International Journal of Neuroscience, 119:1061–1075, 2009

ISSN: 0020-7454 / 1543-5245 online
DOI: 10.1080/00207450802336691

informa
healthcare

LEVELS OF PROCESSING AND AMNESIA AFFECT PERCEPTUAL PRIMING IN FRAGMENTED PICTURE NAMING

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In this paper we examine the impact of amnesia and of levels of processing on implicit memory by using a well-established fragmented picture-naming test with proven adequate reliability. A group of patients with amnesia of non-Korsakoff etiology was compared to a control group. While amnesic patients showed a deficit in perceptual priming, both groups showed a comparable level of processing effect. Our results confirm that when a reliable implicit memory test is used amnesia and levels of processing can both be shown to affect implicit memory performance. Thus, functional dissociations between explicit and implicit memory tests may be the consequence of a methodological artifact, that is, a difference in the reliability of the tests.

Keywords Amnesia, implicit memory, levels of processing, picture priming, reliability

Dissociations between explicit and implicit memory have attracted much attention over the last two decades. Explicit memory refers to the deliberate remembering of a previous study episode, while implicit memory refers to

Received 3 October 2008.
We thank Josephine Cock and Todd Woodward for valuable comments on an earlier version of the manuscript.
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a change in performance due to a prior study episode without the person's awareness thereof—that is, a priming effect (Graf & Schacter, 1985). One of the most compelling observations is that amnesic patients suffering from very poor explicit memory show intact priming (Cave & Squire, 1992; Cermak, Talbot, Chandler, & Wolbarst, 1985; Graf, Shimamura, & Squire, 1985). Additional evidence for the distinction between the two types of memory is based on experimental manipulations. Most prominent is the impact of levels of processing on explicit memory tests, but not perceptual implicit memory tests.[1]

These dissociations have been regarded as strong evidence for the existence of independent memory systems mediating explicit and implicit memory (Gabrieli, 1998; Squire, Knowlton, & Musen, 1993). However, a closer look at studies on perceptual priming in amnesia, as well as on the effect of levels of processing, reveals that many results do show a tendency toward impaired priming in amnesia (Gabrieli et al., 1994; Milner, Corkin, & Teuber, 1968) and small, and sometimes even significant, effects of the levels of processing manipulation (see Brown & Mitchell, 1994; Challis & Brodbeck, 1992).

How can these inconsistent results be explained? Regarding the performance of amnesic patients it has been suggested that deficits occur under difficult rather than easy task conditions (Ostergaard, 1999). In addition, in many studies the statistical power has been low. Moreover, in many studies the patient groups tested as "amnesics" were heterogeneous with regard to etiology, which may have contributed to the inconsistent pattern of results.

Regarding the levels of processing manipulations it has been suggested that their impact could be attributed to explicit contamination of implicit memory tests (Brown & Mitchell, 1994; Challis & Brodbeck, 1992). In addition, it has been suggested that lexical processing at encoding may facilitate repetition priming and that many indirect perceptual tests may reflect conceptual as well as perceptual processes (Roediger & McDermott, 1993). Moreover, some results can be explained as a consequence of the type of design used (i.e., within vs. between subjects; Challis & Brodbeck, 1992).

A further explanation for the inconsistent results is that implicit and explicit memory tests differ with respect to their psychometric measurement properties. Many implicit memory tests are lower in reliability than explicit memory tests (Buchner & Wippich, 2000; Meier & Perrig, 2000). As most experimental and quasiexperimental variables appear to affect explicit memory, but not implicit memory, it is possible that differences in reliability have contributed to dissociations between the two types of memory measures. Therefore, variations in reliability differences may also account for priming deficits in amnesic patients and levels of processing effects in implicit memory.

It should be noted, however, that not every implicit memory test is necessarily less reliable. Buchner & Wippich (2000) as well as Meier (2001) reported that an implicit fragmented object naming test was just as reliable as an explicit object recognition test. Moreover, Meier (2001) found that a levels of processing manipulation affected performance in both kinds of tests, explicit and implicit. This finding suggests that dissociations can, in fact, disappear when the reliability of implicit and explicit tests is comparable. Nevertheless, it can be claimed that this result was caused by explicit contamination of the implicit memory test. A strategy to control for this possibility is to study the performance of amnesic patients, whose poor explicit memory renders contamination by explicit memory very unlikely.

