been suggested as a reason for apparently impaired priming of

nonwords by amnesics. This suggestion has some plausibility, particularly because studies of nonword priming in normal subjects have typically failed to produce dissociations between priming and explicit memory of the sort that could rule out the use of intentional retrieval strategies by control subjects (see Schacter etal., 1989, for more extensive discussion of this general point). Nevertheless, it is not satisfactory to invoke the use of explicit strategies by normal subjects whenever amnesic patients fail to show intact priming; the problems of circular reasoning inherent in such an approach should be clear enough. This sort of explanation carries some force only when there are good reasons to believe that a particular priming paradigm invites the use of explicit strategies by control subjects, and when appropriate implicit/explicit dissociations that could rule out the use of such strategies have not been obtained with normal subjects (Schacter et al., 1989).

<u>Priming of new associations</u> A second major domain in which priming of novel verbal information has been assessed involves the analysis of implicit and explicit memory for newly-acquired associations, using a cued stem completion task developed and explored in a series of studies by Graf and Schacter (Graf & Schacter, 1985, 1987, 1989; Schacter & Graf, 1986a, 1986b, 1989). In these studies, subjects studied unrelated word pairs, (e.g., WINDOW-REASON), and were then given a stem completion test in which word stems are preceded by either the paired word from the study list (e.g., WINDOW-REA___; same context condition), or by some other unrelated word (e.g., OFFICER-REA___; different context condition). Numerous experiments with normal subjects have revealed significantly higher

levels of completion performance in the same context than in the different context condition, thereby demonstrating priming for newly-acquired associations. However, in contrast to priming effects with familiar words, which are generally insensitive to level of processing manipulations (cf., Bowers & Schacter, 1990; Graf & Mandler, 1984; Jacoby & Dallas, 1981), priming of new associations tends to be observed only following some degree of elaborative study processing (Graf & Schacter, 1985; Schacter & Graf, 1986a; but see Miccio & Masson, 1991). Furthermore, some evidence indicates that associative priming in college students is observed only in those subjects who exhibit some awareness of the relation between the completion task and the study list, whereas priming of familiar words can be observed in subjects who exhibit no such awareness (Bowers & Schacter, 1990). However, experimental conditions do exist in which college students and elderly adults can show associative priming in the apparent absence of test awareness (Howard, Fry, & Brune, 1991).

Several studies have examined whether associative priming effects on stem completion performance can be observed in amnesic patients. In their initial study, Graf & Schacter (1985) tested 12 amnesic patients of varied etiologies, 12 matched control subjects, and 12 college students. They found associative priming effects of comparable magnitude in all three groups. However, in a subsequent re-analysis of these data, it was observed that the associative effect -- more priming in the same- than in the different-context condition -- was observed only in patients with relatively mild disorders; severely amnesic patients showed priming, but there was

little difference between same- and different-context conditions. A similar pattern of results was observed in a subsequent study that compared priming of new associations in groups of mildly and severely amnesic patients (Schacter & Graf, 1986b).

Subsequent studies that have used the Graf and Schacter paradigm with amnesic patients have revealed a quite mixed pattern of results. Cermak, Bleich, and Blackford (1988) reported no evidence of associative effects in severely amnesic Korsakoff amnesics, but Cermak, Blackford, O'Connor, and Bleich (1988) did find that a densely amnesic encephalitic patient (S.S.) exhibited more priming in the same- than in the different-context condition. Shimamura and Squire (1989) replicated Cermak et.al.'s finding of no associative effects in Korsakoff patients, but found trends for associative priming in patients with presumed or demonstrated damage to the medial temporal region: these amnesic patients showed an 8.7% context effect, whereas matched control subjects showed a 10.5% context effect. In addition, Shimamura and Squire (1989) found a positive correlation between the amount of associative priming that was exhibited by individual patients and their score on the General Memory index of the Wechsler Memory Scale (Revised), thus replicating and extending Schacter and Graf's (1986b) finding that associative priming is related to severity of amnesia. Finally, Mayes and Gooding (1989) found little evidence of associative effects in a mixed group of amnesic patients.

