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On the Relationship Between Recall and Recognition Memory

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The relationship between recall and recognition has been a central topic for the study of memory. A test of alternative views about recall and recognition was arranged by studying amnesic patients. In amnesia, damage has occurred to a brain system important for declarative (conscious) memory, but skill learning, priming, and other forms of nonconscious memory are intact. Recall and recognition were found to be proportionately impaired in amnesic patients, and confidence ratings for the recognition judgments were commensurate with the level of impaired performance. The results are contrary to views that either recognition memory or associated confidence judgments are ordinarily supported significantly by nonconscious memory. The results favor the view that recall and recognition are related functions of declarative memory and equivalently dependent on the brain system damaged in amnesia.

During the past century, ideas about the structure and organization of human memory have benefited significantly from evidence of functional dissociations between different performance measures. One major focus of research has concerned the relationship between recall and recognition memory (Anderson & Bower, 1973; Kintsch, 1970; Mandler, 1980; Tulving, 1976). Two early views were represented by *strength* theory and *generate-recognize* theory. Strength theory used a threshold notion to explain the typical finding that recognition is usually superior to recall. That is, recalling an item from memory requires more information in storage (i.e., memory strength) than recognizing an item (McDougall, 1904; Postman, 1963). The generate-recognize view proposed that recall depends on a two-stage process in which retrieval of candidate items from memory is followed by a familiarity decision, whereas recognition memory requires only a familiarity decision (Hollingworth, 1913; James, 1890). More formal versions of this view were later developed (Anderson & Bower, 1973; Bahrick, 1970; Kintsch, 1970).

Strength models and generate-recognize models of memory have been largely replaced by accounts that attribute important retrieval functions to both recall and recognition. For example, according to the *encoding specificity* principle (Tulving, 1983), successful retrieval depends on achieving a match between the information encoded at the time of learning and the information that is available at the time of retrieval. Recollection is successful to the extent that the information available at retrieval can reinstate features of the learning event (see Horowitz & Prytulak, 1969). Recall is typically more difficult than recognition because, compared with recognition, recall requires more extensive reinstatement of the learning event (for similar views, see Anderson & Bower, 1972, 1974; Gillund & Shiffrin, 1984; Kintsch, 1974; Lockhart, Craik, & Jacoby, 1976; Ratcliff, 1978; Roediger, Weldon, & Challis, 1989).

Recent studies of memory have distinguished between *declarative, explicit,* or *conscious* memory on the one hand and *nondeclarative, implicit,* or *nonconscious* memory on the other (see Hintzman, 1990; Richardson-Klavehn & Bjork, 1988; Schacter, 1987; Shimamura, 1989; Squire, 1987; Tulving, 1985; Weiskrantz, 1987). This distinction receives strong support from findings with amnesic patients, who are severely impaired on conventional tests of learning and memory (e.g., recall, recognition, and paired-associate learning), but who can nevertheless perform entirely normally on indirect or implicit tests of memory (e.g., priming, skill learning, and conditioning). On the basis of these findings, as well as other findings from normal subjects, it has been appreciated that memory is not a single faculty but is composed of multiple processes or systems. The memory system impaired in amnesic patients (i.e., declarative memory) is dependent on the integrity of the hippocampus and related structures (Squire & Zola-Morgan, 1991).

Both recall and recognition memory are generally considered to depend on declarative memory. By one view, recognition memory performance is closely linked to recall. Subjects explicitly evaluate their memory and can either retrieve items (recall) or make judgments as to whether or not items are familiar (recognition). By this view, recall and recognition depend equivalently on declarative memory. Alternatively, recognition memory has been proposed to depend importantly on the facility with which a subject processes the recognition cue. This notion is based on perceptual priming,

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a nonconscious process whereby the facility for detecting and identifying words and other perceptual objects is improved by recent encounters with the same words or objects (Shimamura, 1986; Tulving & Schacter, 1990). The view is that recognition memory performance benefits not only from the ability to judge consciously whether a previous event has occurred but also from increased perceptual fluency, that is, from priming (Gardiner, 1988; Jacoby, 1983; Johnston, Dark, & Jacoby, 1985; Mandler, 1980). That is, subjects can detect the facility or fluency with which they process a test item and can then attribute this increased fluency to a recent occurrence of the item. Thus, by this view recall depends on declarative memory, and recognition depends on declarative memory as well as on nondeclarative memory.

Evidence relevant to the nature of recognition memory could potentially come from the study of human amnesia, because amnesia selectively impairs declarative (explicit) memory. If recognition performance depends importantly on nondeclarative memory (specifically, on perceptual fluency), then the relationship between recognition and recall performance should be different in amnesic patients than in normal subjects. In both subject groups, recognition should be superior to recall because it is typically easier to recognize items that were encountered recently than to recall them. However, in amnesic patients recognition memory should be disproportionately better than would be expected from the level of recall, because recognition is presumed to depend importantly on nondeclarative (implicit) memory, which is spared in amnesia. Furthermore, to the extent that recognition performance depends on nondeclarative (i.e., nonconscious) memory, it could be supposed that amnesic patients would perform well on a recognition test but be unable to reflect their correct performance in confidence ratings, that is, they would report that they were simply guessing (Weiskrantz, 1988). By this view, recognition memory should be disproportionately spared in amnesia, relative to both recall and the confidence ratings given for recognition items. Alternatively, if recall and recognition memory depend primarily on declarative memory (and on the integrity of the brain system damaged in amnesia), then recall and recognition should be proportionately impaired in amnesia and the confidence ratings given for recognition items should be commensurate with the level of recognition memory performance that is achieved.

