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When Amnesic Patients Perform Well on Recognition Memory Tests

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Extended exposure to study material can markedly improve subsequent recognition memory performance in amnesic patients, even the densely amnesic patient H.M. To understand this phenomenon, the severely amnesic patient E.P., 3 other amnesic patients, and controls studied pictorial material and then were given either a yes–no (Experiment 1) or a 2-alternative, forced-choice (Experiment 2) recognition test. The amnesic patients and controls benefited substantially from extended exposure, but patient E.P. consistently performed at chance. Furthermore, confidence ratings corresponded to recognition accuracy. The results do not support the idea that the benefit of extended study time is due to some kind of familiarity process made available through nondeclarative memory. It is likely that amnesic patients benefit from extended study time to the extent that they have residual capacity for declarative memory.

Declarative memory involves the conscious (explicit) recollection of facts and events and is supported by medial temporal lobe and diencephalic brain structures (Schacter & Tulving, 1994; Squire, 1992; Weiskrantz, 1990). Amnesic patients with damage to the medial temporal lobe or midline diencephalon exhibit impaired declarative memory but perform normally on tasks of nondeclarative memory that do not require the explicit recollection of previously encountered information (Schacter, Chiu, & Ochsner, 1993; Squire, Knowlton, & Musen, 1993). Impaired declarative memory also is evident in patients with histologically confirmed lesions limited to the hippocampus or the hippocampal formation (Rempel-Clower, Zola, Squire, & Amaral, 1996; Zola-Morgan, Squire, & Amaral, 1986), even when the patients are tested on simple tests of recognition memory (Reed & Squire, 1997).

Despite their deficient declarative memory, the performance of amnesic patients on recognition memory tests can be elevated substantially when the patients are given sufficient time to study the to-be-remembered items (Huppert & Piercy, 1979). Even the severely amnesic patient H.M. (Scoville & Milner, 1957) correctly recognized 78.8% of the items on a yes–no recognition memory test after studying 120 pictures for 20 s each (Freed, Corkin, & Cohen, 1987). Controls correctly recognized 78.2% after seeing each picture for 1 s.

This phenomenon is well established and has been demonstrated in amnesic patients with both medial temporal lobe and diencephalic lesions (Freed & Corkin, 1988; Freed et al., 1987; Huppert & Piercy, 1979; McKee & Squire, 1992; Squire, 1981). Nevertheless, the basis for the phenomenon remains unclear. Why are amnesic patients able to improve their recognition memory performance as a result of extended study time? According to one account, recognition memory depends partly on nondeclarative memory. Specifically, it has been proposed that recognition memory may be based on some kind of familiarity process made available through priming (Cermak, Verfaellie, Sweeney, & Jacoby, 1992; Dorfman, Kihlstrom, Cork, & Misiaszek, 1995; Mandler, 1980). Thus, individuals can detect the facility with which they process an item on a recognition test and then attribute this facility to the item's recent presentation on a study list (Jacoby, 1983a, 1983b). In this view, when amnesic patients improve their performance on a recognition memory test, one must consider the possibility that the improvement is supported partly by priming. Furthermore, if this improvement does depend on priming (i.e., on a nonconscious form of memory), then the improvement should not be reflected in the confidence ratings that patients give for their recognition responses. In the limiting case, patients could perform well but report that they were simply guessing.

Another view is that recognition memory is wholly dependent on declarative memory and independent of priming (Haist, Shimamura, & Squire, 1992; Hamann & Squire,

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1997; Hayman & Tulving, 1989; Squire & Knowlton, 1995). When making recognition memory judgments, individuals may not ordinarily consult the memory system that supports priming (Gabrieli, Fleischman, Keane, Reminger, & Morrell, 1995). According to this view, improved recognition memory performance in amnesia after extended exposure to study items is based on residual declarative memory capacity. Consistent with this view, all the amnesic patients so far studied in extended-exposure paradigms have some capacity for declarative memory as well as incomplete damage to the medial temporal lobe. Even the severely amnesic patient H.M. has some capacity for new learning (Corkin, 1984; Milner, Corkin, & Teuber, 1968), and recent neuroimaging studies showed that he has sparing of the parahippocampal cortex in the posterior medial temporal lobe (Corkin, Amaral, Gonzalez, Johnson, & Hyman, 1997). H.M.'s surgical removal extends approximately 5.0–5.5 cm posteriorly from the tips of the temporal lobes, not 8 cm, as estimated at the time of surgery (Scoville & Milner, 1957).