In view of the finding that associative priming effects on stem completion performance in college students often depend on elaborative study processing and test awareness, it is tempting to suggest that the phenomenon might be attributable to the use of explicit memory strategies, thereby accounting for why associative effects are not consistently observed in amnesic patients. However, this idea has difficulty accommodating the fact that several experiments that have produced experimental dissociations between the associative effects on stem completion and associative effects on cued-recall performance under condition in which the cues on the two tests were the same and only instructions (implicit vs. explicit) were varied. For example, manipulations of degree and type of elaborative study processing, as well as proactive and retroactive interference, had no effect on priming of new associations despite large effects on explicit memory (Graf & Schacter, 1987, 1989; Schacter & Graf, 1986a; Schacter & McGlynn, 1989). By contrast, study/test modality shifts nearly eliminated the context effect on priming but had little or no effect on cued recall performance (Schacter & Graf, 1989). If associative priming is a simple consequence of intentional retrieval, it should not have been possible to obtain such dissociations in normal subjects under conditions in which nominal cues were held constant on implicit and explicit tasks, and only test instructions were varied.

Evidence concerning priming of new associations in amnesic patients has been obtained with two additional paradigms. Tulving, Hayman, and Macdonald (1991) reported an extensive case study of a severely amnesic head-injured patient, KC, who exhibits essentially no episodic memory. KC showed normal levels of priming on a fragment completion test for previously studied low frequency words, and these priming effects were quite long lasting. However, when target words

were paired with associatively unrelated phrases and pictures, KC showed no more priming when these contextual cues were reinstated during the fragment completion test than when they were not. KC was able, however, to acquire novel associations after extensive repetitions (Tulving etal., 1991), a finding that confirms and extends previous reports that with extensive repetition, KC can learn, and retain over long retention intervals, complex new associations and knowledge (Glisky, Schacter, & Tulving, 1986a, 1986b; Glisky & Schacter, 1988).

A further paradigm that has been used to investigate priming effects for unrelated word pairs in amnesic patients was developed by Moscovitch, Winocur, and McLachlan (1986). Subjects initially read pairs of words, and then re-read either the same pairs, or recombined pairs that were formed by repairing study list items. Moscovitch etal. found that following a single exposure to an unrelated word pair, amnesic patients, elderly adults, and young control subjects all read same pairs faster than recombined pairs, thus suggesting that newly-acquired associative information affected reading performance in all groups. However, Musen and Squire (1990) failed to replicate this result. They found associative effects on reading time (i.e., faster reading of same than recombined pairs) only following several study-list exposures to the unrelated word pairs.

The evidence on priming of new associations in amnesic patients, then, is similar to the previously discussed evidence on priming of nonwords, inasmuch as a relatively inconsistent pattern of positive and negative results has been obtained. Although it seems unlikely that this inconsistency is attributable to the use of explicit retrieval strategies by control subjects, it is possible that the initial acquisition or setting up of novel associations depends on an episodic or declarative memory system that is damaged in amnesia (cf., Shimamura & Squire, 1989).

Priming of unfamiliar objects and unfamiliar visual patterns

The majority of research on priming and implicit memory has focussed on verbal materials; there is less evidence available on priming of nonverbal information and still less on priming of novel or unfamiliar nonverbal information (for review, see Schacter, Delaney, & Merikle, 1990). Nevertheless, studies with normal subjects have established quite clearly that priming effects can be observed for novel objects and patterns, and have further indicated that such effects can be dissociated from explicit memory. For example, Schacter, Cooper, and Delaney (1990) observed priming effects on an object decision task that requires subjects to judge whether previously studied and nonstudied novel objects are structurally possible or impossible. The priming effect was observed for possible but not for impossible objects and was not enhanced by various encoding manipulations that increased explicit memory for the novel objects (see also, Schacter, Cooper, Delaney, Peterson, & Tharan, 1991). More recent work has shown that priming of novel objects was not reduced by study/test changes of object size and reflection that impaired explicit memory (Cooper, Schacter, Ballesteros, & Moore, 1992). Musen and Triesman (1990) demonstrated priming of novel dot patterns on a task that involved identifying briefly exposed patterns, and a subsequent study showed that this priming effect does not benefit from verbal

