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Effect of Spaced Repetitions on Amnesia Patients' Recall and Recognition Performance

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This study examined the effects of repetition and spacing of repetitions on amnesia patients' recognition and recall of a list of words. Like controls, amnesia patients recognized items better when repetitions were spaced compared with when they were massed. This finding was attributed to the additional rehearsal that distributed presentations typically encourage. Amnesia patients also showed normal spacing effects in a recall task, suggesting that they were able to benefit from the variable encoding that spaced repetitions allow to establish additional retrieval cues. However, even though instructions to encode repeated items in a variable manner enhanced massed presentations to the point where spacing no longer produced an advantage for the normal controls, it did not have a similar effect for the amnesia patients. This led to the conclusion that amnesia patients cannot take advantage of strategically provided opportunities to enhance their variable encoding of interitem associations. Instead, it is suggested that the automatic activation of different aspects of items and interitem associations is responsible for the spacing effect in their recall.

The ability of amnesia patients to demonstrate enhanced performance on the second occurrence of an item has been investigated extensively in the context of implicit memory tasks. Beneficial effects of repetition have been demonstrated on tasks of perceptual identification (Cermak, Talbot, Chandler, & Wolbarst, 1985; Haist, Musen, & Squire, 1991), stem and fragment completion (Graf, Squire, & Mandler, 1984; Warrington & Weiskrantz, 1970), and lexical decision (Moscovitch, 1992; Verfaellie, Cermak, Letourneau, & Zuffante, 1991). Indeed, amnesia patients' intact repetition priming in the face of severely impaired recognition or recall of the same stimuli has been a major source of evidence for the dissociation between implicit and explicit memory favored by many systems theorists (Cohen & Eichenbaum, 1993; Schacter, 1994; Zola-Morgan & Squire, 1992).

Less frequently cited are studies demonstrating that amnesia patients can also profit from repetition in explicit memory tasks (Huppert & Piercy, 1978; Strauss, Weingartner, & Thompson, 1985; Verfaellie & Cermak, 1994; Weingartner et al., 1993). The effects of repetition of a stimulus on amnesia patients' recall and recognition are usually overshadowed by the large differential in absolute performance between amnesia patients and matched controls. Nonetheless, the fact that amnesia patients benefit from repetition at all deserves further attention.

Among the first to explore the effect of repetition in amnesia in tests of explicit memory were Huppert and Piercy (1978) who found that amnesia patients demonstrated better recognition for repeated pictures than they did for pictures that were presented only once. Because of ceiling effects in the performance of controls, however, it was impossible to ascertain whether the magnitude of the repetition effect was normal in amnesia patients. Using a recall rather than a recognition test, Strauss et al. (1985) reported that an increase in the number of times an item was repeated had a parallel effect on the recall performance of Korsakoff amnesia patients and controls, thus suggesting that the repetition effect was entirely normal. However in a more recent study, the recall performance of Korsakoff patients benefited considerably less from repetition than did the performance of controls (Weingartner et al., 1993). Consequently, the question as to whether amnesia patients demonstrate normal repetition effects remains unresolved in both recall and recognition tasks.

An interesting side observation made by Huppert and Piercy (1978) was that although the performance of the amnesia patients improved with repetition, they were totally unable to state which pictures had been repeated. Likewise, in the study by Strauss et al. (1985), the amnesia patients were unable to judge the frequency with which the items had been presented. Thus it appears that amnesia patients can demonstrate repetition effects in explicit memory, even in the absence of awareness of an item's repetition.

We (Verfaellie & Cermak, 1994) also have found that repetition facilitates amnesia patients' recall, albeit less so than for controls, and discovered yet another indication that memory for the individual presentations of items is very poor. We used a task in which the repeated items were printed in different colors and found that amnesia patients' recall of these individual colors was extremely weak, yet their recall of

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repeated items still exceeded that of nonrepeated items. From this, and the small set of investigations presented above, we concluded that amnesia patients profit from repetition on explicit memory tasks but are unaware of this increase and cannot even reconstruct the fact that items have been repeated.

To explore further the mechanisms that might contribute to the effects of item repetition on amnesia patients' explicit memory performance, in the present study we compared the effects of massed versus distributed practice. In normal subjects, it has often been demonstrated that when repeated items are spaced during presentation, performance is better then when the repetitions occur on adjacent trials (Hintzman, 1974; Melton, 1970). Theories proposed to explain these spacing effects have generally been assigned to two categories, deficient processing theories and encoding variability theories (Greene, 1989). Deficient processing theories propose that presentation of items in massed fashion results in impoverished processing. When an item is repeated immediately, it will appear more fluent upon its second presentation, and consequently, it will receive less rehearsal (Rundus, 1971). In contrast, when repetitions of items are spaced, the item will only be slightly fluent on its second presentation and consequently it will receive additional processing (Begg & Green, 1988). According to this view, then, the major difference between items presented in a massed and spaced manner lies in the amount of rehearsal they receive. On the other hand, encoding-variability theories stress the number of different ways in which an item can be encoded. Two presentations of an item are more likely to be encoded distinctively when they are spaced than when they are adjacent to one another. This occurs because different features of an item are more likely to be processed under spaced presentation conditions. In addition, associations with neighboring items are formed during encoding. Spaced repetitions of an item allow for the formation of many different interitem associations, whereas massed repetitions of an item will likely be associated with the same items. Consequently, a greater number of cues will be available to the subject at the time of retrieval for spaced items than for items presented adjacent to one another (Glenberg, 1979).