Although a number of experiments using different methods have shown recognition memory to be independent of priming, it also is true that these investigations have been limited to conventional paradigms in which to-be-remembered items are presented briefly once or twice for study. Accordingly, it remains possible that the extreme conditions involved in presenting items for extended viewing might permit subsequent recognition memory judgments to be supported by priming phenomena.

In this study we examined why the recognition performance of amnesic patients benefits from extended study time. We studied the severely amnesic patient E.P. (Squire & Knowlton, 1995), who has virtually no declarative memory capacity. E.P. performs more poorly than patient H.M. on equivalent tests of recognition memory (Hamann & Squire, 1997). We also tested three other less severely impaired amnesic patients. We addressed two questions: First, considering that we have been unable to detect any declarative memory in patient E.P. and that radiological evidence suggests that he has complete damage to the medial temporal lobe memory system (Squire & Knowlton), we asked whether his recognition memory performance could benefit at all from extended study of the to-be-remembered items. Second, we asked what sort of confidence ratings amnesic patients would provide in conjunction with their recognition memory judgments. If recognition memory depends substantially on declarative memory, we would expect confidence ratings to increase when the patients improve their recognition scores. Alternatively, if recognition memory depends partly on some kind of familiarity process derived from nondeclarative memory, then confidence ratings might be uniformly low, even in the face of good performance, as if the patients were simply guessing.

Experiment 1

The severely amnesic patient E.P., 3 other amnesic patients with lesions limited to the hippocampal formation, and healthy volunteers viewed pictures either once for 0.2 s each (short exposure) or twice for 10 s each (extended exposure). Ten minutes later, a yes–no recognition memory test was given. The extended-exposure condition was expected to improve the recognition memory performance of the 3 amnesic patients to a level as good as or better than the level of performance achieved by controls tested in the short-exposure condition. The first question of interest was whether the recognition memory of patient E.P. would also improve. The second question was whether, for all the amnesic patients, the confidence ratings provided for the recognition memory judgments would correlate with recognition performance or whether they would remain low even when performance improved, as if improved performance were associated with the experience of guessing.

Method

Participants. We tested the severely amnesic patient E.P., 3 other amnesic (AMN) patients, and 4 controls (CON; see Tables 1 and 2). E.P. developed profound anterograde and retrograde amnesia in 1992 after contracting herpes simplex encephalitis. Neuroimaging studies revealed large lesions of the medial temporal lobe (Squire & Knowlton, 1995). The damage involves primarily bilaterally the amygdaloid complex; the entorhinal, perirhinal, and parahippocampal cortices; and the hippocampus. In addition, he has small foci of damage in the right medial and dorsal frontal cortices. There is also reduced volume of the insular cortex and inferotemporal gyrus bilaterally.

E.P. is so severely amnesic that after more than 40 visits to his home in a single year, he failed to recognize the examiner and denied having been previously tested. Nevertheless, he is alert, attentive, appears normal at first contact, and has an IQ score in the normal range. In addition, like other amnesic patients (Cave & Squire, 1992), his immediate (short-term) memory is intact as

Table 1
Characteristics of Amnesic Patients

Patient	Year of birth	Education (years)	WAIS–R IQ	WMS–R Attention	WMS–R Verbal	WMS–R Visual	WMS–R General	WMS–R Delay
E.P.	1922	12	103	94	57	82	61	56
A.B.	1937	20	104	87	62	72	54	<50
P.H.	1922	19	120	117	67	83	70	57
L.J.	1937	12	98	105	83	60	69	<50

Note. The Wechsler Adult Intelligence Scale—Revised (WAIS–R) and the Wechsler Memory Scale—Revised (WMS–R) yield mean scores of 100 in the normal population with a standard deviation of 15. The WMS–R does not provide numerical scores for individuals who score below 50.