encoding strategies enhance explicit memory (Musen, 1991; for additional examples of nonverbal priming, see Kroll & Potter, 1984; Kunst-Wilson & Zajonc, 1980; Mandler, Nakamura, & Van Zandt, 1987).

Only a few studies have assessed priming of unfamiliar nonverbal materials in amnesic patients, but their results are relatively consistent. One study examined the performance of the well known amnesic patient H.M. and control subjects with a paradigm that assessed priming of unfamiliar dot patterns (Gabrieli, Milberg, Keane, & Corkin (1990). The target materials consisted of a spatial arrangement of five dots in a 3x3 matrix that were connected by four lines to form a specific pattern. After exposing H.M. and controls to a series of these patterns, priming was assessed with a "dot completion" test in which subjects were asked to connect any five dots with four straight lines. A variety of possible patterns could be generated, and the key question was whether subjects showed an enhanced tendency to connect dots to form previously studied patterns -- that is, whether they showed a priming effect. Gabrieli etal. found that H.M. and control subjects exhibited similar levels of priming on this task in two experiments that used slightly different procedures to estimate baseline performance. Moreover, a striking dissociation between priming and explicit memory was observed: H.M. showed intact priming despite chance levels of performance on the recognition test.

Schacter, Cooper, Tharan, & Rubens (1991) used their possible/impossible decision task to examine priming of novel three-dimensional objects in six amnesic patients, matched control subjects, and college student. During the study phase, subjects performed a structural encoding task used previously by Schacter, Cooper, & Delaney (1990) in which they judged whether objects faced primarily to the left or to the right. After a short retention interval of several minutes, they made possible/impossible decisions about briefly exposed studied and nonstudied objects, followed by yes/no recognition memory decisions. The amnesic patients showed a normal pattern of performance on the object decision task -- priming for possible but not for impossible objects -- despite impaired recognition memory. Musen and Squire (1991b) examined amnesic patients' performance on the dot pattern identification task developed by Musen and Treisman (1990). They found that amnesics did show significant priming on this task, as expressed by more accurate identification of studied than of nonstudied dot patterns. However, the absolute magnitude of the priming effect in amnesic patients (7.6%) was nonsignificantly smaller than the magnitude of the effect (10.4%) in control subjects.

To summarize, evidence for priming of novel nonverbal information has been obtained consistently in amnesic patients, and has also been observed in normal subjects under conditions in which priming can be dissociated from explicit memory (for related research, see Cohen etal., 1986; Johnson, Kim, & Risse, 1985; Nissen & Bullemer, 1987). Accordingly, it seems safe to conclude that stronger evidence exists for normal priming of novel objects and patterns in amnesic patients than for normal priming of nonwords and new associations.

Priming of Novel Information in Amnesia: Theoretical Implications

We began by noting that evidence on priming of novel information has

potentially important implications for theories of implicit memory and amnesia, and then delineated some problems entailed in the conceptualization of "novel information". We now return to these issues in light of the data that we have reviewed.

The main conclusion to emerge from our review is that conditions do indeed exist under which priming of novel information can be demonstrated at normal or near-normal levels in amnesic patients, at least when "novel information" is defined as the absence of a preexisting unit in memory that corresponds in some sense to the target item. As noted above, the strongest evidence for this conclusion comes from research on priming of novel nonverbal information. Although evidence on nonword priming is rather mixed, several studies have produced relatively clear-cut data showing normal priming of nonwords (Cermak etal., 1991; Gabrieli & Keane, 1988; Haist etal., 1991; Musen & Squire, 1991a). By contrast, while data indicating some degree of priming for newly-acquired associations have been obtained in certain kinds of patients with memory disorders, there is little or no evidence for intact priming effects of this kind in severely amnesic patients.