In the present study, a parametric study of free recall, two-choice recognition, and confidence ratings for recognition judgments was carried out in a group of amnesic patients and control subjects. The small amount of data available from amnesic patients on this issue have been equivocal. In one report amnesic patients appeared to exhibit proportionate impairment on free recall and recognition tests (Squire & Shimamura, 1986). Similar findings were reported by Shimamura and Squire (1988) in comparisons of cued recall and recognition memory. Moreover, confidence ratings given for recognition judgments were commensurate with recognition performance. However, two studies also have reported that amnesic patients exhibited disproportionate sparing of recognition in comparison to recall (Hirst et al., 1986; Hirst, Johnson, Phelps, & Volpe, 1988). The difficulty in interpreting all these findings is that comparisons between normal and impaired performance on two different tasks are beset by formidable methodological problems (Chapman & Chapman, 1973; Meudell & Mayes, 1982). One important concern is that the scales used to measure recall and recognition cannot be assumed to be linear across the entire range of normal and abnormal scores (see Loftus, 1978; Loftus, 1985; Loftus, Shimamura, & Johnson, 1985; Shimamura, 1990). Accordingly, direct comparisons between amnesic patients and control subjects on tests of recall and recognition memory (e.g., an analysis of nonordinal interactions) cannot be used to infer disproportionate impairment in patient groups.

One useful approach to the problem of measurement scaling is to match performance on one measure and then compare performance on the second measure. For example, one could match recognition scores of amnesic patients and normal subjects by increasing the retention interval for normal subjects and then compare performance of the two groups at the same retention intervals on a measure of recall. Several studies have used such a strategy to investigate differences in performance between amnesic patients and control subjects (Hirst, Johnson, et al., 1988; Meudell & Mayes, 1981; Shimamura & Squire, 1987, 1988; Squire, Wetzel, & Slater, 1978). However, in all previous studies only a single retention interval was used for the matching procedure. An alternative method for comparing recall and recognition scores of amnesic patients and normal subjects, and one that provides a more secure basis for making such a comparison, is to match performance on one measure across a range of retention intervals and across various levels of performance and then compare performance on the other measure at the same retention intervals. This more elaborate procedure involves comparing performance curves between subject groups (for similar approaches, see Bamber, 1979; Dunn & Kirsner, 1988). Accordingly, in the present study we tested free recall, recognition memory, and confidence ratings across a wide range of retention intervals in both amnesic patients and control subjects. We were able to match amnesic patients and control subjects at several levels of recognition performance. We then compared the performance of the two groups on the other two measures: recall and confidence ratings.

Experiment 1

Method

Subjects

Amnesic patients. Twelve amnesic patients were tested. Six of these patients (Patients NC, RC, VF, DM, PN, and JW) had alcoholic Korsakoff's syndrome with radiographically confirmed reductions of mammillary nuclei volume, thalamic density, and frontal lobe atrophy (Shimamura, Jernigan, & Squire, 1988; Squire, Amaral, & Press, 1990). Of the other 6 patients, 2 had hippocampal lesions confirmed by magnetic resonance imaging (MRI) (Press, Amaral, & Squire, 1989; Squire et al., 1990). Patient LM became amnesic in 1984 following a respiratory arrest that occurred during an epileptic seizure. Patient JL became amnesic gradually during a span of about 2 years from early 1985 to early 1987; his memory impairment has remained stable since that time. Two amnesic patients had suspected hippocampal lesions on the basis of the etiology of their amnesia. Patient AB became amnesic in 1976 following an anoxic episode during a cardiac arrest. Patient GD became amnesic in 1983 following a period of hypotension that occurred during major surgery. Two other amnesic patients had diencephalic lesions confirmed by MRI. Patient MG became amnesic in 1986 after a bilateral medial thalamic infarction. Patient NA became amnesic in 1960, primarily for verbal material, after a penetrating stab wound to the left diencephalic region (Squire, Amaral, Zola-Morgan, Kritchevsky, & Press, 1989; Teuber, Milner, & Vaughan, 1968). These patients have been studied in our laboratory for a number of years, and their memory impairments are well documented. Individual Wechsler Adult Intelligence Scale-Revised (WAIS-R) Full-Scale IQ and Wechsler Memory Scale-Revised (WMS-R) index scores appear in Table 1.

Immediate and delayed (12 min) recall of a short prose passage averaged 5.7 and 0 segments, respectively. Free recall of 15 words (Rey Auditory Verbal Learning Test; Lezak, 1983; Rey, 1964) averaged 4.0, 4.8, 5.7, 5.1, and 5.2 across five successive study-test trials. Recognition of 15 previously presented words and 15 new words presented one at a time, with instructions to make a yes/no choice, averaged 21.8, 25.1, 24.9, 25.4, and 26.8 correct responses across five successive study-test trials. Individual scores on these and other memory tests appear in Table 2. The mean score on the nonmemory portions of the Dementia Rating Scale (Mattis, 1976) was 113.8 points (119 points possible). The mean score on the Boston Naming Test (Kaplan, Goodglass, & Weintraub, 1983) was 54.8 (maximum = 60).

Control subjects. Nineteen subjects served as the control group for the amnesic patients. The 19 control subjects consisted of 10 abstaining alcoholic subjects (8 men and 2 women) and 9 healthy subjects (4 men and 5 women). The alcoholic subjects were current or former participants in alcohol treatment programs in San Diego County. None reported a history of cirrhosis or severe head injury (specifically, a period of unconsciousness lasting longer than 5 min). The alcoholic subjects reported an average drinking history of 22 years (range: 2 to 37 years) and had abstained from alcohol for an average of 4.5 years (range: 0.4 to 15 years). The healthy normal subjects were employees or volunteers of the San Diego Veterans Affairs Medical Center or were recruited from the University of California, San Diego, retirement community. The 19 control subjects were matched to the amnesic patients with respect to age (54 years), years of education (14 years), and scores on the Information and Vocabulary subtests of the WAIS-R (control subjects = 20.6 and 52.5, respectively; amnesic patients = 20.0 and 54.2, respectively). Immediate and delayed (12 min) recall of a short prose passage averaged 7.4 and 6.1 segments, respectively.