Although it is likely that the amount of rehearsal and the variability of encoding both contribute to the spacing effect, they may do so differently depending on the experimental situation (Greene, 1989). Because recall is sensitive to interitem associations and contextual cues, spacing effects in recall tasks are thought to be due mostly to encoding variability. On the other hand, in tasks such as recognition or cued recall, cues are provided by the experimenter, so processing of item information itself is considered to be more important than the presence of internally generated retrieval cues.

This interpretation of spacing effects can provide a new approach to the study of the effects of repetition on amnesia patients' explicit memory performance. Given that amnesia patients seem to be less capable of elaborative processing than normal subjects (Cermak, Butters, & Moreines, 1974; Cermak & Reale, 1978), we hypothesized that they would process fewer aspects of stimuli and form fewer associations with neighboring items. Consequently, they ought to be less sensitive to the effects of spacing in a recall task. On the other hand, given amnesia patients' ability to maintain or continuously reinstate their processing when not disrupted (Cermak, Naus, & Reale, 1976; Milner, 1970), we felt that amnesia patients would show normal spacing effects in a recognition task. Experiment 1 was designed to examine amnesia patients' performance in a recognition memory task in which items were presented either once or twice, with the repeated items presented either on adjacent trials or separated by five intervening items.

Experiment 1

Method

Participants. Four groups participated in this experiment. The first group consisted of 6 male amnesia patients, all of whom were alcoholic Korsakoff patients residing at various private care facilities in the greater Boston area. All had histories of chronic alcoholism, were unable to recall day-to-day events, were disoriented to time and place, and had retrograde amnesias of varying degrees. The mean age for this patient group was 62 years, and they had an average education of 11 years. The average Wechsler Adult Intelligence Scale—Revised (WAIS-R) Verbal IQ for this group was 96, Wechsler Memory Scale—Revised (WMS-R) Attention score was 99, General Memory score was 80, and Delayed Memory score was 57.

The control group for the Korsakoff patients consisted of 6 chronic alcoholic men living in private homes in the Boston area. None of these men evidenced any signs of neurological or psychiatric illness. All had abstained from alcohol for at least 4 weeks prior to testing. Their average age was 61 years, and the group had an average education of 14 years. The mean WAIS-R score for this group was 106, WMS-R Attention score was 104, General Memory score was 108, and the Delayed Memory score was 104.

The second amnesia group had 7 patients, 4 men and 3 women, with varying etiologies, all residing in private homes in the greater Boston area. Two patients in this group suffered from anoxia following cardiac arrest. Neuroimaging studies showed diffuse cortical atrophy and enlarged ventricles in 1 patient, but no noticeable structural damage was evident in the other patient. Two patients suffered from encephalitis, 1 of whom has been a subject of several single case studies (Cermak, 1976; Cermak & O'Connor, 1983). This patient has extensive bilateral damage to the medial and anterolateral temporal lobes. An MRI scan of the other patient with encephalitis also showed extensive damage to the medial temporal lobes. Of the 3 remaining patients in this group, 1 became amnesic following a bilateral medial thalamic infarction, confirmed by CT imaging. The second underwent surgery for a left hematoma following a head injury and subsequently became amnesic after an episode of status epilepticus. According to MRI scans, this patient had extensive tissue loss in the area of the left temporal lobe, including all of the anterior hippocampus, amygdala, and anterior efferent pathways. The last amnesia patient in this group suffered from a ruptured aneurysm of the posterior cerebral artery. Her amnesia was thought to be due partly to direct structural damage to the medial temporal region, partly to hypoxic ischemic injury from vasospasm. The mean age for this group was 43 years, with an average education of 15 years. Their mean WAIS-R score was 99, mean WMS-R Attention Score was 104, General Memory was 76, and Delayed Memory was 58.

The final group consisted of 7 normal adults who were matched in terms of age, WAIS-R Verbal IQ, education, and socioeconomic background to the mixed etiology amnesia group for whom they served as controls. These controls had a mean age of 42 years, with an average education of 14 years. Their mean WAIS-R Verbal IQ was 103.

Materials and design. Stimuli for this experiment consisted of 68 high-frequency nouns (125 to 500 per million) of four to six letters in length (Francis & Kucera, 1982). Thirty of these words were selected as targets to be studied, and another 30 were selected as distractors for a recognition test. The remaining 8 words were used as filler items. The assignment of stimuli to target or distractor conditions was counterbalanced across subjects. In the study list, 10 of the 30 words were repeated with five items intervening (Lag 5 condition), 10 were repeated with zero items intervening (Lag 0 condition), and 10 words were presented only once. In total, the study list consisted of 50 experimental items and eight fillers. Four of the fillers were placed at the beginning of the list and four at the end. To eliminate item effects, we counterbalanced the assignment of words to conditions across subjects. Thus, there were a total of six different presentation lists counterbalanced across all experimental conditions and across the distractor and target positions. The recognition test list consisted of 30 target items and 30 distractor items that were randomly intermixed.

