Priming of Old and New Knowledge in Amnesic Patients and Normal Subjects[a]

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Neuropsychological studies of memory pathology have demonstrated that amnesic patients who are characterized by diverse forms of neurological dysfunction are severely impaired on tasks that tap recall and recognition of recently studied information.[1-3] One feature of virtually all memory tasks on which amnesic patients are impaired is that they demand explicit recollection of the context and content of recent learning episodes. During the past decade, however, two kinds of evidence have established that amnesic patients can demonstrate relatively normal memory performance on implicit tests, which do not demand explicit recollection of a learning episode. One is that amnesic patients can acquire motor, perceptual, and cognitive skills in a normal or near-normal manner, even though they recall little or nothing of the learning episodes in which they acquired the skills.[4-7] A second kind of evidence that amnesic patients perform normally on implicit tests is provided by the phenomenon of repetition priming: A single exposure to an item on a list facilitates amnesics' processing of that item on a variety of retention tests that do not require explicit recollection of the study episode. Warrington and Weiskrantz,[8,9] for example, demonstrated that amnesics and controls showed a similar tendency to complete three-letter fragments of familiar words with items from a recently studied list. However, the amnesics' performance on a Yes/No recognition task was seriously impaired. Similar data have been reported by others.[10,11] Amnesics also exhibit intact repetition-priming effects, in the face of poor recall and recognition, on implicit tests such as lexical decision[7] and homophone spelling.[12]

The dissociation between priming and recollection in amnesia is paralleled by demonstrations in normal subjects that experimental variables that have large effects on recall and recognition have little or no effect on the magnitude of repetition priming in word completion,[13,14] word identification,[15,16] and lexical decision.[17,18] Moreover, the magnitude of priming effects on these tasks can be statistically independent of recognition memory performance.[12,14,18] The observed dissociations have led a number of investigators to propose that repetition-priming effects are mediated by a "memory system," "memory process," or "form of memory" that is relatively spared in amnesia and that can function independently of the damaged memory process or system that underlies conscious and explicit recollection.[3,4,10,11,14,19-22]

A fundamental question regarding the process or system that underlies repetition priming is whether it can support the acquisition of new knowledge or it is restricted to the activation of old, existing knowledge. One of the hallmarks of organic amnesia is the virtual absence of any capacity to retain new information. The possibility that the

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implicit kind of memory that is involved in priming can support the creation of new knowledge is of considerable interest. However, intact repetition-priming effects in amnesics have been observed only with old information, such as familiar words. Thus, it can be argued that the normal performance of amnesics on implicit tests, such as word completion, represents a temporary increase in the activation level of old or existing knowledge.[10,19,22,23] Support for this idea derives from the work of Diamond and Rozin,[10] who found that amnesics exhibited no priming on a completion task when pseudowords were used as the experimental materials. They suggested that with the pseudowords there was no pre-established knowledge to activate, hence no priming was observed.

There is, however, evidence that amnesic patients may be able to acquire some new knowledge, even in the absence of conscious recollection. Schacter, Harbluk, and McLachlan[24] found that amnesics retained some new information about well-known and unknown people, even though they could not remember when or where they acquired it. In an experiment by Moscovitch,[25] amnesics and controls studied weakly related word pairs and later read over lists that contained either the same intact pairs, re-pairings of list items, or new pairs that had not appeared on the list. Moscovitch found that amnesics, as well as controls, read lists of old intact pairs faster than lists of new pairs. More importantly, he found that both groups of subjects read lists of old intact pairs faster than lists of old broken pairs, indicating that new relationships established at the time of study affected amnesics' performance. These data suggest that priming on implicit tests may reflect more than just the activation of existing knowledge and that it may reveal the presence of new knowledge. The purpose of the present article is to describe and discuss some recent research that attempts to determine the conditions under which priming can support new learning in amnesic patients.

PRIMING OF NEW INFORMATION IN WORD COMPLETION

Graf and Schacter[26] have explored whether normal retention of new associations by amnesics could be demonstrated with a word-completion task. We investigated this hypothesis by comparing probability of word completion in two conditions. In the same context condition, a preexperimentally unrelated cue and target were studied (e.g., *window*–REASON), and the study cue was present along with a three-letter fragment of the target on a word-completion test (e.g., *window*–REA___). In the different context condition, the target fragment appeared on the completion test with a word other than its list cue (e.g., *mold*–REA___). We reasoned that the presence of a new association between the unrelated cue and target would be demonstrated if probability of word completion in the same context condition exceeded probability of word completion in the different context condition. The major question of interest was whether completion performance of amnesics and controls is affected similarly by a new association between two words that is established for the first time on the study list.