Materials and Design

Eighteen lists of 20 words each were randomly assembled from 360 unrelated one-syllable and two-syllable nouns. Each word was four to nine letters long with a mean frequency of 95 occurrences per million (Kucera & Francis, 1967). The words were printed individually in 18-point, uppercase block letters on 3 in. × 5 in. index cards. The order of the 20 words in each list was the same for all subjects. The 18 lists were first divided randomly into three sets of six lists each. For a given subject, one set of six lists was selected to assess free recall at six different retention intervals, another set of six lists was used to assess two-alternative, forced-choice recognition memory at six different retention intervals, and the remaining six lists were used as distractor items for the recognition test. Across subjects, lists were equally likely to be used in these three ways. The assignment of the six lists in each set to the six retention intervals was done randomly. For the recognition tests, words were always presented in a different order than the one in which they appeared during the study.

To obtain forgetting curves that would permit matches in performance between amnesic patients and control subjects, the retention intervals used for amnesic patients were shifted toward shorter intervals than those used for control subjects. For amnesic patients, recall was tested after 15 s, 1 min, 5 min, 10 min, 2 hr, and 1 day; and recognition was tested on separate occasions after 15 s, 1 min, 10 min, 2 hr, 1 day, and 2 weeks. For control subjects, recall was tested after 15 s, 10 min, 2 hr, 1 day, 2 weeks, and 8 weeks; and recognition was tested on separate occasions after the same six retention intervals.

Table 1
Description of Amnesic Patients

Subject	Age (in years)	Sex	Education (in years)	Etiology	WAIS-R IQ	WMS-R				
						Attention	Verbal	Visual	General	Delay
AB	50	M	19	Anoxia	119	87	62	72	54	<50
GD	47	M	13	Ischemia	92	109	86	88	85	60
LM	58	M	15	Anoxia	111	132	87	96	90	65
JL	69	M	14	Unknown	116	122	73	83	74	58
NA	49	M	13	Penetrating brain injury	120	102	67	89	68	71
MG	56	F	13	Thalamic infarction	111	113	89	84	86	63
NC	45	F	12	Korsakoff	90	62	80	60	69	<50
RC	72	M	9	Korsakoff	106	115	76	97	80	72
VF	69	M	10	Korsakoff	103	101	78	72	72	66
DM	54	M	12	Korsakoff	101	92	55	64	50	51
PN	60	F	11	Korsakoff	94	81	77	73	67	53
JW	52	M	14	Korsakoff	98	104	65	70	57	57
Mean	56.8		12.9		105.1	101.7	74.6	79.0	71.0	59.7

Note. The WAIS-R (Wechsler Adult Intelligence Scale—Revised) Full-Scale IQ and the five indices of the WMS-R (Wechsler Memory Scale—Revised) yield a mean score of 100 in the normal population with a standard deviation of 15. The WMS-R does not provide scores for subjects who score below 50. Therefore, the two scores below 50 were scored as 50 for calculating the group mean. M = male; F = female.

Table 2
Performance on Standard Memory Tests

Patients	Diagram recall	Paired associates	Word recall (%)	Word recognition (%)	50 words	50 faces
AB	4	1 - 1 - 2	33	83	32	33
GD	7	2 - 1 - 2	36	79	25	28
LM	11	1 - 1 - 3	44	98	30	37
JL	1	0 - 0 - 0	40	93	31	20
NA	17	0 - 0 - 2	49	93	34	42
MG	0	0 - 0 - 2	33	71	30	34
NC	0	1 - 0 - 1	23	71	31	37
RC	3	0 - 0 - 3	19	85	37	30
VF	8	0 - 0 - 0	27	91	27	31
DM	0	0 - 0 - 2	32	56	24	29
PN	2	1 - 1 - 1	29	83	27	38
JW	4	0 - 0 - 2	29	90	29	34
Mean	4.8	0.5 - 0.3 - 1.7	32.8	82.8	29.8	32.8
Controls (n = 8)	20.6	6.0 - 7.6 - 8.9	71.0	97.0	41.1	38.1

Note. The diagram recall score is based on delayed (12 min) reproduction of the Rey-Osterrieth figure (Osterrieth, 1944; maximum score = 36). The average score for copying the figure was 27.4, a normal score (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 percentage of words recalled out of 15 across five successive study-test trials (Rey, 1964). The word recognition score is the percentage of words identified correctly across five successive study-test trials (yes/no recognition of 15 new words and 15 old words). The score for words and faces is based on a 24-hour recognition test of 50 words and 50 faces (modified from Warrington, 1984; maximum score = 50, chance = 25). The mean scores for normal subjects shown for these tests are from Squire and Shimamura (1986). Note that patient NA is not severely impaired on the two nonverbal memory tests because his brain injury is primarily left unilateral.

Procedure

Each subject participated in a total of 12 independent study-test conditions (six recall and six recognition conditions) during an 18-month period. The average interval between the completion of one condition, that is, the test session, and the study session for the next condition was 20 days (minimum interval = 1 day). No study-test sequences were ever scheduled within other study-test intervals. The order of conditions was random with the constraint that the two test measures (recall and recognition) and the six retention intervals were distributed evenly across the 12 study-test conditions. For each study list, subjects were instructed to read aloud each word and to attend to the words because a memory test would later be administered. Neither the nature of the memory test nor the length of the retention interval was specified. Words were presented individually at a rate of 5 s per word. Following the final word in the list, a 15-s distraction task was administered (counting backward by 2). Subjects were then scheduled for testing at the specified retention interval or were tested immediately following the distraction task in the case of the 15-s retention interval. For tests of free recall, subjects were asked to report as many of the words from the list as they could remember and they were given 3 min to do so. For tests of recognition memory, subjects were asked to determine, for each of 20 word pairs, which one had been presented in the study list. Word pairs were printed side by side on a single sheet of paper, and target and distractor items were distributed evenly between left and right choices. For each recognition response, subjects were also asked to rate how confident they were of their choice. A 5-point scale for responses was printed on a card and placed at the top of the answer sheet. The scale ranged from 1 (*pure guess*) to 5 (*very sure*).