Procedure. Participants were seated in front of a Macintosh IIcx computer and monitor for both the study and recognition phase of the experiment. In the study phase, a list of words was presented one at a time in the center of the screen. Each item was presented for 2 s and was followed by an interstimulus interval of 500 ms. They were asked to read each word aloud and to try and remember the words for a later memory test.

The recognition phase of the experiment followed a few minutes after completion of the presentation phase. Participants were shown a list of 60 words, one at a time, in the center of the computer screen. Each item was presented for a duration of 2 s. They were asked to make a yes or no recognition decision, indicating whether they thought the word currently on the screen had been presented earlier during the presentation phase ("yes") or had not been presented earlier ("no"). Telegraph keys connected to a Macintosh keyboard were utilized to record the responses. Participants used the index fingers of both hands to indicate their responses, pressing the right key to indicate a yes response and pressing the left key indicated a no response.

Results

Corrected recognition scores were computed for each participant by subtracting the proportion of false alarms from the proportion of hits in each of the three repetition conditions. Because preliminary analyses revealed no significant differences between the Korsakoff patients and mixed etiology amnesia patients or between the alcoholic and normal controls, the two amnesia groups were combined, as were the two control groups. Mean accuracy data for each group for each condition are presented in Table 1.

An analysis of variance (ANOVA) with group (amnesia or control group) as the between-subjects variable and repetition (nonrepeat, Lag 0, or Lag 5) as the within-subjects variable revealed a significant main effect of group, $F(1, 24) = 33.49$, $p < .01$, as well as repetition, $F(2, 48) = 14.18, p < .01$. The interaction of Group × Repetition was not significant.

To examine in more detail the effects of repetition and spacing, we performed several further analyses. To provide a conservative measure, these analyses used the interaction error term from the overall analysis (Keppel, 1982). First, to examine the overall effect of repetition, performance in the nonrepeat condition was compared with the mean of the two repeated conditions. This analysis revealed better recognition of repeated compared with nonrepeated items, $F(1, 24) = 12.29, p < .01$, an effect that was equivalent across the two groups. Second, to examine the effect of spacing, performance in the Lag 0 and Lag 5 conditions was compared. Words repeated after a lag of 5 were recognized significantly better than words repeated after a lag of 0, $F(1, 24) = 11.59, p < .01$. The Group × Lag effect again was nonsignificant, indicating that even though the amnesia patients' recognition performance was overall significantly lower than that of the controls, the effect of spacing was equivalent for both groups. Finally, an analysis of the Lag 0 and nonrepeat conditions revealed a marginally significant effect of repetition, $F(1, 24) = 3.29, p < .10$. This effect was clearly dampened by the amnesia patients' performance because simple effects indicated that controls benefited from immediate repetition of items, $F(1, 24) = 4.41$; $p < .05$, whereas amnesia patients did not.

Table 1
Corrected Recognition Scores as a Function of Repetition Condition

Group	Nonrepeat	Lag 0	Lag 5
Amnesia	.25	.27	.42
Control	.56	.67	.76

Discussion

The amnesia patients were as sensitive to the effects of repetition as were controls on this recognition task. Both groups recognized more repeated than nonrepeated items, and both groups performed better when repeated items were spaced than when they were presented adjacent to one another. Although amnesia patients' recognition memory was significantly impaired overall, the benefits of repetition and spacing were of equal magnitude for the two groups.

Most contemporary models of memory suggest that recognition can be based either on the intentional retrieval of information or on the automatic effect of fluency of processing (Jacoby, 1983; Mandler, 1980). We have previously demonstrated (Verfaellie & Treadwell, 1993) that when amnesia patients' recognition memory is impaired, it is primarily due to an impairment in their intentional retrieval. Their ability to profit from repetition might reflect a normal sensitivity to the automatic component. Repeated items may appear more fluent at the time of recognition than once presented items. Such a view would also explain the superiority of spaced over massed repetition if it is agreed, as deficient processing theories propose, that this difference is due to the amount of processing an item receives. Items presented on adjacent trials may elicit less overall processing relative to those that are spaced, hence the effect of spacing in recognition memory.

Increased processing following spaced repetitions may be sufficient to support amnesia patients' improved performance on a recognition task, but it seemed unlikely that it would be sufficient to support their performance on a free recall task. Most theorists (Glenberg, 1979; Greene, 1989; Hintzman, Summers, & Block, 1975) have agreed that some form of variable encoding is necessary to produce spacing effects in recall. Because amnesia patients' are unable to perform the elaborative processes that allow one to note new attributes of items and interitem relationships, we hypothesized that they would not show spacing effects on a free recall task. This hypothesis was directly tested in the next experiment.