Table 2
Performance on Standard Memory Tests

Patient	Diagram recall	Paired associates Trial 1	Trial 2	Trial 3	Word recall (%)	Word recognition (%)	50 words	50 faces
E.P.	0	0	0	0	24	65.3	24	28
A.B.	4	1	1	1	33	82.7	32	33
P.H.	3	0	0	1	27	84.0	36	34
L.J.	3	0	0	0	40	92.7	33	29
Control mean (n = 8)	20.6	6.0	7.6	8.9	71.0	97.4	48.4	41.9

Note. The diagram recall score is based on the delayed (12-min) reproduction of the Rey–Osterrieth figure (Osterrieth, 1944; maximum score = 36). For copying the figure, the amnesic group and patient E.P. obtained normal scores (29.6 and 27, respectively; Kritchevsky, Squire, & Zouzounis, 1988). The paired-associates score is the number of word pairs recalled on three successive trials (maximum score = 10/trial). The word recall score is the mean percentage of 15 words recalled across five successive study–test trials (Rey, 1964). The word recognition score is the mean percentage of words identified correctly across five successive study and test trials (yes–no recognition of 15 new words and 15 old words). Note that scores on the recall test are above zero because on this test of immediate recall, several items can be retrieved from immediate memory, which is intact in amnesia. Note, too, that recognition scores are above chance, also presumably because some items can be retrieved from immediate memory (E.P.'s score was not reliably above chance), $t(29) = 1.9, p = .07$. The scores for words and faces are based on a 24-hr recognition test of 50 words and 50 faces (modified from Warrington, 1984; maximum score = 50, chance = 25). The mean scores for the controls are from Squire and Shimamura (1986).

measured by a digit span test. His average forward digit span was 7.3 digits, averaged across seven test sessions.

Patient A.B., who is unable to participate in magnetic resonance imaging studies, became amnesic in 1976 after an anoxic episode and is presumed to have hippocampal damage on the basis of this etiology. Other patients with amnesia caused by anoxia have proved at histological examination to have hippocampal formation damage (Cummings, Tomiyasu, Read, & Benson, 1984; Rempel-Clower et al., 1996). Patients P.H. and L.J. have bilateral hippocampal damage confirmed by magnetic resonance imaging (for P.H., Polich & Squire, 1993; for L.J., unpublished observations). P.H. had a 6-year history of 1- to 2-min "attacks" (with a possible epileptic basis) that were associated with gastric symptoms and transient memory impairment. In July 1989, he suffered from a series of brief episodes, after which he had a marked and persistent memory loss. Patient L.J. became amnesic during a 6-month period that began in 1988 with no known precipitating event. Her memory impairment has remained stable since that time.

The controls were employees and volunteers at the San Diego Veterans Affairs Medical Center. They were selected to match the 3 AMN patients with respect to age (M = 65.8 years), education (M = 15.5 years), and Wechsler Adult Intelligence Scale–Revised subscale scores for Information (Ms = 22 and 21.7 for the CON and AMN groups, respectively) and Vocabulary (Ms = 57.8 and 58 for the CON and AMN groups, respectively).

Materials and procedure. A pool of 160 unique color slides of magazine pictures were selected as stimuli (McKee & Squire, 1992). These were divided into two sets of 80 slides each, which were used in two different exposure conditions (short = 0.2 s/slide; extended = 20 s/slide). Both sets of 80 slides were further divided to form a 40-item set of study items and a 40-item set of distractor items. All slides were presented on the viewing monitor of a Telex Caramate projector (Model 4490).