The goal of the present study is to further investigate influences on perceptual priming with a psychometrically reliable implicit memory test. Therefore, we tested a group of amnesic patients and a control group with the fragmented picture-naming test, for which reliability has been shown to be comparable to that of explicit memory tests (Buchner & Wippich, 2000; Meier, 2001). In light of our hypothesis that prior null results were caused by the poor reliability associated with many implicit memory tests we expected a priming deficit for amnesic patients using a reliable measure of implicit memory. In contrast, if prior null results were not caused by poor reliability, amnesic patients should perform at the level of normal controls. We also included a level of processing manipulation. On the assumption that the levels of processing effect observed in previous implicit memory studies was not due to contamination by explicit memory, we expected the levels of processing manipulation to impact amnesics and controls equally. In contrast, if the levels of processing manipulation do not affect performance of amnesic patients, explicit contamination can be considered a reasonable explanation for previous failures to find a dissociation. To our knowledge no previous study has investigated the impact of levels of processing on fragmented picture naming in amnesic patients. However, there have been a few studies investigating levels of processing effects in amnesic patients with word material. Next, we provide a brief review of these studies.

Graf, Squire, and Mandler (1984) found normal stem completion performance and a level of processing effect on word-completion in a patient group consisting mainly of Korsakoff patients. In addition, they found no interaction between retention interval and orienting task, suggesting a similar level effect when participants were tested after 2 hours compared to when tested immediately. In contrast, in a study by Squire, Shimamura, and Graf (1987) a level of processing effect in word stem and word fragment completion performance was evident only when tested immediately. Carlesimo (1994) tested a group of amnesics (consisting of seven Korsakoff patients and five patients with non-Korsakoff etiologies) and a control group (consisting of chronic alcoholics). Most relevant for our purpose is the result of an implicit word stem completion test and an implicit word identification test. The amount of priming was comparable in both groups. Moreover, the level of processing effect was significant in stem completion, but failed to reach significance in word identification. Similar results—that is, larger priming effects after semantic than physical processing—have been reported by Carlesimo, Marfia, Loasses, and Caltagirone (1996) and Hamman & Squire (1996). Jenkins, Russo, and Parkin (1998) used a word fragment completion test to investigate two amnesic groups, a group of Korsakoff patients and a group with closed head injury. Their results showed a deficit for both patient groups in the semantic encoding condition. However, overall there was no significant deficit in priming.

This inconsistent pattern of results is also present in studies testing amnesic patients with pictorial materials: Studies with Korsakoff's syndrome patients revealed consistent impairments in pictorial priming (Cermak, Verfaellie, Letourneau, and Jacoby, 1993; Warrington & Weiskrantz, 1968). However, some studies with amnesics with other etiologies reported normal priming effects (Cave & Squire, 1992), while other studies did not (Milner et al., 1968; Gabrieli et al., 1994). In the latter study, in a group of non-Korsakoff amnesics with different etiologies, Gabrieli et al. found impaired priming for naming fragmented objects. In a subsequent study, Verfaellie, Gabrieli, Vaidya, Croce, & Reminger (1996) systematically manipulated the study and test conditions. In addition, they included Korsakoff amnesics and patients with amnesia of non-Korsakoff etiology in their study in an attempt to solve these inconsistencies. In line with Cave & Squire, they found no impairment in priming when complete stimuli were presented for naming at study *and* at test, for both amnesic groups. However, when fragmented pictures were presented for naming at study *and* at test, both amnesic groups were impaired. Finally, when pictures were presented complete at study, but fragmented at test, Verfaellie et al. reported a deficit for Korsakoff patients, but not for non-Korsakoff amnesics. They reasoned that, under these testing conditions, controls were not able to use explicit memory to aid implicit memory performance and, as a consequence, they did not outperform the non-Korsakoff patients. This specific method seems, therefore, to be well suited to examine levels of processing effects in implicit memory without explicit contamination.

To summarize, existing evidence of the impact of amnesia on perceptual priming and of the effect of levels of processing in amnesia is inconsistent. Further research is necessary to clarify the pattern of results. The focus of the present study is on investigating the impact of levels of processing and amnesia in implicit memory with a psychometrically reliable implicit memory test. More specifically, we compare priming of a group of non-Korsakoff amnesics and a control group in a fragmented object-naming test. With this method we expect to find a difference between the two groups. We also expect to find a level of processing effect for both groups, amnesic and control.

METHOD

Participants

The group of amnesic patients consisted of 10 subjects (six males and four females) from the Rehabilitation Center, Leukerbad, Switzerland. All patients were suffering from severe memory disorder. Four patients had mediotemporal lesions (two patients due to closed head injury, one due to herpes simplex encephalitis, and one due to insult), two patients had frontal lesions (both due to anterior communicating artery aneurism), one patient had a diencephalon lesion (due to thalamus infarct), and three patients suffered from closed head injury (unspecific). Table 1 provides an overview of etiology, age, and performance on specific neuropsychological tests. Inclusion criteria for this study were intact language comprehension and sufficient capacity to cope with the 1-hour testing session. Moreover, no demented patients or patients with only minor memory deficits were included in this study. An age and education matched control group consisting of 10 healthy subjects was tested to compare patient performance.