Experiment 2

Method

Participants. The same Korsakoff and mixed etiology amnesia patients who participated in Experiment 1 participated in this experiment. One subject in the alcoholic control group was replaced because he was unavailable for testing. The newly constituted alcoholic control group had a mean age of 61 years, with a mean education of 14 years. Their overall mean WAIS–R Verbal IQ score was 107, their WMS–R Attention score was 101, General Memory was 106, and Delayed Memory was 102. The normal controls matched to the mixed etiology amnesia patients were identical to those of Experiment 1.

Materials and design. Stimuli for this experiment were 52 four-to-six letter nouns with frequencies ranging from 125 to 550 per million (Francis & Kucera, 1982). These words were different from those utilized in Experiment 1, but they shared a similar frequency range. Four word lists were constructed, each containing 13 words from the initial selection of 52 words. Within each list, three words were randomly assigned to a Lag 5 condition, a Lag 0 condition, and a nonrepeat condition. The remaining four words served as fillers, with two at the beginning of the list and two at the end. Therefore, each list consisted of a total of 19 items. Within each list, items were counterbalanced across the three repetition conditions. Thus, a total of 12 lists were created, with each participant receiving four of these lists.

Procedure. In the study phase of the experiment, participants were seated in front of a Macintosh IIcx computer and monitor. The list of words was presented to the participant with each word appearing in the center of the screen for 2 s followed by a 500-ms interstimulus interval. They were asked to read each word aloud and to try and remember the words because they would be receiving a memory test at a later time.

The recall phase of the experiment followed immediately upon conclusion of the study phase. Participants were given an answer sheet and were asked to record as many words as they could recall from the list just presented. They completed the recall phase in less than 10 min; if someone exceeded this period of time, the experimenter asked if the participant was finished, at which time it was necessary to stop work on the task. Participants were given two lists on the same day, each separated by at least 20 min. A second test session was administered to each patient at least 1 week later. During this second test session, each patient was shown and tested on the other two lists.

Results

For each participant, the proportion of words correctly recalled in each condition was computed across all four lists. Because there were no significant differences between the two amnesia groups or the two control groups, their data were again combined for all subsequent analyses. Mean accuracy data for each condition are presented in Table 2. An ANOVA performed on these data with group (amnesics or controls) as the between-subjects variable and Repetition (nonrepeat, Lag 0, and Lag 5) as the within-subjects variable revealed significant main effects of group, $F(1, 24) = 45.05, p < .01$, and repetition, $F(2, 48) = 25.72, p < .01$, as well as a marginally significant Group × Repetition interaction, $F(2, 48) = 2.54, p < .10$.

Table 2
Recall Accuracy as a Function of Repetition Condition

Group	Nonrepeat	Lag 0	Lag 5
Amnesia	.09	.14	.26
Control	.28	.45	.60

To further examine the effects of repetition, in our first analysis we compared performance in the nonrepeat condition to the mean of the Lag 0 and Lag 5 conditions. A main effect of repetition was obtained, $F(1, 24) = 27.65, p < .01$, as well as a marginally significant Group × Repetition interaction, $F(1, 24) = 3.64, p < .10$. Testing of simple effects indicated although both groups benefited from repetition, controls did so more than did the amnesia patients.

A second analysis focused on the effect of spacing. A robust effect of spacing, $F(1, 24) = 14.56, p < .01$, was obtained, with items repeated at a lag of 5 being recalled better than items repeated at a lag of 0. This effect did not interact with group, indicating that although amnesia patients performed more poorly than controls overall, they benefited from spacing between repetitions to the same extent as did controls.

A final analysis compared performance in the nonrepeat and Lag 0 condition. Across groups, a significant effect of repetition was obtained, $F(1, 24) = 11.23, p < .01$. Although the Group × Repetition interaction was not significant, testing of simple effects revealed that the advantage of items repeated at a lag of 0 over nonrepeated items was significant only for the controls, $F(1, 24) = 12.63, p < .01$.

Discussion

Two major findings emerged from this recall task. First, contrary to our hypothesis, amnesia patients demonstrated a significant spacing effect. Not only was their recall of words repeated after five intervening items superior to that of words repeated immediately, but the magnitude of this benefit was equivalent to that obtained for controls. Second, this spacing effect occurred in the context of an overall diminished repetition effect primarily because of the amnesia patients' impoverished performance when items were repeated immediately. The fact that amnesia patients demonstrated a spacing effect in recall of similar magnitude to that obtained in controls was unexpected. Greene (1989) proposed that encoding variability is necessary to explain the occurrence of spacing effects in free recall. On the basis of the dual assumption that variable encoding requires elaborative processing and that amnesia patients are not capable of this type of processing, we predicted that amnesics would not demonstrate a spacing effect in the current task because they have so consistently failed on other recall tasks that demand self-initiated elaboration. Now we either have to conclude that in the context of the present task, amnesia patients do elaborate on stimuli sufficiently to process them differently across presentations, or we must propose that variable encoding does not necessarily require intentional elaboration.