Twelve amnesic patients of varied etiologies participated in the study. All had severe difficulties on standard memory tests such as paired-associate recall and Yes/No or forced-choice recognition. Twelve matched controls and twelve college students also participated. Subjects studied lists of words that were composed of either unrelated word pairs (e.g., *window*–REASON) or moderately related word pairs (e.g., *window*–GLASS). They were instructed to relate the two words by placing them in a sentence, because an earlier experiment with normal subjects indicated that priming of new information depends upon semantic processing.[26] The subsequent completion task contained some context pairings of items that had appeared together on the study list,

and also contained different context pairs that represented re-pairings of A and B terms from the study list or included a new stimulus term that had not appeared on the study list along with a three-letter fragment of a list target. Other cue-fragment pairs had not appeared on the study list at all and were included to provide baseline data. Subjects were instructed to read over each pair and to complete each three-letter fragment with the first word that came to mind. Previous work has demonstrated that the instructions on a completion test influence performance markedly. When subjects are told to complete test fragments with the first word that comes to mind, amnesics and controls perform similarly; when subjects are told to complete the test fragments with words from the study list, normals' performance exceeds that of amnesics.[11] Following the completion test, a cued recall test was given in which the first members

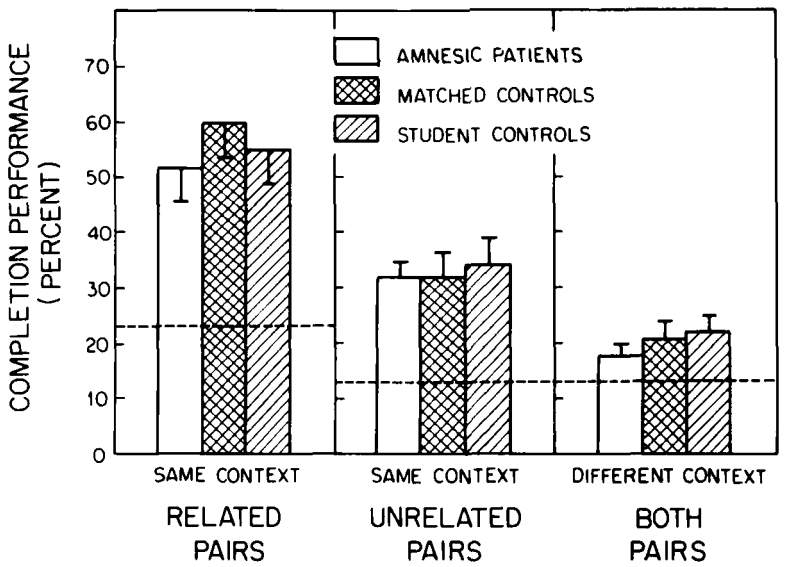

FIGURE 1. Mean word-completion performance for related and unrelated pairs in amnesic patients, matched controls, and student controls. The completion test presented the initial three letters of the response word from each study-list pair, either with the paired stimulus word from the study list (same context) or with another word (different context). A separate control group was used to obtain an estimate of baseline completion performance on the target response words, shown by the dashed lines. Vertical bars show the standard errors of the means.

of the word pairs were presented and subjects were asked to try to remember which word had been presented with each cue on the study list.

Consider first the outcome of the word-completion task. FIGURE 1 displays probability of word completion for unrelated and related pairs in the three groups of subjects. Probability of completing the targets in different context conditions significantly exceeded baseline levels, and there were no differences among groups. This finding is consistent with previous data indicating that presentation of a familiar word on a list enhances completion performance of amnesic patients in a normal manner. The critical new finding displayed in FIGURE 1 is that probability of completion was significantly higher in the same context conditions than in the different context

conditions for amnesics, matched controls, and college students. Moreover, probability of completing the same context pairs did not differ among the three groups. These data demonstrate clearly that some sort of new association between previously unrelated pairs of words can be retained normally by amnesic patients. This new association is revealed when they are tested with a word-completion task.