Materials and Design

Originally, a total of 150 drawings of easy-to-name objects was selected from the materials of Snodgrass & Vanderwart (1980). Following a pilot-study (cf. Meier, 1999), four series with 25 items each were selected from the original item pool such that (1) approximately half of the objects in each series contained a circle embedded in the picture (e.g., the eye of an animal, the wheel of a car, etc.), and such that (2) each series had the same baseline completion rate. These materials were used in a previous study to assess split-half reliability of perceptual priming (Meier, 2001). Spearman-Brown corrected reliability was

Table 1. Patient etiology, age, and neuropsychological test scores (percentiles): California verbal learning test (CVLT), short and long delay, Wechsler memory scale—R (WMS-R) story recall, short and long delay, Rey Osterrieth complex figures, and memory span

Patient	Etiology	Age	CVLT short delay	CVLT long delay	WMS-R short delay	WMS-R long delay	Rey-Osterrieth complex figures	Memory span
1	Closed head injury (mediotemporal)	34	10	<1	38	<1	7	45
2	Aneurisme (frontal lesion)	56	<1	<1	<1	<1	<1	7
3	Closed head injury (mediotemporal)	26	<1	<1	<1	<1	<1	31
4	Aneurisme (frontal lesion)	48	<1	<1	12	2	18	31
5	Herpes simplex encephalitis	23	<1	<1	<1	<1	10	31
6	Thalamus infarct (diencephal)	67	<1	<1	23	18	<1	31
7	Insult (mediotemporal)	63	14	82	50	48	<1	45
8	Closed head injury (unspecific)	32	5	7	5	10	<1	31
9	Closed head injury (unspecific)	53	31	18	<1	<1	<1	31
10	Closed head injury (unspecific)	43	31	31	28	31	<1	45

between $r = .73$ and $r = .78$, depending on condition. These reliabilities did not differ from the reliability of an explicit object recognition test. In the present study the very same material was used.

To detect priming effects, for each group a one-factorial repeated measures design was used with item type as the critical factor (semantic, perceptual, new). The design of the final analysis consisted of a 2 $\times$ 2 mixed factorial design with group (patients vs. controls) as a between-group variable, and levels of processing (semantic vs. perceptual) as a within-group variable.

Procedure

Participants were tested individually. The test session consisted of a study phase and a test phase. At the beginning of the experiment subjects were seated in front of a computer and were informed that they would be shown pictures of easy-to-name objects on a computer screen. For a first study phase (semantic processing), participants were further instructed that their task was to name each picture as fast as possible. For a second study phase (perceptual processing), participants were instructed to decide for each picture as fast as possible whether or not it contained a circle. In both study phases, one series of 25 pictures was presented. The experimenter initiated each trial by a key-press upon which the drawing of an object was presented on the screen for 1 sec, followed by a blank screen during which the participants responded verbally. Another key-press by the experimenter then initiated the next trial. Objects were presented in the center of the computer screen, in black against a white background, and within a square approximately 8 $\times$ 10 cm in size.

Immediately after the two study phases an explicit free recall test was administered. Participants were asked to tell the experimenter the names of all objects that were presented during either the conceptual or perceptual study phase. Then, instructions for the test phase of the implicit memory test were given. Participants were informed that they would be presented with more drawings of objects. They were also informed that, this time, the task would be more difficult because only fragments of the objects would be shown. Participants were instructed to tell the experimenter what they thought the object represented. In this phase, a total of a hundred objects was presented: the 25 objects from each study phase together with 50 completely new objects, which were not presented in the study phase. For each participant, the drawings were presented in a new random order, without replacement. The experimenter initiated each trial by a key-press upon which the fragment of an object was presented on the screen for 3 sec, followed by a blank screen during which