In deciding between these alternatives, we felt that it might be useful to directly manipulate encoding instructions given to participants. If the lag effect in controls is due to the fact that items repeated after a lag of 5 are elaborated on in more different ways than items repeated immediately, then it should be possible to eliminate the lag effect by guiding participants' encoding. We did so by instructing them to encode a different aspect of a stimulus upon each presentation. We hypothesized that by doing so, the effect of repetition should be maintained, as repeated items would receive more differential processing than nonrepeated items. However, the lag effect should be eliminated, as items repeated immediately and items repeated following a lag of 5 would be encoded under comparable encoding instructions. Of particular interest in this regard would be the amnesia patients' performance for items repeated following a lag of 0. In Experiment 2, their recall of immediately repeated items did not exceed that for nonrepeated items. If amnesia patients can benefit from differential elaboration, then guiding their encoding of immediately repeated items should boost their memory of these items above the level obtained for nonrepeated items and make it similar to that for items repeated following a lag of 5. On the other hand, if performance for immediately repeated items is not enhanced by the encoding instruction, then elaborative processing on the part of amnesia patients could not underlie the encoding variability thought to mediate spacing effects in recall. Rather, it would have to be proposed that encoding variability can arise in the absence of strategic, elaborate processing. To explore these possibilities, in Experiment 3 we tested the effects of variable encoding instructions during massed and spaced repetitions on the recall performance of amnesia patients and controls.

Experiment 3

Method

Participants. The same group of Korsakoff patients who had participated in the prior experiments also took part in the current experiment. Six alcoholic controls, drawn from the same general population described above, served as controls. Their mean age was 57 years, and they averaged 12 years of education. Their average WAIS–R Verbal IQ was 112, WMS–R Attentional score was 111, General Memory was 117, and Delayed Memory was 116.

The mixed etiology amnesia group was identical to that used in the prior experiment, except for the patient with a ruptured aneurysm of the posterior cerebral artery, who was unable to participate. The mean age of this amnesia group was 47 years, and they had an average education of 14 years. Their mean WAIS–R Verbal IQ was 107, their WMS–R Attention score was 106, General Memory was 80, and Delayed Memory was 60. Six normal subjects served as controls for the mixed etiology amnesia patients. They had a mean age of 46 years, with an average of 12 years of education. Their WAIS–R Verbal IQ was 106.

Materials and design. A new set of 104 nouns, four to six letters in length, with frequencies ranging between 100 and 493 per million (Francis & Kucera, 1982) was used as stimuli. Fifty-two items that were conducive to multiple graphemic queries were selected to be used in the graphemic encoding tasks, whereas 52 items that were conducive to multiple semantic queries were used in the semantic encoding tasks. The items to be used in each type of task were further subdivided into four lists of 13 words each. In each of these 13 item lists, three items were randomly assigned to the Lag 5 condition, three to the Lag 0 condition, and three to the nonrepeat condition. The assignment of stimuli to condition (Lag 5, Lag 0, and nonrepeat) was counterbalanced, creating a total of 12 possible lists for the graphemic tasks and the semantic tasks, respectively. The remaining four words in each list served as filler items, two at the beginning and two at the end of the list. Thus, each list contained a total of 19 items. All study lists thus created were matched in terms of word frequency and word length.

Procedure. The procedure in Experiment 3 was the same as in Experiment 2 except for two changes. During the study phase, the examiner asked the participant a question about each word as it was being presented. The question could be either graphemic or semantic, depending on the nature of the task being administered. Graphemic questions required that the participant make judgments about the physical characteristics of each word. One question required them to determine whether a word contained at least two closed letters; the other question required them to determine whether a word contained at least two ascenders (i.e., letters extending above the body of the word). For example, for the word *ball* the answer to both questions would be yes, as the word contains three ascenders and has two letters with closed components. Semantic questions required that the participants make decisions about the semantic properties of each word. One question required participants to determine whether a word referred to something pleasant; the other question required them to determine whether the word denoted an object that was alive. When an item was repeated within a list, the participant received two different queries of the same type, with the order of the queries counterbalanced across items. Importantly, the type of query (graphemic or semantic) was kept constant within a list.

The only other difference between this and the preceding experiment was that the presentation time for each item was increased to 3 s in order to give participants sufficient time to answer the question asked about each item. They were told to read the word silently and to provide a yes or no response to every question. Upon conclusion of the presentation of all words, the recall phase occurred immediately, and it followed the exact procedure of the previous recall experiment.

Testing was conducted in two sessions, separated by at least a week. Each test session consisted of the presentation of four study lists that were separated by at least 20 min. During each test session, participants received two graphemic and two semantic encoding tasks presented in alternating order. The type of encoding task presented first was counterbalanced across subjects.

Results

Data from each of the four lists were combined to compute an overall proportion of words correctly recalled in each condition for each participant. Again, because preliminary analyses revealed no significant differences between the two amnesia groups or the two control groups, the data from the two amnesia groups were combined, as were the data from the two control groups. Mean accuracy data for the two groups as a function of encoding and repetition are presented in Table 3.