In the short-exposure condition (which was administered to the AMN and CON groups, but not to patient E.P.), 40 study slides were presented once for 0.2 s each. The interslide interval was 0.75 s. Participants were instructed to study each slide so that they might be able to identify it on a subsequent memory test. The study phase, which required about 40 s, was followed by a conversation-filled, 10-min retention interval and then by a yes–no recognition test.

The recognition test consisted of 80 slides, 40 from the study set (old) and 40 from the distractor set (new). The slides were presented one at a time in a mixed order, and participants indicated whether they thought they had seen each slide previously (yes–no). After each yes–no response, participants also rated how confident they were in their responses. Confidence ratings were made using a 5-point scale, with a rating of 1 indicating *pure guess* and a rating of 5 indicating *very sure.* An index card showing the scale and the two labels at each end of the scale was in view throughout the retention test. Rather than balance the new and old items across participants, as in conventional group studies, we administered the identical memory test to each participant. This was done because the overall strategy of this study was to evaluate the performance of patient E.P. and to determine how he performed relative to the other participants.

In the extended-exposure condition (which was administered to all the participants, including E.P.), the second set of 40 study slides was presented once for 10 s each, and the same 40 slides were immediately presented a second time for another 10 s (total exposure time/slide = 20 s). In all other respects, this condition proceeded like the first condition. Thus, after the study phase, which took approximately 15 min, there was a 10-min retention interval followed by a yes–no recognition test. Those in the AMN and CON groups were tested once. E.P. was tested three different times, separated by at least 1 week, using the identical study and test materials. E.P.'s confidence ratings were collected only on his second and third tests. (The results confirmed that E.P.'s memory impairment was so severe that he showed no carryover from one test to the next. His performance on the first test was essentially the same as his performance on each of the other tests; see the *Results* section.)

Results

Figure 1 shows yes–no recognition performance and confidence ratings for correct and incorrect responses. Recognition test performance was assessed by calculating discriminability scores (d') for each participant (Green & Swets, 1966). When a participant's hit rate was 1.0 or the false-alarm rate was 0.0, 1.0 was replaced by $1 - 1/2N$ or 0 was replaced by $1/2N$ ($N = 40$ in the present case; Bock & Jones, 1968). For the short-exposure condition (0.2 s/slide; see Figure 1A), the CON group performed well above chance levels ($d' = 1.17$), $t(3) = 5.85$, $p < .01$, but the AMN group performed near chance ($d' = 0.70$), $t(2) = 1.62$, $p > .10$. The percentage of correct scores (based on total hits plus correct rejections) were 72.3% (CON) and 58.8% (AMN). Because of the variability in the scores of the 3 amnesic patients (d's = 0.38, 0.17, and 1.57; 66.3%, 57.5%, and 52.5% correct, respectively), the difference between the AMN and CON groups did not reach significance ($p > .10$).

For the extended-exposure condition (see Figure 1B), the CON group performed better than the AMN group (d's = 4.1 vs. 2.0), $t(5) = 3.9$, $p = .01$ (96.9% correct vs. 77.9% correct). Both groups performed much better than they did in the short-exposure condition ($ts > 4.4$, $ps < .05$). Indeed, extended exposure to the slides enabled the AMN group to perform about as well as the CON group performed in the short-exposure condition (CON, $d' = 1.17$, 72.3%; AMN, $d' = 2.0$, 77.9% correct), $t(5) = 2.77$, $p = .13$. In contrast to the findings for all the other participants, Patient E.P. was not able to recognize the pictures after seeing them for 20 s each ($d' = 0.1$, 50.6% correct). Thus, for E.P., the extended-exposure condition did not result in detectable recognition performance. His performance was similarly poor on each of the three tests that he was given (d's = −0.07, −0.36, and 0.47; 48%, 47.5%, and 56.2% correct, respectively).