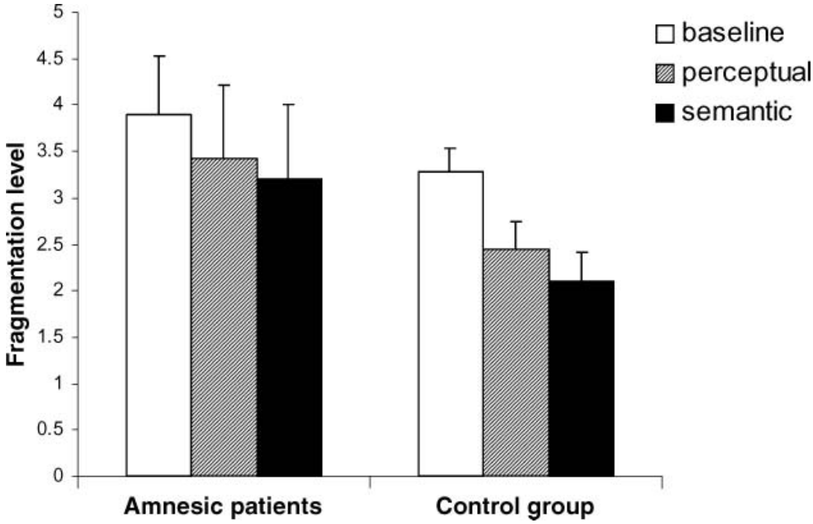

Figure 1. Mean fragmentation level (+*SD*) for baseline (new), perceptually studied and semantically studied objects in the implicit fragmented objects completion test for amnesic patients and controls.

the subjects were required to respond. If an object was named correctly, the experimenter initiated the presentation of the next picture in its most fragmented version. If the object was named incorrectly, or if the participant did not respond, the same object was presented again, but in a less fragmented form, until the participant was able to name it correctly. A total of six different levels of fragmentation were used. If an object was identified in its most fragmented version, it was scored as 1; if an object was identified in the second most fragmented version, it was scored as 2, etc.

RESULTS

For each participant we calculated the mean fragmentation level at which the objects were identified. Mean fragmentation level for amnesic patients was 3.20 for semantically processed objects, 3.43 for perceptually processed objects, and 3.93 for new objects. Mean fragmentation level for the control group was 2.10 for semantically processed objects, 2.44 for perceptually processed objects, and 3.28 for new objects. These results are shown in Figure 1.

In both groups, one-way analyses of variance (ANOVAs) revealed significant differences between the three encoding conditions with F (2,18)

Table 2. Relative priming scores (%) for both groups and conditions (SD in parentheses)

		Level of processing	
		Perceptual	Semantic
Group	Amnesic	13.5 (7.5)	19.6 (9.6)
	Control	25.1 (9.9)	35.9 (8.6)

= 56.6, $p < .01$ for the amnesic patients, and F (2,18) = 70.9, $p < .01$, for the control group. According to Scheffé tests, for both groups, the sources of these effects related to differences between the "old" study conditions (i.e., the semantic and the perceptual study conditions), and the "new" condition (i.e., baseline), all $p < .01$. Semantic and the perceptual processing conditions were also significantly different in both groups, all $p < .05$. These results indicate, therefore, consistent priming effects as well as a level of processing effect for both, the amnesic patients and the control group. Before the amount of priming was compared directly between the two groups, baseline performance was analyzed. As a between-subjects t-test revealed a significant difference in baseline performance, $t(18) = 3.05$, $p < .01$, relative priming scores were calculated as the percentage priming in naming old-compared-to-new objects: relative priming = (new—old)/new × 100. These relative priming scores are presented in Table 2. The relative priming scores were then subjected to a 2 × 2 ANOVA with encoding condition (semantic vs. perceptual) as a within-subjects factor and group (amnesics vs. controls) as a between subjects factor. The analysis revealed a significant main effect of group F (1,18) = 14.3, $p <$ .01 and a significant main effect of encoding condition, F (1,18) = 29.8, $p < .01$. However, the group x encoding condition interaction was not significant, F (1,18) = 2.3, $p = .14$. These results indicate parallel levels of processing effects in amnesics and controls, but a deficit for the amnesics in the overall amount of priming.

Finally, free recall performance was analyzed. Amnesic patients correctly named a total of 6.2 objects (3.4 from the perceptual study condition and 2.8 from the semantic study condition). Control subjects remembered a total of 15.9 items (8.4 from the perceptual study condition and 7.5 from the semantic study condition). A 2 × 2 ANOVA revealed a significant main effect of group F (1,18) = 22.6, $p <$ 01. However, neither the effect of encoding condition nor the group x encoding condition interaction was significant, F (1,18) = 1.2, $p = .28$ and F (1,18) = .04.8, $p = .82$, respectively. These results indicate that the levels of processing manipulation did not affect free recall performance for either group. The absence of levels of processing effects seems to be due to the different retention intervals for the two study conditions. As all participants accomplished the conceptual study phase first, the study-test interval was longer in this condition than in the perceptual study phase. In addition, due to the immediate succession of the free recall test after the perceptual study phase, participants may have recalled these items from short-term memory. However, these results again demonstrate the massive explicit memory deficit of the amnesic patients.