The results of the cued-recall test, which was administered after the completion task, revealed a massive deficit on the part of the amnesic patients. The contrast between completion and cued recall is illustrated by FIGURE 2, which depicts cued-recall performance along with completion performance when pairs were tested in the same context. In contrast to the indistinguishable levels of the three groups on

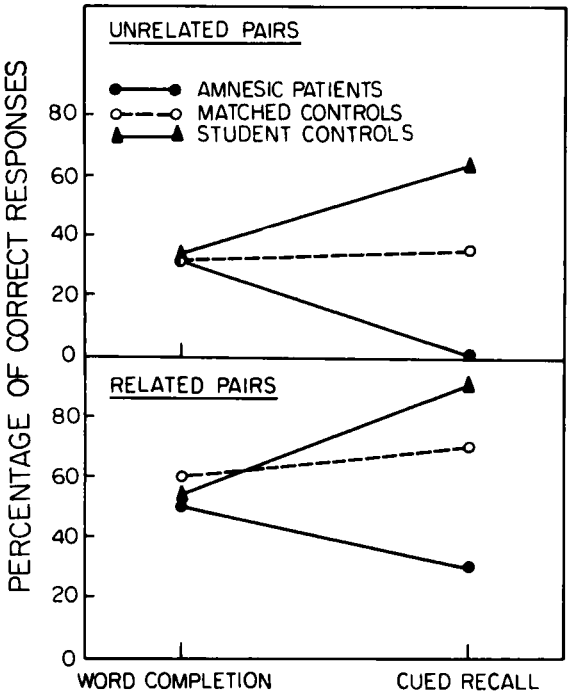

FIGURE 2. Mean word-completion performance for related and unrelated pairs in the same context condition, along with mean cued-recall performance, for the three subject groups.

completion, there were large differences on cued recall in both related and unrelated conditions.

The dissociation between completion and cued recall performance in amnesic patients suggests that qualitatively different forms of memory are tapped by the two tasks. It is possible, however, that amnesic patients simply form "weak" associations (cf. Milner[27]) that can be elicited on the completion task because there is more retrieval information on it than there is on the cued-recall test (e.g., *window*–REA___ versus *window*–_____). It would then follow that performance of matched controls and college students should also decline from completion to cued recall, although by a smaller amount, because both "weaker" and "stronger" associations can be contacted

on the completion test, whereas only the "stronger" associations can be contacted on the recall test. Contrary to such a view, the data in FIGURE 2 indicate that both groups of controls produced more target items on the cued-recall test than on the completion test. Further information on this point is provided by a contingency analysis of the fate of individual items on the two tests. If the extra information on the completion test permitted amnesics and normals to gain access to weak associations, there should be few cases in which subjects fail to complete an item and then retrieve it on the cued-recall test. Subjects should not fail on a test that requires only weak associations for successful performance, and then succeed on a test that requires stronger associations. The contingency analysis was performed on those items that were tested in the same context on the completion test. It revealed that the conditional probability of failing to complete items that were recalled ($p(\bar{C}|R)$ was substantial in all conditions. For related word pairs, $p(\bar{C}|R)$ was 36% in amnesic patients, 32% in matched controls, and 44% in college students; for unrelated word pairs, $p(\bar{C}|R)$ was 62% in college students and 52% in matched controls (the analysis could not be performed on the amnesics' data, because cued recall of unrelated pairs was negligible). These data indicate that the "first thing that comes to mind" on the completion test represents a qualitatively different kind of mnemonic information than what is remembered on the cued-recall test.

The foregoing data indicate that the implicit form of memory that underlies repetition-priming effects goes beyond the mere activation of existing knowledge. The implicit form of memory makes possible the acquisition of a kind of new knowledge that can be retained and expressed normally by amnesic patients and that is specific to an individual encounter with a pair of pre-experimentally unrelated words. Old knowledge, however, may have played a critical role in the new learning observed in this experiment, because the target fragments were themselves part of pre-existing, integrated units—familiar words. It seems highly unlikely that amnesics would have revealed evidence of new learning had they been asked to give the first word that comes to mind to an unrelated cue without the benefit of the three-letter target fragments; after all, amnesics produced virtually no target items on the cued-recall test. A pilot study with four amnesic patients confirmed this expectation. When patients studied unrelated word pairs and were later asked to give the first word that came to mind in response to the cue word, without any target letters, no evidence of priming was observed. Considering the results of word-fragment completion studies more generally, it is apparent that amnesics demonstrate intact priming when part of a pre-existing unit, such as a familiar word, is present on the test and they respond by giving the rest of the unit. These observations lead to the suggestion that it is possible to demonstrate acquisition of new knowledge on a priming task only when part or all of a pre-existing unit is a target on the test. If this idea has general validity, amnesics should reveal evidence of priming with well-established units other than single words. Recent data that demonstrate normal priming of highly related paired associates in amnesia[28,29] are consistent with this notion, because primary associates such as *table*–CHAIR can be viewed as unitized representations (cf. Hayes-Roth[30]). The purpose of the next experiment is to test the generality of the idea that pre-existing units play a critical role in priming effects.