The confidence ratings provided by participants for their recognition judgments corresponded closely to their recognition accuracy (see Figure 1, C and D). Thus, when they performed well above chance (in both the short-exposure and the extended-exposure conditions for the CON group and in the extended-exposure condition for the AMN group), participants were more confident in their correct responses

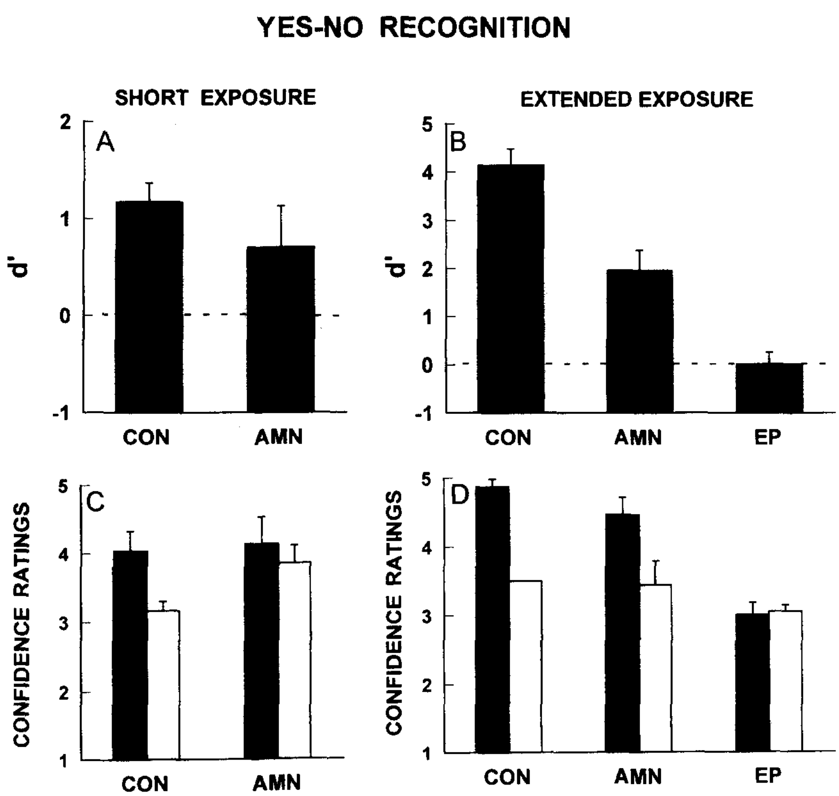

Figure 1. Yes–no recognition memory test performance following either a short or an extended exposure to study items. A: Four controls (CON) and 3 amnesic (AMN) patients with lesions limited to the hippocampal formation were given a short exposure (0.2 s) to each of 40 pictures. B: The same CON group, the 3 AMN patients, and the amnesic patient E.P. were given extended exposure (total = 20 s) to each of 40 pictures. C: Confidence ratings for the correct (shaded bars) and incorrect (open bars) responses in the yes–no recognition test that followed a short exposure to each picture. D: Confidence ratings for the correct (shaded bars) and incorrect (open bars) responses in the yes–no recognition test that followed extended exposure to each picture. The CON group rating for incorrect responses is from the individual who made errors. Patient E.P. was tested three times in the extended study condition. All bars show means and standard errors of the mean.

than in their incorrect responses ($ts > 4.4$, $ps < .03$). By contrast, when performance was at chance levels (in the short-exposure condition for the AMN group and in the extended-exposure condition for patient E.P.), the confidence ratings associated with correct and incorrect responses did not differ significantly ($ts < 0.9$, $ps > .10$). Finally, the confidence ratings given by E.P. (about 3.0 for both correct and incorrect responses; see Figure 1D) were well above what they in principle could have been on the 1–5 rating scale. However, previous studies with this rating scale indicate that respondents tend not to use its lower range. For example, even healthy volunteers who performed at chance on a forced-choice recognition test for words 8 weeks after learning, gave confidence ratings of about 3 on the same 1–5 scale (Haist et al., 1992).