Results and Discussion

The data were analyzed first by comparing separately the patients with Korsakoff's syndrome to alcoholic control subjects and the non-Korsakoff amnesic patients to normal control subjects. The results from these two analyses were virtually identical and did not differ noticeably from the results when the two amnesic groups were combined and compared with the combined control groups. Therefore, to obtain increased statistical power, we present here the combined results for both groups of amnesic patients and control subjects. We also determined that the order in which the 12 test conditions were given had no effect on the results. Thus, for the 19 control subjects, performance was virtually the same on the first test given to each subject as on the last test given (mean scores = 53.9% and 50.3% words correct, respectively). For the 12 amnesic patients, the corresponding scores were 37.1% and 38.3% words correct, respectively. Thus, practice effects or interference effects did not operate across the 12 test administrations.

Figure 1 displays performance curves for amnesic patients and control subjects on the three measures: free recall, recognition memory, and confidence ratings for the recognition choices. The data for these three measures were analyzed with three separate analyses of variance (ANOVAs) that compared the amnesic patients and the control subjects at the four common retention intervals at which recall was tested (15 s, 10 min, 2 hr, and 1 day) and at the five common retention intervals at which recognition and confidence ratings were tested (15 s, 10 min, 2 hr, 1 day, and 2 weeks). Amnesic patients performed more poorly than control subjects on the recall tests, $F(1, 29) = 33.1$, $p < .001$, $MS_e = 540.4$, and on the recognition tests, $F(1, 29) = 84.5$, $p < .001$, $MS_e = 229.6$, and they were also less confident of their recognition responses, $F(1, 29) = 26.9$, $p < .001$, $MS_e = 1.4$. For both groups, recall and recognition memory performance declined

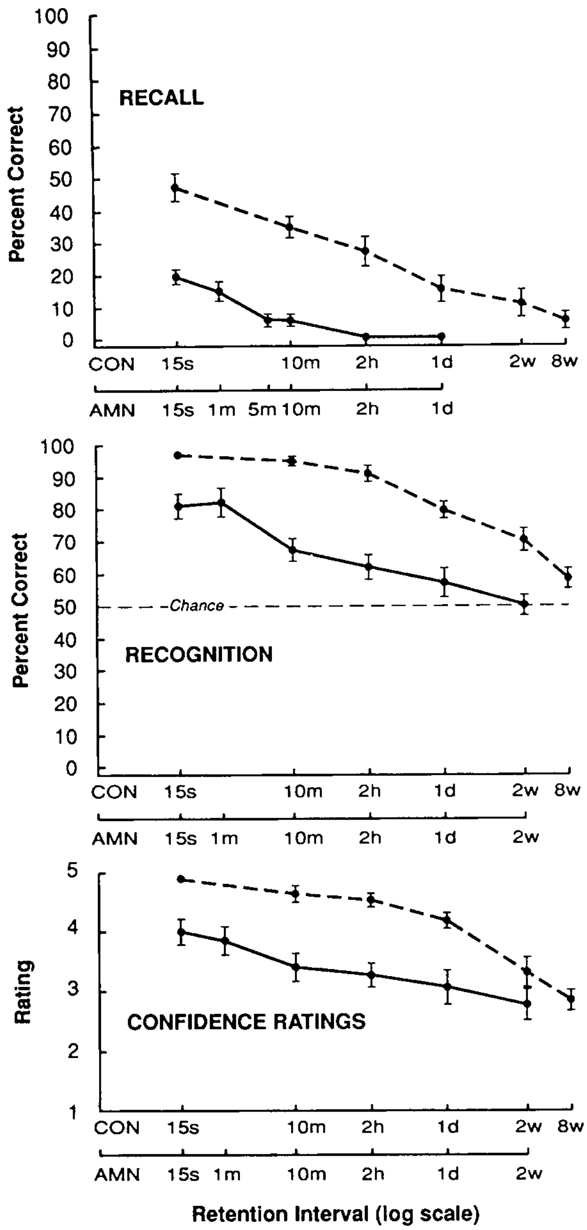

Figure 1. Performance of patients with amnesia (AMN; n = 12, solid lines) and control subjects (CON; n = 19, dashed lines) on tests of free recall (upper panel) and recognition (2-alternative, forced-choice; middle panel). (Memory for different 20-word lists was tested at each of the indicated retention intervals. The bottom panel shows confidence ratings [5-point scale: 1 = *pure guess* to 5 = *very sure*] for the correct answers on the recognition test at each retention interval. Control subjects were tested at relatively long intervals after learning so that their performance could be evaluated at a time when it was as poor as the performance of amnesic patients. Error bars indicate standard error of the mean [SE_M]. No error bar indicates $SE_M < 2\%$.)

significantly as a function of retention interval, and subjects became less confident in their recognition responses as the retention interval increased, $Fs(1, 29) > 32.0$, $ps < .001$. There was also a significant interaction of Group × Retention Interval for recall, $F(1, 29) = 3.2$, $p < .05$, $MS_e = 102.2$, indicating that the difference between groups was smaller at the longer retention intervals. This interaction was probably due to floor effects at the long retention intervals. There was no significant Group × Retention Interval interaction for the recognition test, $F(1, 29) = 1.8$, $p > .10$, $MS_e = 108.6$, but there was a significant interaction in the case of confidence ratings, $F(1, 29) = 2.6$, $p < .05$, $MS_e = 0.2$. Again, the interaction may be attributed to floor effects at longer retention intervals (subjects tended not to use the lower part of the rating scale). Indeed, amnesic patients and control subjects did not differ in their confidence ratings at the 2-week retention interval, $F(1, 29) = 2.2$, $p > .10$, $MS_e = 1.0$.

To match performance of control subjects and amnesic patients, we next shifted the forgetting curves of the amnesic patients to the right until a point was reached where the level of recognition memory performance for the amnesic patients was comparable with that of control subjects. Figure 2 shows that when recognition scores were matched for the two groups in this way, recall scores and confidence ratings also matched. Thus, the scores of control subjects tested 1 day and 2 weeks after learning matched the scores of amnesic patients who were tested 15 s, 1 min, and 10 min after learning. The mean scores for control subjects for the 1-day and 2-week retention intervals were 74.9% for recognition, 13.4% for recall, and 3.8 for confidence ratings. For amnesic patients, the mean scores for recognition, recall, and confidence ratings for the 15-s, 1-min, and 10-min retention intervals were 76.8%, 11.6%, and 3.8, respectively. When performance was matched in this way, a Group × Test (recall and recognition) ANOVA revealed no significant two-way interaction ($F < 1.0$). This finding does not support the hypothesis that recall and recognition are disproportionately affected in amnesia. Indeed, it was not possible to match the recognition scores of the two groups at any point and to find a significant difference in recall scores. (This was true despite the fact that the average recall scores of the control subjects at the long retention intervals [>10 min] were increased by the markedly superior performance of 1 subject suspected of keeping notes whenever the retention interval permitted him to leave the test area.)