PRIMING OF PRE-EXISTING UNITS: EVIDENCE FROM LINGUISTIC IDIOMS

In this experiment, priming of unitized and non-unitized materials was compared by presenting subjects with idiomatic, unitized phrases such as *sour grapes* and *small*

potatoes or with non-unitized phrases that were formed by recombining the components of the idioms (e.g., *sour potatoes, small grapes*). The first part of the phrases (e.g., *sour, small*) were included on a priming task in which subjects gave the first words that came to mind in response to these cues. The question of interest is whether amnesics and normals show priming for the unitized phrases and little or no priming for the non-unitized phrases. Idioms are of interest for two reasons. First, they constitute well-integrated bits of knowledge that behave in a unitized manner.[31] Second, the probability of giving the second word of the idiom to the first in a free-association task is virtually zero.[31] An idiom is thus unlike a highly related paired associate, such as *table*–CHAIR, in which subjects have a strong tendency to give the response to the stimulus in the absence of any experimental input. To the extent that priming is observed for idioms, then, it is the unitized nature of the representation that is crucial.

The experiment included three groups of subjects: six severely amnesic patients of diverse etiologies (closed-head injury, encephalitis, ruptured anterior communicating artery aneurysm, anoxia, and third ventricle tumor), six matched control subjects, and six college students. The 24 idioms that constituted the target materials were all two-word, adjective-noun phrases selected from the idioms of Horowitz & Manelis.[31] The idioms were randomly divided into three sets of eight. Within each set, pairs of idioms were rearranged to form non-unitized but meaningful phrases, yielding a total of three unitized sets and three non-unitized sets. For a given subject, one set of materials was studied in a unitized manner and one set was studied in a non-unitized manner. To obtain baseline data, the first word of the set that was not studied appeared on the priming test. Materials were completely counterbalanced across conditions.

Each of the two study sets was presented twice, in a blocked manner, at a rate of six seconds/phrase. Subjects were told to try to remember each two-word phrase and were given a brief sentence that specified the meaning of each unitized and non-unitized pair. Following presentation of the study phrases, subjects were told that they would fill out some forms before beginning the memory task. The first form contained a list of common first names (e.g., Frank, Mary). Subjects were told to write next to each one the first surname that came to mind. The second form represented the priming test, 74 common words that included the first words of the 24 critical phrases. Subjects were told that they should write next to each cue the first word that came to mind. Upon finishing the task, subjects were told to try to recall each of the two-word phrases that had been presented earlier. Two minutes were provided for free recall. Subjects were then given a sheet that contained the first words of the sixteen study phrases, and were instructed to try to remember the second word that had appeared with each cue at the time of study.

Consider first the results on the priming task. Consistent with expectations, baseline probability of giving the second word of the unitized idiom in response to the first was functionally zero; only one subject (an amnesic) provided a single target idiom in the baseline condition. There was, however, a substantial priming effect in the unitized condition that did not differ among subject groups (TABLE 1): Amnesics produced as many unitized responses from the study list as controls did. In sharp contrast, there was virtually no evidence of priming in the non-unitized condition for either amnesics or controls: Only one subject (a matched control) produced one target from a non-unitized phrase in response to the first member of the phrase.

An entirely different pattern of results was observed when subjects were asked to remember target items on the free- and cued-recall tests. On the free-recall test, amnesics remembered none of the unitized or non-unitized phrases, whereas matched controls and college students remembered many of them (TABLE 1). On the cued-recall test (TABLE 1), amnesics did not recollect a single non-unitized phrase and produced no

more unitized phrases than they had on the priming test. By contrast, matched controls recalled 35% of the non-unitized phrases and came up with over twice as many unitized phrases as they had on the priming task. College students remembered 75% of both unitized and non-unitized phrases.