DISCUSSION

The purpose of this study was to further investigate the circumstances under which amnesic patients show decreased perceptual priming and to establish whether levels of processing effects in normal subjects are artifacts of explicit contamination. We used a test for which psychometric reliability has been established in a previous work. We found a deficit for amnesic patients in perceptual priming and moreover, a level of processing effect in both groups, amnesic and control. These results replicate and extend previous research. They indicate that levels of processing effects in implicit memory are significant and cannot be explained purely in terms of explicit contamination. Rather, it seems that using a reliable test can reveal effects that are not reaching statistical significance with less reliable tests.

Consistent with this interpretation are results from other studies that have used similar methods to assess the impact of other experimental and quasiexperimental variables on implicit memory performance. For example, Snodgrass & Surprenant (1989) reported similar forgetting functions for implicit and explicit memory for fragmented objects, Maki, Zonderman, and Weingartner (1999) reported a small, but reliable age effect with a fragmented object identification task, and Cycowicz, Friedman, Snodgrass, and Rothstein (2000) reported a developmental trend, in both explicit and implicit memory performance, by using an implicit picture fragment completion task. Although no information is provided in these studies about the reliability of the tests, it seems likely that the fragmented objects identification test is generally a highly reliable implicit memory test.

Besides an explanation in terms of test reliability, there are other accounts that can explain specific aspects of our results. As predicted by the framework of Ostergaard (1999), the observed priming deficit in amnesics cooccurred with lower base-line performance. It is therefore possible that the difference in baseline performance resulted in a priming measure that is more sensitive to differences in the availability of information from the prior study episode. Such an interpretation is also consistent with our findings.

In addition, the results of the present study fit well into recent findings from neuroimaging work. From these studies, it seems clear that the differences between semantic and perceptual processing are associated with differences in brain activity localized in the regions of the left prefrontal cortex (PFC; Grady, McIntosh, Rajah, and Craik, 1998; Kapur et al., 1994; for a review see Cabeza & Nyberg, 2000). These regions are typically intact in amnesic patients. It is assumed that increased activity in frontal regions leads to more readily retrievable memory traces. Therefore, from a neuroimaging perspective we would not expect a priori differences between amnesic patients and controls for a level of processing manipulation.

In addition, differences in brain activity for new compared to primed items have also been located in the left PFC, and with greater activity for new than for primed items (e.g., Buckner, Koutstaal, Schacter, & Rosen, 2000; Wagner, Koutstaal, Maril, Schacter, and Buckner, 2000). Furthermore, recent findings suggest that structures in the mediotemporal lobes (MTL) are also involved in implicit memory (Buckner et al., 2000; Habib, McIntosh, Wheeler, and Tulving, 2003). The latter brain areas are those typically damaged in amnesic patients. The findings from these neuroimaging studies suggest that priming is mediated by a large-scale network, with components in the MTL and PFC regions (Buckner et al., 2000; Habib et al., 2003). As a consequence, the more traditional distinction between an explicit and an implicit memory system, with the former being damaged and the latter being spared in amnesic patients, may turn out to be premature.

Similar arguments, challenging the distinction between an explicit and an implicit memory system, have been put forward in recent simulation studies (Kinder & Shanks, 2001; Nosofsky & Zaki, 1998; Zaki, Nosofsky, Jessup, and Unversagt, 2003). These studies have shown that dissociations, as well as associations, between implicit and explicit memory can be modeled within a single memory system.

In fact, various new findings are now amassing that demonstrate impairments of amnesic patients on a wide range of implicit learning and memory tasks, originally thought to depend on the “implicit memory system” (e.g., Channon et al., 2002; Chun & Phelps, 1999). The present findings fit well with this pattern. The data suggest that dissociations between explicit and implicit memory tests can materialize as a consequence of reliability differences, a result that can be easily accommodated by a single system theory.

To conclude, however, it is important to note that it would be unwise to claim that all dissociations between explicit and implicit memory tests are simply a consequence of reliability differences. We believe that many studies have shown truly differential effects of independent variables on explicit and implicit memory tests. However, the present work indicates that test reliability is an important, but neglected, issue in implicit memory research.

NOTES

1. This paper focuses on perceptual priming, as the current state of research on this topic is still controversial. In contrast, there is a general agreement that amnesic patients show deficits in conceptual implicit memory tests (Carlesimo, 1994, Keane et al., 1997). Similarily, there is convincing evidence that levels of processing consistently affect performance in conceptual implicit memory tests (cf. Hamann, 1990).

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