The absence of a significant difference between the recall scores of the two groups after the recognition test scores had been matched was not due to a lack of statistical power. Indeed, a disproportionate sparing of recognition memory (i.e., a significant Group × Test interaction of recall and recognition scores, $p < .05$) would have been detected in this experiment if the control subjects had performed only 6.5% better on the recall test (about one additional word recalled on average) or if the amnesic patients had performed 6.8% worse on the recall test. A more formal consideration of statistical power indicated that in this experiment the probability was .79 of detecting a difference between the mean recall scores of amnesic patients and normal subjects (assuming that the recognition scores matched and that the difference between the recall scores in the two populations was as large as one standard deviation of the normal subject recall scores) (Cohen, 1969; Kirk, 1968).

Another way to evaluate the functional relationship between recall and recognition measures is to construct a state-trace plot (Bamber, 1979). In state-trace plots, the recall and recognition scores for a subject group at a given retention

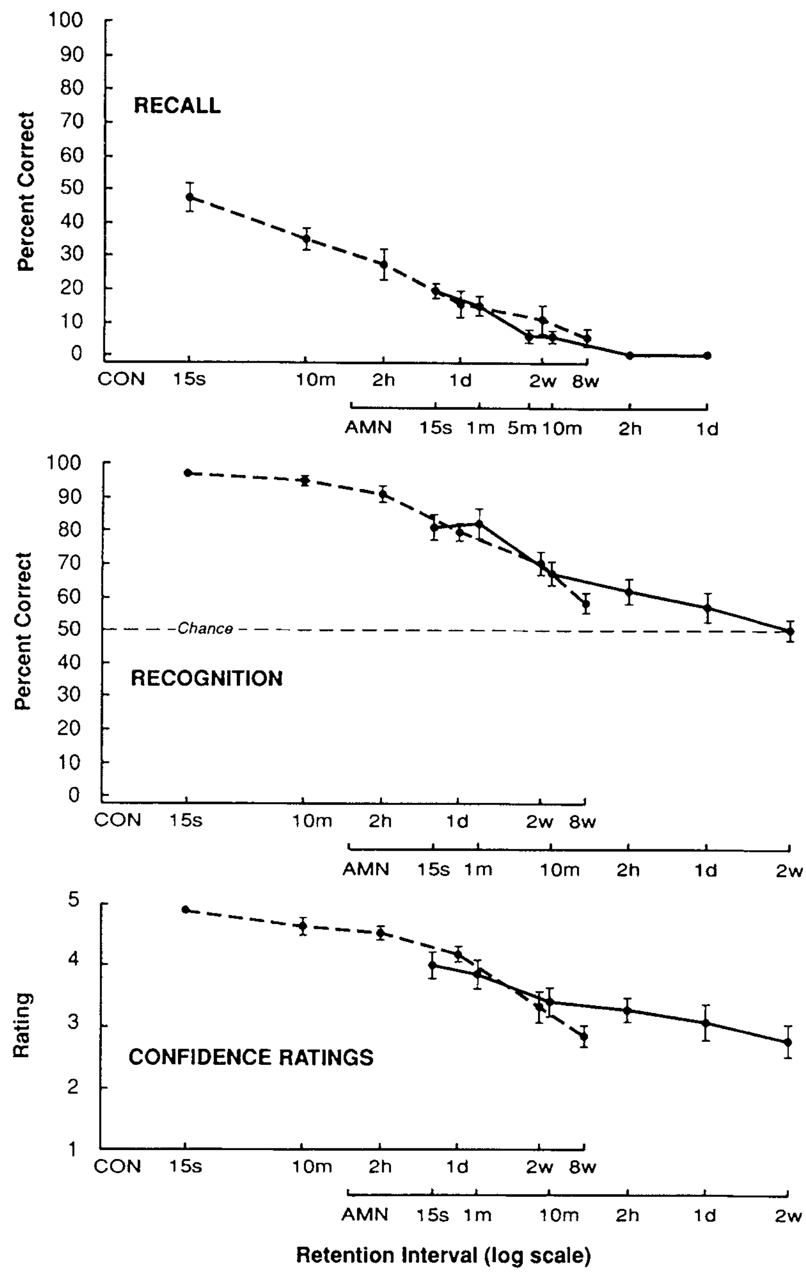

Figure 2. The curves from Figure 1 have been redrawn such that the performance of amnesic patients (AMN; solid lines) on the recognition tests (middle panel) approximately equaled that of control subjects (CON; dashed lines). (The scores of amnesic patients tested 15 s, 1 min, and 10 min after learning matched the scores of control subjects tested 1 day and 2 weeks after learning. When the recognition test scores matched, the performance curves for free recall [top panel] and confidence ratings [bottom panel] also matched. Error bars indicate standard error of the mean [SE_M]. No error bar indicates SE_M < 2%.)

interval are used as *x*-*y* coordinates. Figure 3 displays a state-trace analysis for the 11 mean scores for which the same retention interval was used to test recall and recognition performance (five mean scores were available for amnesic patients and six for control subjects). When one data point for control subjects in Figure 3 was excluded because of a ceiling effect for recognition scores, both the linear slopes and the intercepts for the two groups of points were virtually identical, $t(29) < 1.0$, $p > 0.1$. Thus, the points align themselves well along a single monotonically increasing function, indicating that the recall and recognition data obtained from amnesic patients and control subjects can be expressed succinctly as a quantitative change along a single dimension. This same conclusion was reached in an earlier study by