Consider how these data are related to those of Graf and Schacter concerning priming of new associations. The finding of no priming for non-unitized phrases supports the idea that the presence of the target letters was critical for the priming of unrelated paired-associates observed by Graf and Schacter. However, the finding of substantial priming with unitized phrases indicates that the target letters need not be present if the priming cue is part of a pre-existing unit. Taken together, these observations support the generality of the notion that intact priming in amnesics depends upon the presence of part of a pre-existing unit on the test. In addition, two features of the data are consistent with the idea that fundamentally different forms of memory are involved in recall and priming. First, amnesics exhibited virtually no explicit recollection, even though they showed normal priming of unitized phrases. Second, non-unitized phrases were recalled frequently by normal subjects—as frequently as unitized phrases by college students—but they were not susceptible to priming. If priming and recall were based upon the same form of memory, non-unitized

TABLE 1. Priming and Recall of Unitized and Non-unitized Phrases in Amnesic Patients, Matched Controls, and Student Controls

	Unitized phrases			Non-unitized phrases		
	PR	FR	CR	PR	FR	CR
Amnesic patients	.27	.00	.27	.00	.00	.00
Matched controls	.23	.31	.54	.02	.19	.35
Student controls	.29	.40	.75	.00	.44	.75
M	.26	.24	.52	.01	.21	.37

Note: PR = Priming; FR = Free Recall; CR = Cued Recall.

phrases should have been susceptible to priming, because they were available for recall.

METHOD OF VANISHING CUES: DISCONTINUITY BETWEEN PRIMING AND RECOLLECTION

The purpose of the next experiment was to examine in more detail the role played by the presence of the target letters on a test when amnesic patients attempt to learn a set of unrelated paired associates. The experiment was conducted in collaboration with Elizabeth Glisky and Endel Tulving. We used a procedure called the method of vanishing cues.[32] Patients are first shown the stimulus terms of unrelated paired associates on an Apple II+ microcomputer and are provided with the successive letters of the target until they guess it or the complete word is displayed on the screen (e.g., *tobacco*–B———; BO———; BOU———; BOUL———; BOULD———; BOULDE–; BOULDER). On the next trial, patients are given one less letter than they needed to identify the response on the first trial. This procedure continues over successive trials. Patients are always given one less letter on trial $n + 1$ than they needed to complete the target on trial n, and letters are added until they provide the correct response. The question of interest is whether the letter-by-letter withdrawal of target information enables patients to learn

the new information in such a manner that they can provide the response to the stimulus in the absence of any target letters.

If pre-existing units play a crucial role in amnesic patients' performance, they should have relatively little difficulty when at least the initial letter of the target word, part of the pre-existing unit, is present. Thus, amnesics should show a relatively rapid reduction in number of letters required to complete the target in the presence of the stimulus term until the final target letter is withdrawn. The amnesics should then have a great deal of difficulty giving the target to the stimulus in the absence of any letters, because part of the pre-existing unit is no longer present in the response.

Four amnesic patients (two closed-head injury, one encephalitic, and one ruptured anterior communicating artery aneurysm) participated in an extended procedure that involved eight sessions, each consisting of eight trials. The materials were 12 unrelated paired associates consisting of six to seven letter common nouns. The general procedure was as described above.

The critical data with respect to the present concerns derive from an analysis of the number of trials required to make the initial reduction from n to $n - 1$ letters at each of the pairwise transition points in the task (i.e., the number of trials required to move for the first time from needing five letters to needing four, from four to three, three to two, two to one, and one to zero). These data indicated that amnesics took on average 1.7 trials to make each pairwise transition up until the final letter was withdrawn. At this point a large discontinuity was observed. Patients required a mean of 24.9 trials to produce the item for the first time in the absence of any target letters. Thus, the presence of the first letter of the target, part of the pre-existing unit, was of special importance for amnesics. Control studies suggest that college students have no more difficulty with the final reduction, from one letter to no letters ($\bar{X}$ = 1.1 trials), than they have with any of the other reductions ($\bar{X}$ = 1.1 trials). Matched control subjects have only slightly more difficulty with the final reduction ($\bar{X}$ = 2.6 trials) than with the preceding ones ($\bar{X}$ = 1.5 trials). It is not surprising that normals do not have severe difficulties upon withdrawal of the final letter, because subjects treat this task as one of deliberate recall (it is not possible to conceal the nature of the task when repeated trials are used). Normals are able to use conscious recall mechanisms to remember the response, whereas amnesics must rely heavily on priming and hence depend upon the presence of the target letters.