Table 3
Recall Accuracy as a Function of Encoding and Repetition Condition

	Encoding		
Group	Nonrepeat	Lag 0	Lag 5
	Graphemic		
Amnesia	.02	.05	.07
Control	.19	.31	.40
	Semantic		
Amnesia	.05	.09	.14
Control	.35	.59	.62

An ANOVA with group (amnesics or controls) as the between-subjects variable and encoding (graphemic or semantic), and repetition (nonrepeat, Lag 0, or Lag 5) as the within-subjects variable revealed significant main effects of group, $F(1, 22) = 85.635, p < .01$, encoding, $F(1, 22) = 57.39$, $p < .01$, and repetition, $F(2, 44) = 31.87, p < .01$. A significant interaction between group and encoding, $F(1, 22) = 24.71, p < .01$, was also obtained, indicating that controls, but not amnesia patients, were affected by the level at which items were encoded. Finally, the interaction between group and repetition was also significant, $F(2, 44) = 10.85, p < .01$, and revealed that amnesia patients and controls responded differently to the effects of repetition.

To further examine the effects of repetition across encoding conditions, in our first analysis we compared performance in the nonrepeat condition to the mean of the two repeated conditions. Both the effect of repetition, $F(1, 22) = 41.8, p < .01$, and Group × Repetition, $F(1, 22) = 15.3, p < .01$, were significant. Analysis of simple effects indicated that the controls, $F(1, 22) = 53.9, p < .01$, showed a significant effect of repetition, whereas for amnesia patients, the effect was marginally significant, $F(1, 22) = 3.2, p < .10$.

A second analysis focused on the effects of spacing. A significant effect of spacing was obtained, $F(1, 22) = 5.7, p < .05$, indicating that participants recalled items repeated at a lag of 5 better than items repeated at a lag of 0. Although this effect did not interact with group, separate analyses were performed on the data of the amnesia patients and controls to test the a priori hypothesis that spacing effects differed across groups. In neither group did the effect of spacing reach significance.

Finally, comparison of performance in the Lag 0 and nonrepeat condition revealed a significant effect of repetition, $F(1, 22) = 27.8$, $p < .01$, as well as Group × Repetition interaction, $F(1, 22) = 12.8, p < .01$. Tests of simple effects indicated that only controls benefited from immediate repetition of an item, $F(1, 22) = 39.1, p < .01$.

Discussion

Directly manipulating the encoding of items in the study list had different effects on the performance of the amnesia patients and controls. First, the level at which information was encoded had a significant effect on the recall performance of controls in that semantically analyzed words were recalled better than graphemically analyzed words. However, this manipulation failed to affect amnesia patients' recall. This finding is consistent with previous studies demonstrating that amnesia patients fail to show a levels of processing effect in explicit memory tasks (Cermak, 1988; Cermak & Reale, 1978). Second and of more importance for the present discussion is the finding that amnesia patients also failed to benefit from encoding variability. When items repeated adjacent to one another were probed with two different encoding questions, amnesia patients' performance was no better than was performance for once presented items. This was true regardless of whether questions were directed toward graphemic or semantic characteristics of the words. In contrast, encoding variability had a beneficial effect on the performance of controls. Recall of immediately repeated items was significantly better than recall of nonrepeated items and was now equivalent to the level of recall obtained for items repeated following five intervening items.

The fact that for controls, instructions promoting variable encoding enhanced recall of immediately repeated items to the level of items repeated following five intervening items suggests that encoding variability may be the determining factor in their performance. When no instructions were given, as in Experiment 2, variable encoding may occur only with spaced repetitions; but with encoding instructions that focus subjects' analysis on different aspects of the stimuli, immediately repeated items receive the same encoding variability as items presented with spaced repetitions, hence, their equivalent level of recall. In contrast, amnesia patients did not benefit from variable encoding instructions. Their performance of immediately repeated items did not exceed that of once presented items, and the spacing effect that was presented in Experiment 2 was now absent. Taken together, these findings argue against the notion that the spacing effect that amnesia patients demonstrated in Experiment 2 was due to their ability to intentionally encode different aspects of the stimuli.

Before accepting this conclusion, however, it has to be acknowledged that amnesia patients' recall was extremely low across all conditions of this experiment. Instructions to analyze variable features of the words seemed to distract the amnesia patients rather than facilitate their performance. Recall was so low that the failure to observe repetition or spacing effects might simply have been due to floor effects. To rule out this possibility, in Experiment 4 we examined the effects of variable encoding instruction in a recognition task in which higher levels of performance might be expected. We hypothesized that if amnesia patients do not benefit from instructions that encourage encoding variability, their performance of immediately repeated items would not be enhanced by this manipulation. Furthermore, to the extent that such encoding disrupts their spontaneous rehearsal of stimuli, it might also eliminate the spacing effect obtained in Experiment 1.

Experiment 4

Method

Participants. The Korsakoff group consisted of 6 patients, 5 of whom had participated in the previous experiments. The mean age of the group was 64 years, and they had an average of 10 years of education. Their average WAIS-R score was 96, their WMS-R Attention score was 98, General Memory score was 81, and Delayed Memory was 58. A group of 6 chronic alcoholics selected from the same general population described above formed the control group for the Korsakoff amnesia patients. The alcoholic controls had a mean age of 57 years and averaged 12 years of education. Their mean WAIS-R score was 103, their WMS-R Attention score was 100, General Memory was 107, and Delayed Memory was 105.