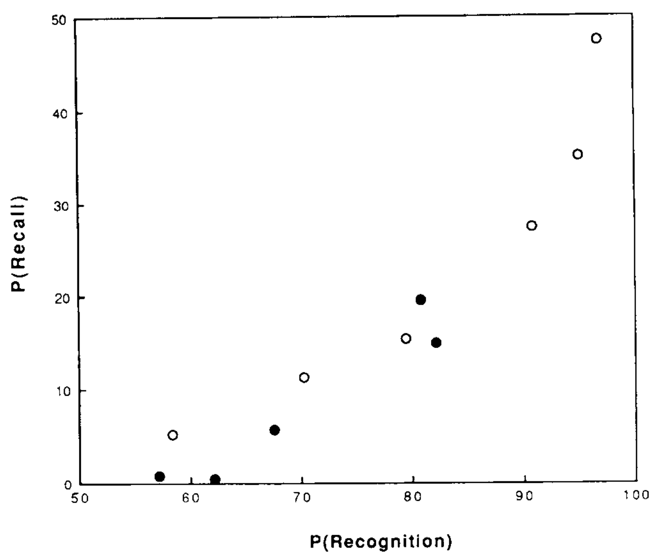

Figure 3. State-trace plot showing the probability of recall as a function of the probability of recognition. (Mean scores were plotted for amnesic patients [filled circles] and for control subjects [open circles] in the 11 cases in which both recall and recognition memory were assessed at the same retention interval. The points appear to align themselves along a single monotonically increasing function.)

Bamber (1979). A similar analysis was recommended by Dunn and Kirsner (1988).

To analyze further the relationship between recall and recognition, the amnesic patients were divided into two subgroups to determine whether the severity of amnesia affected the results. Two subgroups of 6 amnesic patients each were identified according to their performance on the Verbal Index of the WMS-R. (The results that follow were identical when other measures were used to identify two subgroups of amnesic patients on the basis of the severity of their amnesia, e.g., the General Memory Index and the Delayed Memory Index of the WMS-R.) The less impaired subgroup of amnesic patients had a mean score of 82.8 on the WMS-R Verbal Index, and the more impaired subgroup had a mean score of 66.3 (normal population M = 100, SD = 15). As would be expected, the recognition scores of each subgroup matched the recognition scores of normal subjects at different retention intervals. For the less impaired amnesic patients, the recognition scores obtained from 15 s to 10 min after learning matched the scores of normal subjects tested from 2 hr to 2 weeks after learning. For the more impaired patients, the scores obtained from 15 s to 10 min after learning matched the scores of normal subjects tested from 1 day to 8 weeks after learning.

The important finding was that when the recognition scores of each subgroup of amnesic patients were matched to control scores, the recall scores and the confidence ratings also matched. Thus, for the less impaired amnesic patients, the mean scores for recall, recognition, and confidence ratings for the 15-s, 1-min, and 10-min retention intervals were 14.0%, 80.0%, and 3.7, respectively. For the 2-hr, 1-day, and 2-week retention intervals, control subjects averaged 18.1%, 80.2%, and 4.0, respectively. For the more impaired patients, the corresponding scores for the 15-s, 1-min, and 10-min retention intervals were 9.2%, 73.6%, and 3.9, respectively. For the 1-day to 8-week retention intervals, control subjects averaged 10.7%, 69.4%, and 3.4 on these three measures, respectively (in all cases, group main effects and Group × Test interaction Fs < 1.0). Thus, just as with the amnesic group as a whole, a proportionate impairment of recall and recognition was found in both the less severely impaired and the more severely impaired patients.

Experiment 2

Experiment 1 found no evidence for disproportionately impaired recall performance in amnesic patients when the patients and their control subjects were matched on recognition performance. Nevertheless, two previous reports did conclude that recall can be disproportionately impaired in human amnesia (Hirst et al., 1986; Hirst, Johnson, et al., 1988). There were several differences between the methods used in Experiment 1 and the methods used by Hirst et al. (1986) and Hirst, Johnson, et al. (1988). First, the earlier authors tested a group of 7 memory-impaired patients with mixed etiologies. With the advantage of recent neuroimaging technology, we were able to study 6 patients with Korsakoff's syndrome and 6 non-Korsakoff amnesic patients who in all but 2 cases had confirmed and quantified damage to either the diencephalic midline or the hippocampal formation. Second, in the earlier studies, recall and recognition were evaluated at only a single performance level. An important feature of our experiment was that we were able to evaluate performance across a range of different levels. That is, we compared performance curves, not single points on a performance curve.

One of the two earlier studies (Hirst, Johnson, et al., 1988) used the same approach as ours to equate the performance of control subjects and amnesic patients at the single point at which they were compared, that is, control subjects were tested at a long retention interval. In addition to the two points just noted, this study differed from ours in four other respects. First, the earlier study (Hirst, Johnson, et al., 1988) used a 30-item word list and presented words at a rate of 8 s per word, whereas we used a 20-item word list and presented words at a rate of 5 s per word. Second, in the earlier study, recall and recognition memory were assessed during the same study-test trial, with the recall test preceding the recognition test. We tested recall and recognition separately in independent study-test trials. Third, in the earlier study, the words used as targets and distractors in the recognition test were not counterbalanced across subjects. In our study, a word was equally likely to be used as a target or distractor item across subjects. Finally, Hirst, Johnson, et al. (1988) administered a 30-s distraction task to their amnesic patients following word presentation, and the memory test occurred immediately after the distractor task. Control subjects were tested after a 24-hr retention interval and were not administered a distraction task. We administered a 15-s distraction task after word presentation to both amnesic patients and control subjects in every study-test condition. Because of these several methodological differences, we next attempted to study recall and recognition performance in amnesia using exactly the same experimental procedure that was used in the earlier study (Hirst, Johnson, et al., 1988).

Method

Subjects

Amnesic patients. Eleven of the 12 amnesic patients that participated in Experiment 1 were tested (all but GD).