THEORETICAL ACCOUNTS OF INTACT PRIMING IN AMNESIA

The experiments discussed in this article contain three critical findings concerning repetition priming in amnesic patients. First, amnesic patients revealed intact priming of new information concerning the relation between two normatively unrelated words on a word-completion task that included the stimulus term and part of the response. Second, amnesics showed normal priming of unitized phrases and, like controls, showed no priming of non-unitized phrases, under conditions in which only the first word of the phrase was presented on a priming task. Third, amnesic patients had special difficulties upon withdrawal of the final target letter in the vanishing-cues procedure. The principal theoretical challenge presented by this pattern of findings is to account simultaneously for the fact that priming in amnesia includes new, contextually specific information, yet also depends heavily upon the presence of part of a pre-existing unit in the test response. Let us consider briefly the implications of these facts for several relevant theoretical positions.

One class of theories holds that repetition priming and conscious recollection do not tap fundamentally different forms of memory, but involve different retrieval processes

that make contact with the same mnemonic representation of a prior episode.[16,33] By these views, amnesics exhibit intact priming because tasks such as word completion, word identification, and lexical decision bypass the intentional or reconstructive retrieval processing that is assumed to be defective in amnesics.[12,33,34] This general notion has no problem accounting for priming of new information, although it might have difficulty handling the outcome of the contingency analyses discussed earlier. If, however, a word-completion task simply represents one way of contacting a single representation of a prior episode, it is not obvious why there is significant priming for unitized pairs and no priming for non-unitized pairs or why the presence of an initial target letter in the vanishing-cues experiment affected amnesics' performance so dramatically.

Several theories have proposed that two fundamentally different types of memory (one impaired in amnesia, the other spared) are involved in priming and recollection. One version holds that priming reflects a process of activation of old information that is preserved in amnesia and relatively independent of the process of elaboration that is impaired in amnesia.[13,19] This view accounts nicely for the pre-existing unit data, because the activation process is assumed to operate by reaffirming relationships that are well established. But it may have difficulty accommodating the finding that amnesics demonstrate intact new learning on a completion task, because this goes beyond affirming an existing relationship. A somewhat different notion that encounters similar problems is that priming reflects the activation of a semantic-memory system that is spared in amnesia, whereas recall and recognition depend upon an episodic or cognitive system that is damaged (cf. References 22, 35, and 36). If a decontextualized semantic memory underlies priming, it is not clear how completion performance of amnesics and normals can reflect retention of a new, contextually specific relationship that was established during a single learning episode. Data reported by others concerning the modality specificity of priming effects raise further problems for this interpretation, as has been discussed elsewhere.[14,16] Another account holds that priming tasks such as word completion depend upon a procedural memory system (i.e. "knowing how") that is spared in amnesics, whereas recall and recognition depend upon a declarative memory system (i.e. "knowing that") that is impaired in amnesics.[3-5] It is not easy to see how this distinction would account for intact priming of entirely new associations in amnesics, nor is it clear how this distinction would explain the critical importance of the target letters on a priming test. For example, to account for the discontinuity observed in the vanishing-cue experiment, it would be necessary to argue that amnesics perform relatively well when given a cue such as *tobacco*–B——— because they can rely on procedural memory, and perform disastrously when given *tobacco*——— because they must then depend upon declarative memory. But why would the task be considered "procedural" when a single target letter is present and "declarative" when it is not? To accommodate these data, it may be necessary to transform the notions of "procedural" and "declarative" beyond recognition.

Most of the foregoing ideas are consistent with one of the critical findings noted earlier, but are inconsistent with the others. In the short space that remains, I will suggest the outlines of an approach that may help to make sense of both facts. These ideas are similar to, and represent extensions of, various other hypotheses that have been proposed to account for preserved priming in amnesia.[11,22,23,25,34] They are offered as preliminary and somewhat speculative hypotheses to be tested in future research.