The performance of patient E.P. was consistent with the impression that his anterograde amnesia is so severe that he has no declarative memory capacity. He was attentive and cooperative, and he often commented on the slides as they were presented. For example, on each of the three study sessions, when he was presented with a picture of a cantaloupe harvest, he responded in the same way, expressing amazement at the size of the harvest. Yet, each time that this slide appeared on the yes–no recognition test, he failed to identify it as a slide that he had seen previously. Similarly, during each test session, E.P. reacted incredulously when the experimenter informed him that he in fact had seen some of the slides previously.

Experiment 2

Forced-choice recognition tests can be more sensitive measures of memory for previously studied items than yes–no recognition memory tests (MacMillian & Creelman, 1991). Accordingly, in Experiment 2 we repeated the procedures of Experiment 1 but with a two-alternative, forced-choice recognition test instead of a yes–no recognition test.

Method

Participants. The amnesic patients and the controls were the same as those tested in Experiment 1.

Materials and procedure. A new pool of 160 color slides was used to construct two recognition tests as described in Experiment 1. For study, participants saw 40 slides under one of two study conditions (0.2 s/slide or 20 s/slide). Ten minutes after the study phase was completed, a two-alternative, forced-choice test was given.

On each trial of the recognition test, two slides were presented (one studied slide and one distractor were presented on two slide projectors sitting side by side), and participants indicated which slide they had seen earlier. Half of the studied slides were presented on the right-hand slide projector and half were presented on the left-hand projector. Groups CON and AMN were tested once in each of the two study conditions. Patient E.P. was tested only in the extended-exposure condition (on two different occasions separated by 1 week). All participants provided confidence ratings after each choice.

Results

Figure 2 shows forced-choice test performance and confidence ratings for correct and incorrect responses. The results were similar to those of Experiment 1. For the short-exposure condition (see Figure 2A), the CON group performed well above chance (80.8% correct), $t(3) = 6.2$, $p < .01$, but the AMN group did not (56.7% correct), $t(2) = 1.6$, $p = .25$. The CON group performed much better than the AMN group, $t(5) = 3.55$, $p = .01$. In the extended-exposure condition (see Figure 2B), the CON group again performed better than the AMN group (100% vs. 90%), although performance was so good in both groups that they did not differ significantly ($p > .10$). Both groups performed considerably better than they had in the short-exposure condition ($ts > 3.9$, $ps < .02$). In fact, in the extended-exposure condition, the AMN group performed numerically better than the CON group in the short-exposure condition, $t(5) = 1.15$, $p > .10$. Finally, in marked contrast to all the other participants, patient E.P. did not perform above chance levels when given extended exposure (20 s) to each slide (50.0% correct). His performance was similarly poor on both retention tests (45.0% and 55.0% correct).

The confidence ratings associated with correct and incorrect recognition judgments were consistent with the recognition memory scores (see Figure 2, C and D). When recognition performance was good (in both exposure conditions for the CON group and in the extended-exposure condition for the AMN group), the confidence ratings were high for correct responses and much lower for incorrect responses (note that the CON group in the extended-exposure condition made no incorrect responses). In the short-exposure condition, the CON group expressed more confidence in their correct responses than in their incorrect responses, $t(3) = 8.6$, $p < .01$. In the extended-exposure condition for the AMN group, 1 patient (L.J.) made no incorrect responses. The difference between the confidence ratings for correct and incorrect responses did not reach significance for the 2 remaining patients, $t(1) = 4.84$, $p = .13$, despite the large numerical difference in ratings (4.6 vs. 2.8). When performance was near chance for the AMN group (in the short-exposure condition), the patients were more confident of their correct responses than their incorrect responses, but not significantly so, $t(2) = 2.6$, $p > .10$. Finally, E.P. was equally confident in his correct and incorrect responses, demonstrating no ability at all to discriminate familiar from novel pictures, even after extrended exposure (see Figure 2D). In fact, he was slightly more confident in his incorrect responses than his correct responses.