Although we cannot specify with any certitude the exact reasons for these differences, some clues are provided by considering recent accounts of preserved priming in amnesia. As noted earlier in the chapter, one view holds that priming effects on so-called data driven implicit tests such as word completion, perceptual identification, and object decision depend on a presemantic perceptual representation system (PRS), which is composed of various cortically-based subsystems (Schacter, 1990, 1992a, 1992b; Tulving & Schacter, 1990). By this view, priming effects for nonwords and for novel objects or patterns -- which have been observed on data-driven tests -- depend on changes occurring within PRS. By contrast, priming effects for newly-acquired associations often involve semantic processing (Graf & Schacter, 1985; Schacter & Graf, 1986a), and may depend on processes outside of PRS -- processes that may be impaired in amnesic patients and are hence unable to support the normal acquisition of novel semantic information (Schacter, Cooper, Tharan, & Rubens, 1991). Stated slightly differently, PRS may be able to function independently of the episodic or declarative memory system that is supported by the hippocampus and related structures and, hence, novel perceptual representations can be acquired normally by amnesic patients. However, the acquisition of novel semantic associations may depend to a large extent on hippocampal and other limbic structures that are typically impaired in amnesic patients (cf., Musen & Squire, 1991b; Schacter, 1990; Tulving etal., 1991).

The foregoing line of analysis leads to the suggestion that amnesic patients should show robust priming of novel information as long as a priming phenomenon depends primarily on perceptual processing and and does not require extensive semantic analyses. It would be interesting in this regard to determine whether normal priming of new perceptual associations could be observed in amnesic patients -- that is, to assesss whether amnesic patients would show normal performance on an implicit memory test in which associative effects are observed

following study tasks that focus attention on perceptual relations among target items. As stated earlier, associative effects on the stem completion paradigm used by Graf and Schacter are typically observed following semantic study tasks (although associative priming apparently can be observed following study tasks that do not explicitly require semantic analysis; Micco & Masson, 1991). An important task for future research would be to devise paradigms in which priming of new associations can be demonstrated following study tasks that restrict processing to the perceptual level. If the failure to observe consistently normal priming of new associations in amnesic patients is attributable to the dependence of such priming on semantic-level processing, then it should be possible to observe intact priming of novel perceptual associations.

Whatever the ultimate resolution of this issue, the positive results that have been obtained would appear to cast serious doubt on the activation theories of amnesia discussed earlier that hold that priming in amnesics is observed only for materials with preexisting memory representations (cf., Diamond & Rozin, 1984; Graf etal., 1984; Mandler, 1980). However, the force of this conclusion depends on the view of word and object representation that one holds. If the "lexical" view is adopted, where words or objects are represented by a single entry or unit, then the data on priming of nonwords and novel objects are difficult for an activation theory to handle. If, on the other hand, a "sublexical" view of word and object representation is held, where words or objects are represented in terms of connections between lower-level units, then some form of activation theory can accommodate the priming data.

In addition to providing a way for activation theories to account for some of the data that we have considered, this latter idea highlights again the question of what constitutes "novel information": If items that are novel at one level of analysis (i.e., word or object level) are to be defined as combinations of features that already exist at a lower level, then it is no longer clear how to determine what qualifies as a novel word, object, or pattern, or even whether it is sensible to make a distinction between "novel" and "preexisting" representations. From an empirical standpoint, the distinction is sensible so long as the data suggest important differences in the nature of priming effects for novel items and items that have preexisting representations; some such differences have been observed (cf., Bentin & Moscovitch, 1988; Feustel etal., 1983; Schacter, 1985; Schacter & McGlynn, 1989). More generally, however, future research on priming of novel information in amnesic patients will need to pay careful attention to the conceptual and theoretical underpinnings of the very construct that is the target of experimental inquiry.

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