Along with many other investigators, I view priming and recollection as manifestations of fundamentally different explicit and implicit forms of memory. In the present discussion, I want to focus upon the representations that may be involved in each kind of memory. Two types of representations are postulated, unitized structures and nested structures. Unitized structures, it is suggested, are involved in repetition priming. They

represent well-integrated and established informational structures that are built by repeated activation and use of a common set of elements (cf. Shimamura and Squire[29]). Unitized structures can be activated in an all-or-none manner by a process of redintegration—the presence of part of the structure is sufficient to elicit the entire unit.[29,30] Examples of unitized structures would be words, idioms, and primary associates. A critical postulated feature of unitized structures is that they are modified by information in the local contexts in which they are activated and used. By "local context," I refer to the semantic information that is encoded when a unitized structure is activated, the modality in which the structure is activated, and the physical parameters of the activating stimulus. The newly encoded features of local context, though modifying the unitized structure and hence altering the conditions in which it can be contacted, do not yet serve as identifying features of the unit.[37] With sufficient repetition, the new information may eventually function as an identifying feature of the unit. Thus, unitized structures are not viewed as decontextualized or abstract pieces of semantic knowledge that are independent of contextual constraints. For example, there might be multiple unitized structures that correspond to a word such as "chair," each of which preserves specific information concerning particular local contexts in which they have been activated and used frequently.

Nested structures, in contrast, are formed as a function of a single experience, and are assumed to underlie conscious recall and recognition. Nested structures are similar to composite traces[38] or vertical associates.[23] They emerge from the combining of existing elements in such a manner that a new gestalt is formed with emergent properties that were not previously present. I use the word "nested" to highlight the suggestion that these structures are part of, and are only accessible through, the global contexts in which they were created. By "global context," I refer to a higher-order representation that contains information about the spatial and temporal features of the episode in which a nested structure is formed. When a subject studies a list of target words that are paired with unrelated cues, the global context (the time and place of occurrence) is similar for each target, whereas the local context, which is defined by the unrelated cues, is different for each item. Nested structures are recalled in a graded, rather than in an all-or-none manner, and are contacted through processes of resonance,[39] correlation,[38,40] or reconstruction,[41] but only when information concerning the global context is available. I refrain from using the term "episodic" memories here because, as noted earlier, unitized structures too can be changed by information encoded during a single episode.

It is suggested that in amnesia, unitized structures can be activated and modified normally. However, the creation of nested structures, of new gestalts or wholes,[23] is defective. Consider how the distinction between unitized structures and nested structures can be applied to amnesics' performance in the experiments described earlier. The intact priming of new associations can be viewed in terms of a normal modification of unitized structures by an encoded feature of local context (in this case, an unrelated word). Because modification of the unitized structure is seen as the source of new learning, it is not surprising that part of the pre-existing unit would have to be present on the test for priming to occur; as suggested earlier, the newly encoded features of local context do not serve as identifying features of the unit. Thus, in the vanishing cues experiment, the critical function of the initial letter may be to identify the recently modified unitized structure. In the absence of this information, performance depends upon contacting the nested structure, which is severely degraded or non-existent in amnesics, although it is available for normals to retrieve in appropriate test conditions. In the idioms experiment, amnesics show intact priming of unitized structures (e.g., *sour grapes*) and, like normals, show no priming of nested structures (e.g., *sour potatoes*). The lack of priming of nested structures is viewed as a

consequence of their being tied to a global context that is not contacted in a priming task, because no attempt is made to reconstruct the study context. However, on a recall test, normals reconstruct the global context and gain access to the nested structures, whereas amnesics do not. By the present hypothesis, amnesics do not gain access to the nested structure because it was not retained or was retained in a degraded manner. It is also possible that amnesics cannot engage in reconstructive retrieval, and are thus unable to gain access to an existing nested structure. The issue requires further investigation.

This fragmentary outline reveals that the present approach takes a middle road between theories that view priming effects in amnesia as an activation of general, semantic knowledge and those that view priming as relying upon the same episodic knowledge as underlies conscious recall and recognition. Although the suggested notions are, of course, no more than preliminary hypotheses, they do suggest future experiments that otherwise might not be as readily perceived. For example, a basic issue concerns the building of new unitized structures, that is, the process by which the first part of an unrelated word pair comes to elicit the second on a priming test in the absence of any target letters. What conditions must be satisfied to build such a structure? Are new unitized structures built from, and hence dependent upon, nested structures? Or are they the result of repeated modification of existing unitized structures such that the modifying information eventually serves as an identifying feature of the unit? Is the building of new unitized structures similar in amnesics and normals, or is it fundamentally different? Detailed exploration of such questions could provide a more complete picture of the implicit form of memory that is preserved in amnesia and hence facilitate understanding of its relation to explicit recollection.

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