General Discussion

In keeping with previous work (McKee & Squire, 1992), we found that amnesic patients with lesions limited to the hippocampal formation markedly improved their recognition memory performance after receiving extended exposure to study items. In addition, there were two new findings. First, the severely amnesic patient E.P. did not improve his recognition performance above chance levels despite extended (20-s) exposure to studied items. We also assessed E.P.'s recognition memory capacity with three additional tests in an attempt to raise his recognition test performance above chance levels (see Table 3). Compared with the five tests administered as part of Experiments 1 and 2, these three

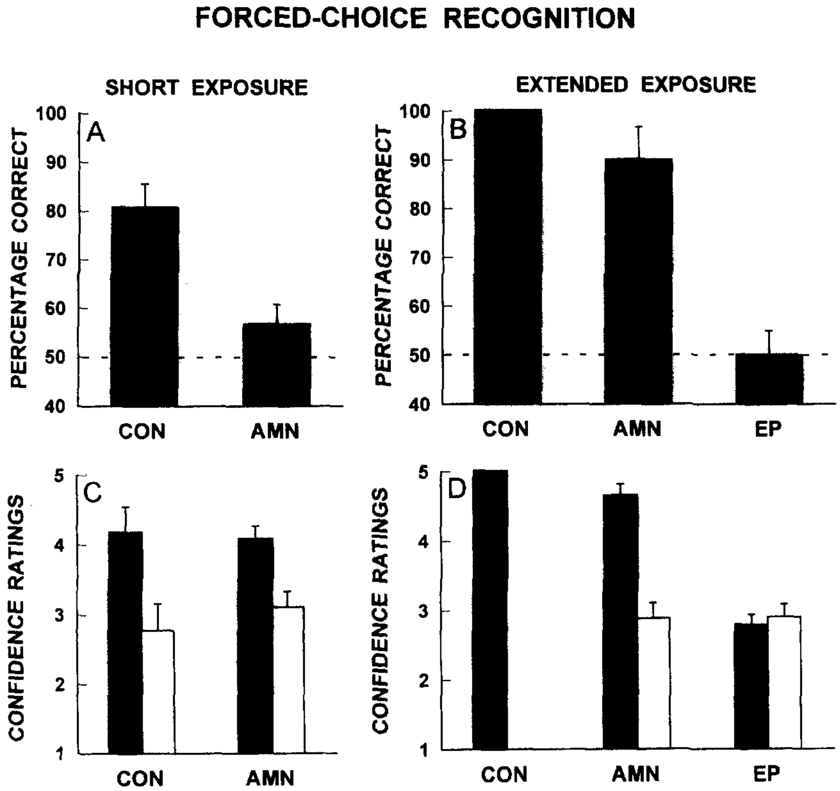

Figure 2. Two-alternative, forced-choice recognition memory test performance following either a short or an extended exposure to study items. A: Four controls (CON) and 3 amnesic (AMN) patients with lesions limited to the hippocampal formation were given a short exposure (0.2 s) to each of 40 pictures. B: The same CON group, the 3 AMN patients, and the amnesic patient E.P. were given extended exposure (total = 20 s) to each of 40 pictures. C: Confidence ratings for the correct (shaded bars) and incorrect (open bars) responses in the yes–no recognition test that followed a short exposure to each picture. D: Confidence ratings for the correct (shaded bars) and incorrect (open bars) responses in the yes–no recognition test that followed extended exposure to each picture. No confidence ratings are presented for incorrect responses for the CON group in the extended study condition (D) because none of them made any incorrect responses. Also, the data for the AMN group (D) are based on only 2 patients because L.J. made no incorrect responses. Patient E.P. was tested twice in the extended study condition. All bars show means and standard errors of the mean.

tests involved shorter lists of to-be-remembered items, increased study time, increased numbers of exposures to each item, or some combination of these. Nevertheless, even when only 20 slides were studied with a total study time per slide of 40 s, E.P. recognized only 45% of the slides as being familiar (for all three tests, $ts < 1.98, ps > .05$). Thus, when memory impairment is sufficiently severe, extended exposure at study does not result in good recognition memory performance.