Control subjects. Eighteen subjects served as the control group for the amnesic patients, 8 abstaining alcoholic subjects (5 men and 3 women) and 10 healthy subjects (7 men and 3 women). Five of these 18 subjects had also participated in Experiment 1. All the subjects were identified by the same methods used in Experiment 1. The alcoholic subjects reported an average drinking history of 20 years (range: 3 to 35 years) and had abstained from alcohol for an average of 3.4 years (range: 0.2 to 7.0 years). The 18 control subjects were matched to the amnesic patients with respect to age (54 years), years of education (14 years), and scores on the Information and Vocabulary subtests of the WAIS-R (control subjects = 21.0 and 55.5, respectively; amnesic patients = 20.4 and 55.5, respectively). Immediate and delayed (12 min) recall of a short prose passage averaged 7.4 and 6.1 segments, respectively.

Materials

Two lists of 30 unrelated words each were randomly assembled from 60 one-syllable and two-syllable nouns as described by Hirst, Johnson, et al. (1988). Each word was four to nine letters long and had a rated frequency greater than 20 occurrences per million, M = 106 (Kucera & Francis, 1967). All of the words were different from the ones used in Experiment 1. The words were printed in 18-point, uppercase block letters on 3 in. × 5 in. index cards. The order of the words within each list was random.

A two-alternative, forced-choice recognition test was constructed for both lists. Distractor words were selected from the same pool of words as the target words, as described by Hirst, Johnson, et al. (1988). The word pairs (target and distractor words) were printed side-by-side on 3 in. × 5 in. index cards as just described. Target words were evenly distributed between left and right choices. A confidence rating scale for responses was printed on a separate card and placed in front of the subject. The scale ranged from 1 (*pure guess*) to 5 (*very sure*).

Design and Procedure

Subjects were informed before the study that they would be participating in a memory experiment and that they should read aloud each word presented to them. Subjects were then shown a list of 30 words (8 s per word). Immediately after reading the final word in the list, the amnesic patients counted backward by 3 for 30 s. Control subjects were given no distraction procedure. Following the distraction period, the amnesic patients were allowed 3 min to recall as many items from the list as possible. Immediately after the free recall test, they were tested for two-alternative, forced-choice recognition and asked to rate their confidence for each response on the 5-point scale. Control subjects received the same two tests after a 1-day delay. All subjects participated in two study-test sessions, separated by 7 days, and the scores for the two tests were averaged together for data analysis.

Results and Discussion

As in Experiment 1, the data for Experiment 2 were analyzed first by comparing the findings for patients with Korsakoff's syndrome to the findings for alcoholic control subjects, and similarly for non-Korsakoff amnesic patients and normal control subjects. Again, the results from the separate analyses were virtually identical to the results obtained when both amnesic patients and control groups were considered together. Accordingly, the results presented here compare all 11 amnesic patients and all 18 control subjects. The amnesic patients matched the control subjects on the recognition test (74.7% and 79.1%, respectively; SE_M = 2.5% and 2.2%, respectively; $t[27] = 1.3$, $p > .20$). The amnesic patients and the control subjects also gave similar confidence ratings for their recognition judgments (3.5 vs. 4.1). The important finding was that the amnesic patients scored similarly to control subjects on the test of free recall (10.5% ± 2.2 and 15.6% ± 3.1, respectively; $t[27] = 1.2$, $p > .20$). Thus, we did not replicate the findings from the earlier study (Hirst, Johnson, et al., 1988). In our study, amnesic patients exhibited a recall impairment commensurate with their recognition impairment. In the earlier study, amnesic patients and control subjects scored 85% and 86%, respectively, on the recognition test and 6% and 22%, respectively, on the recall test.

The different findings in these two studies do not appear to reflect differences in the severity of amnesia in the two patient groups. One traditional method of assessing the severity of amnesia is to compare the difference in scores obtained on the Wechsler Adult Intelligence Scale (WAIS) with the scores obtained on the Wechsler Memory Scale (WMS). These scores were available for 10 of the 11 patients whom we tested in Experiment 2 (mean difference score = 26.5 ± 2.2) and for 4 of the 6 patients tested in the earlier study (mean difference score = 31.2 ± 4.7). (The scores for these patients were obtained from three sources: Hirst, Phelps, Johnson, & Volpe, 1988, and Volpe & Hirst, 1983a, 1983b.) The severity scores of our patients and the 4 patients in the earlier study were not measurably different, $t(12) = 1.1$, $p > .20$. Another way to compare the two groups of patients is to note that the recognition scores for the patients in Experiment 2 were significantly lower than the recognition scores obtained by the patients tested in the earlier study (74.7% ± 2.2 vs. 85.5% ± 3.0, $t[15] = 2.4$, $p < .05$). The difference between the two studies was that our patients performed better on the recall test, though not significantly so (10.5% ± 2.2 vs. 6.1% ± 1.0; $t[15] = 1.4$, $p > .10$).

In summary, we have attempted to reproduce as closely as possible the conditions of one of two previous reports in which recall was considered to be disproportionately impaired in amnesia (Hirst et al., 1986; Hirst, Johnson, et al., 1988). According to the hypothesis that recall is disproportionately impaired in amnesia, our patients should have performed at least as poorly on the recall test as the previously studied patients, but this result was not obtained. However, it should be noted that our results are directly relevant only to one of two earlier studies and do not address directly experiments in which the recognition scores of amnesic patients and control subjects were equated by giving the amnesic patients more exposure to stimulus material (Hirst et al., 1986).

Other subject factors, such as differences in the locus of pathology and differences in the pattern of cognitive deficits that are present in addition to memory, might be important in understanding the different findings in the two studies. In the study by Hirst, Johnson, et al. (1988), 3 of the 6 patients had amnesia resulting from a ruptured anterior communicating artery aneurysm, a condition known to produce personality change and flatness of affect, which are signs of frontal lobe dysfunction (Volpe & Hirst, 1983a). When sensitive measures of recall and recognition are used (e.g., multiple study-test trials using the same test material), patients with frontal lobe lesions can exhibit a significant impairment in recall performance, despite normal recognition performance (Janowsky, Shimamura, Kritchevsky, & Squire, 1989). If frontal lobe damage were otherwise present in patients who were amnesic, recall might be impaired relative to recognition.