The mixed etiology amnesia group consisted of the same patients who had participated in Experiments 1 and 2, with the exception of the patient with bilateral thalamic lesions, who was not available for testing. The mean age for this group was 46 years, and they averaged 16 years of education. Their mean WAIS-R Verbal IQ was 108, their WMS-R Attentional score was 107, General Memory was 79, and Delayed Memory was 55. Six normal individuals served as controls for the mixed etiology amnesia patients. They had a mean age of 56 and averaged 15 years of education. Their mean WAIS–R Verbal IQ was 116.

Materials and design. Stimuli consisted of 136 nouns, four to six letters in length, with frequencies ranging between 100 and 500 per million (Francis & Kucera, 1982). Sixty-eight words that were conducive to multiple graphemic queries were selected to be used in the graphemic encoding task, whereas 68 words that were conducive to multiple semantic queries were selected to be used in the semantic encoding task.

For both the graphemic and semantic conditions, the study list consisted of 38 words. Ten words were repeated at a lag of 5 intervening items, 10 were repeated at a lag of 0, and 10 were presented once. The assignment of stimuli to condition (Lag 5, Lag 0, and nonrepeat) was counterbalanced across subjects. The remaining eight items were fillers and were divided evenly at the beginning and end of the list. The test list for both encoding conditions consisted of the 30 target items and 30 distractors that were randomly intermixed. The assignment of words as targets or distractors was likewise counterbalanced across subjects.

Procedure. Presentation of the words during the study phase was identical to that in Experiment 3. Each word was presented for 3 s, and a graphemic or a semantic question was asked about the word, depending on the condition being administered. A recognition test began immediately upon conclusion of the study stage. It followed the exact procedure of the recognition phase of Experiment 1. Participants were shown each of 60 words for a duration of 2 s, and they were asked to indicate by pressing one of two response keys whether each word had been presented in the study list. There was a break of at least 20 min between the two encoding conditions. Half of the participants received the graphemic condition first, and the other half received the semantic condition first.

Results

Corrected recognition scores were computed for each participant by subtracting the proportion of false alarms from the proportion of hits for each of the three word repetition conditions. Again, because preliminary analyses revealed no significant differences between the two amnesia groups or between the two control groups, the data from the two patient groups and the two control groups were combined for all subsequent analyses. Mean accuracy data for the two groups as a function of encoding and repetition are presented in Table 4.

An ANOVA with group (amnesics or controls) as the between-subjects variable and encoding (graphemic or semantic) and repetition (nonrepeat, Lag 0, or Lag 5) as the within-subjects variables revealed significant main effects of group, $F(1, 22) = 36.53, p < .01$, and encoding, $F(1, 22) = 36.83, p < .01$, as well as a marginally significant effect of repetition, $F(2, 44) = 3.04, p < .06$. The Group × Encoding interaction was also significant, $F(1, 22) = 14.25, p < .01$, and indicated that the effect of encoding was significant for the controls, $F(1, 22) = 48.45, p < .01$, but not for the amnesia patients.

To further examine the effects of repetition, in our first analysis we compared performance in the nonrepeat condition to the mean of the two repeated conditions. The effect of repetition was marginally significant, $F(1, 22) = 3.82; p < .10$, and did not interact with group. However, planned comparisons revealed a significant repetition effect in the performance of the controls $F(1, 22) = 5.41, p < .05$, but not in that of the amnesia patients. A second analysis focusing on the effects of spacing failed to reveal any significant effects. Finally, in the comparison of the Lag 0 and nonrepeat condition, only the effect of Group × Condition was marginally significant, $F(1, 22) = 3.88; p < .10$. Analyses of simple effects revealed a significant difference between the Lag 0 and nonrepeat conditions in the controls, $F(1, 22) = 5.94, p < .05$, but not in the amnesia patients.

Table 4
Corrected Recognition Scores as a Function of Encoding and Repetition Condition

Group	Encoding		
	Nonrepeat	Lag 0	Lag 5
	Graphemic		
Amnesia	.13	.10	.20
Control	.26	.36	.34
	Semantic		
Amnesia	.23	.23	.25
Control	.65	.73	.73

Discussion

The main findings of this recognition task closely parallel those obtained in Experiment 3 in a recall task. Controls' recognition memory was affected by the level at which items were encoded, but amnesia patients' recognition memory was not. More importantly, varying the encoding across presentations again had different effects on the performance of controls and amnesia patients. In the performance of controls, two findings are of importance. First, immediately repeated items were recognized better than nonrepeated items, although it should be noted that the encoding variability manipulation did little to enhance the benefit of immediate repetition that existed in Experiment 1, when participants encoded items spontaneously. This likely reflects the fact that upon immediate repetition of an item, normal individuals spontaneously further elaborate on the item by encoding different attributes. Directing them to do so resulted in little additional benefit, possibly because recognition is less dependent than recall on active reconstruction of the study episode. Second, when participants were guided in their encoding, the spacing effect again disappeared. This finding is consistent with the notion that encoding variability contributes little to spacing effects in recognition. In the present experiment, guided encoding likely interrupted participants' spontaneous rehearsal of items thought to be critical to the occurrence of spacing effects in recognition.