The results of this study provide the first demonstration that improved recognition performance does not inevitably occur in amnesia after extended exposure to study material. The question arises as to what distinguishes E.P. from other patients, including patient H.M., whose recognition memory performance has been improved by extended exposure. On four separate occasions, H.M. saw 120 color slides (twice each for 10 s; total exposure = 20 s/slide) and then 10 min later was given a yes/no recognition test (40 old slides, 40 new slides) (Freed, et al., 1987). His average score on the four tests was 78.8% correct. By contrast, patient E.P. was tested on three separate occasions and obtained an average score of 50.6% correct (Figure 1), despite the fact that a shorter list of color slides was presented (40 color slides were presented twice each for 10 s; total exposure = 20 s/slide; test 10 min later with yes/no recognition; 40 old slides, 40 new slides).

Table 3
Performance of Patient E.P. on Three Additional Tests of Recognition Memory

No. of pictures studied	No. of presentations of each picture	Total seconds of exposure to each picture	% correct
40	4	20	65
40	6	30	48
20	8	40	45

Note. Each of these two-alternative, forced-choice tests used different sets of color slides.

The likely explanation is that E.P.'s medial temporal lobe lesion is more complete than in other patients who have been studied. Specifically, E.P.'s lesion includes components of the medial temporal lobe that are spared or largely spared in patient H.M. (the ventrocaudal perirhinal cortex and the parahippocampal cortex, respectively; Corkin et al., 1997). Both the perirhinal and parahippocampal cortices are components of the medial temporal lobe memory system thought to be important for declarative memory (Squire & Zola-Morgan, 1991). When these structures are spared, as in H.M., they would be expected to support some residual declarative memory ability. When a medial temporal lobe lesion damages the hippocampal formation, as well as the perirhinal and parahippocampal cortices, as in E.P., declarative memory impairment should be even more severe than in H.M.

The second important finding was that confidence ratings varied in accordance with recognition accuracy. When recognition performance was at chance (after extended exposure for E.P. and after short exposure for the AMN group), participants were as confident in their incorrect recognition judgments as in their correct judgments. By contrast, when recognition performance was well above chance (after extended exposure for the AMN group and in both conditions for the CON group), participants were more confident in their correct responses than their incorrect responses.

These neuropsychological findings, as well as the anatomical considerations just reviewed, are consistent with the idea that improved recognition memory performance in AMN patients after extended exposure to study items is based on residual declarative memory capacity. Previous studies have demonstrated intact nondeclarative memory capacity in patient E.P. (Hamann & Squire, 1997; Squire & Knowlton, 1995). In one study (Hamann & Squire, 1997), E.P. exhibited fully intact word priming on two different priming tests despite performing at chance on matched tests of recognition memory. If the improved recognition test performance demonstrated by the AMN patients were based on nondeclarative memory, then one would have expected patient E.P. to benefit to some extent from extended exposure to the test material. At the same time, the possibility cannot be excluded that E.P. and other similarly severe AMN patients might improve their recognition memory performance under some other set of conditions yet to be identified.

Previous studies also have shown that AMN patients can provide confidence ratings commensurate with the success of their recognition memory performance (Haist et al., 1992; Hirst et al., 1986; Hirst, Johnson, Phelps, & Volpe, 1988; Mayes, Meudell, & Neary, 1980; Meudell & Mayes, 1982). AMN patients with damage to the hippocampal formation also are able to predict their impaired recognition performance accurately (Shimamura & Squire, 1988). Similarly, in the current study, patients who performed well also demonstrated in their confidence ratings that they could discriminate correct from incorrect responses. These findings all point to the conclusion that those AMN patients who are capable of recognition performance also are aware of what they know and what they do not know, as would be expected if their recognition memory were dependent on residual declarative memory. Our findings extend this idea to the circumstance in which patients are given extended study time for the material to be learned.

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