General Discussion

The striking similarity of recall, recognition, and confidence ratings in both amnesic patients and normal subjects during the course of forgetting suggests that these measures of memory function are equivalently affected in amnesia. The findings do not support the view that either recognition memory or confidence ratings are significantly supported by processes that are intact in amnesia, for example, nonconscious memory processes that rely on increased facility of perceptual processing. The crucial evidence was that, despite the fact that priming and other forms of implicit (nondeclarative) memory are entirely normal in amnesia, the recognition judgment of amnesic patients, and the confidence ratings attached to these judgments, were no better than what would have been predicted from the level of recall. Additional evidence for the same conclusion (i.e., that implicit memory need not support recognition memory) was obtained in an earlier study of patients receiving electroconvulsive therapy, in which chance levels of recognition performance were observed in the presence of fully intact word completion priming (Squire, Shimamura, & Graf, 1985).

Several recent studies of normal subjects also suggest that recognition memory need not always benefit from priming or perceptual fluency (Hayman & Tulving, 1989; Watkins & Gibson, 1988). Johnston, Hawley, and Elliott (1991) concluded that perceptual fluency can sometimes contribute to recognition memory but that its contribution diminishes with increasing availability of explicit, conscious memory. The present findings show further that even in a condition in which explicit memory is minimally available, that is, in amnesia, perceptual fluency need not contribute to recognition performance. Finally, in normal subjects, brief exposure to stimuli can alter judgments and preferences about the stimuli, presumably as a result of priming, without producing above-chance performance on conventional tests of recognition memory (Bonanno & Stillings, 1986; Kunst-Wilson & Zajonc, 1980; Mandler, Nakamura, & Van Zandt, 1987; Seamon, Brody, & Kauff, 1983; Seamon, Marsh, & Brody, 1984). Thus, in these cases explicit memory was also minimal, yet recognition performance did not benefit from the processes that support priming.

Studies with positron-emission tomography (PET) have shown that the processing of words activates posterior brain regions thought to be important in feature analysis and the analysis of word forms (Petersen, Fox, Snyder, & Raichle, 1990). It has been suggested that perceptual priming reflects changes within one or more of these early-stage perceptual processing systems (Musen, Shimamura, & Squire, 1990; Musen & Squire, 1991; Musen & Treisman, 1990; Schacter, 1990; Schacter, Cooper, & Delaney, 1990), with the result that recently encountered words are perceived with greater facility than novel words. Direct evidence for this view has recently been obtained in a PET study of priming in normal human subjects (Squire et al., 1992). During a priming condition, when recently presented stimuli were presented for processing, a region of right posterior cortex was less active than in a baseline condition when all the stimuli were novel. Thus, for a period of time following the presentation of new material, less neural activity may be required to process the same stimuli. This finding is consistent with the idea that priming occurs prior to and independently of the neural events subserving conscious recall and recognition of previous encounters.

The relationship between recall and recognition memory observed for amnesic patients in the present study might seem surprising if amnesia is presumed to reflect a total loss of declarative (explicit) memory. That is, why should amnesic patients exhibit any recall or recognition? Yet, amnesic disorders rarely, if ever, result in a complete absence of memory function. Even the well-known, severely amnesic patient HM exhibits some residual declarative memory (Milner, Corkin, & Teuber, 1968). Indeed, the finding of residual memory ability (e.g., on a test of recognition or cued recall) is the typical finding in amnesia. The question of interest in the present experiments was to what extent, if any, differences could be detected in amnesia among several dependent measures of memory (recall, recognition, and confidence ratings).

It should also be clear that the mere presence of residual memory performance in amnesia does not by itself demonstrate differences among performance measures nor does it demonstrate that a qualitatively distinct kind of memory has been revealed. In the case of amnesia, the best evidence for a qualitatively separate kind of memory comes from the finding of entirely spared performance (for further discussion, see Shimamura, 1990). Indeed, it can be difficult to distinguish between residual declarative memory capacity and nondeclarative memory in performance tests in which both may play a role (e.g., in the case of priming of new associations or cued recall) (Shimamura & Squire, 1988, 1989). Comparisons of forgetting curves, as was done in Experiment 1, can help to distinguish quantitative effects on performance from qualitative effects.

In summary, recall and recognition were similarly impaired in amnesic patients with hippocampal or diencephalic damage. In addition, the confidence ratings for recognition responses made by amnesic patients were commensurate with their recognition performance. The findings for confidence ratings indicate directly that amnesic patients do not always claim that their recognition responses are simply guesses. Recall, recognition, and confidence ratings appear to be tightly linked functions of declarative memory and similarly dependent on the brain system damaged in amnesia. This conclusion is not inconsistent with the possibility that other brain systems are differentially involved in recall and recognition memory. For example, selective damage to the frontal lobe can affect recall performance more than recognition performance (Janowsky et al., 1989; Jetter, Poser, Freeman, & Markowitsch, 1986). Recall may be disproportionately impaired in patients with frontal lobe lesions because of deficient search strategies that are more important for free recall than recognition. At the same time, frontal lobe damage may need to be substantial to observe this effect. Five of the 6 patients with Korsakoff's syndrome in the present study had participated in an earlier study that identified frontal lobe atrophy in this etiological group (Shimamura et al., 1988), but these patients did not have more difficulty with recall than recognition.

The present results do not rule out the possibility that perceptual fluency or other implicit memory processes may sometimes contribute to recognition performance, either in normal subjects or amnesic patients. However, the results provide strong evidence that such a contribution is not always a component of recognition memory. The results further suggest that implicit memory does not ordinarily contribute to performance in the typical recognition memory test. Thus, in a real-world situation in which material is relatively familiar (i.e., performance is well above chance) and decision time is uncontrolled, recognition performance may draw little benefit from implicit memory. Perceptual fluency can be present and influence the detection and identification of recently encountered stimuli, but it may not materially contribute to conventional measures of recognition performance.

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