In contrast, for amnesia patients, variable encoding failed to enhance their memory for immediately repeated items. Their performance at Lag 0 was equivalent to that for nonrepeated items, and the spacing effect that was present in their recognition performance in Experiment 1 when encoding was not manipulated disappeared. Taken together with the results from the previous experiments, these findings suggest that amnesia patients' performance is not enhanced by intentionally directing their encoding to variable aspects of the stimuli. Instead, it appears that directing amnesia patients' encoding interfered with their normal pattern of rehearsal and disrupted the previously observed spacing effect in recognition.

General Discussion

Amnesia patients benefited from the repetition and spacing of items in both a recognition (Experiment 1) and a recall task (Experiment 2). In both tasks, items that were repeated were remembered significantly better than items that were presented only once and items repeated following a lag of five intervening items were remembered significantly better than items presented on adjacent trials. Furthermore, the effects of repetition and spacing were of equivalent magnitude in the amnesia and control groups.

The finding of intact spacing effects in amnesia patients' recognition memory is consistent with our hypothesis that spacing effects in recognition might be due to the additional rehearsal that items receive when they are repeated following a lag. We know that amnesia patients are capable of rehearsing individual items (Cermak, Naus, & Reale, 1976), so the benefit of repeated processing was expected. However, reinstatement of this kind of processing occurs only when items are repeated in a distributed fashion and not when they are presented on adjacent trials. Either the patient feels no need to perform the same process on adjacent trials or else the continuous action of maintenance has no additive effect, as Craik and Lockhart (1972) previously suggested.

In contrast to these predicted recognition effects, the presence of spacing effects in amnesia patients' recall performance was not expected. Because spacing effects in normal recall have generally been attributed to increased opportunity for variable encoding, amnesia patients were not expected to show such an obviously strategic effect. The fact that amnesia patients did demonstrate a spacing effect forces us either to accept that these patients are capable of normal strategic variations in encoding or to postulate a different explanation for their performance. There are two reasons why we believe that the spacing effect in amnesia patients' recall cannot be accounted for by the ability to intentionally engage in variable encoding. First, when encoding instructions encouraged processing of different aspects of the same item across repetitions, amnesia patients failed to benefit from repetition at all. Second, the effects of spacing were also virtually eliminated following the variable encoding instructions. These findings argue against the notion that the intentional processing of different aspects of a stimulus underlies amnesia patients' observed spacing effect and add to our extensive line of research indicating that amnesia patients' elaboration of information is impaired even following instructions (for a review, see Cermak, 1988).

If intentional variable encoding does not account for the amnesia patients' performance, how then can we explain the occurrence of spacing effects in amnesia patients' recall? One possibility, which is suggested by the work of Nelson, McEvoy, and Schreiber (1990), is that the spacing effect may be mediated by the automatic activation of associates of studied words. When associates activated by two adjacent words on a study list overlap, indirect connections between these two words may become activated. Activation of these associative connections has been shown to enhance the performance of normal subjects on a free recall task because retrieval of one of the target words facilitates retrieval of any of the other associatively linked words in the list (Nelson, McEvoy, & Schreiber, 1990). Because we have previously demonstrated that the activation of associative networks in amnesia is intact (Verfaellie, Cermak, Blackford, & Weiss, 1990), it could be hypothesized that amnesia patients' recall performance may be affected by associations in a similar manner. That is, the effect of spacing on amnesia patients' free recall performance might be due to the fact that the chances of activating remote preexisting connections between a repeated item and adjacent items on the list is increased when repetitions are spaced because an item would have more immediate neighbors to which it could be linked when the repetitions are spaced relative to when they are directly adjacent to one another.

Amnesia patients' failure to benefit from the immediate repetition of items is consistent with this interpretation because immediate repetition of an item would not increase the number of immediate neighbors. Finally, this account can accommodate the fact that spacing effects in amnesics' free recall are eliminated when encoding is directly manipulated. Several studies by Nelson and his colleagues have previously documented that the automatic activation of associates can be inhibited when the encoding context biases the meaning of a target (for a review, see Nelson, Schreiber, & McEvoy, 1992). Providing a specific question each time a word is encoded as was the case in our final two experiments may have had this inhibitory effect for our patients, thus reducing the likelihood that remote connections between adjacent items could be established.

Finally, a question must be raised as to whether the spacing effects observed in the performance of amnesia patients are truly normal. Although these effects were of a similar magnitude to those obtained in controls, it remains unclear whether the effects obtained in the two groups are strictly equivalent, given the differences in overall level of performance between the two groups. Future studies in which amnesia patients and controls are matched in their memory for once presented items are needed to resolve this issue.

In conclusion, our findings suggest that amnesia patients demonstrate spacing effects in both recognition and recall tasks, but the mechanisms underlying these effects are likely to be different. In recognition tasks, spacing effects for both amnesia patients and controls are probably mediated by the additional rehearsal opportunities that distributed presentations allow. In recall tasks, spacing effects are probably due to the fact that spaced presentations allow for the establishment of additional retrieval cues. For normal individuals, these effects may be mediated by strategic encoding processes on individual items; however, for amnesia patients they are probably the result of automatic activation of associations between studied items.

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