Intact Text-Specific Reading Skill in Amnesia

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Amnesic patients were studied to determine whether the acquisition and retention of item-specific skills can be supported by nondeclarative (implicit) memory. In Experiment 1, subjects read 2 different passages 3 times in succession. Reading speed improved at a similar rate in both amnesic patients and normal subjects and was specific to the text that was read. In Experiment 2, amnesic patients and normal subjects read a passage 3 successive times and then reread the same passage after a 0-s, 10-min, 2-hr, or 1-day delay. In both groups, facilitation persisted for at least 10 min and disappeared within 2 hr. It is suggested that facilitated reading speed depends importantly on both semantic and perceptual information and that such information can be supported by nondeclarative memory.

A considerable body of experimental work has accumulated in recent years to support the idea that memory is not a unitary property of the mind but is composed of multiple, different processes or systems (Hintzman, 1990; Richardson-Klavehn & Bjork, 1988; Schacter, 1987; Squire, 1982; 1987; Tulving, 1985). One important kind of evidence comes from the study of human amnesia, which seems to reveal a natural division between different kinds of learning and memory. Although amnesic patients are markedly impaired on tests of recall and recognition, they can learn certain perceptuomotor skills (Brooks & Baddeley, 1976; Nissen & Bullemer, 1987), perceptual skills (Cohen & Squire, 1980; Nichelli, Bahmanian-Behbahani, Gentilini, & Vecchi, 1989), and cognitive skills (Squire & Frambach, 1990) at a normal rate. Furthermore, amnesic patients show a normal shift in preference following exposure to novel material (Johnson, Kim, & Risse, 1985). They also show normal adaptation-level effects (Benzing & Squire, 1989), normal classical conditioning (Daum, Channon, & Canavar, 1989), and intact word priming (Shimamura, 1986; Tulving & Schacter, 1990).

Memory tasks can be divided into two broad categories. The memory tasks on which amnesic patients fail require conscious recollection of previous encounters or previously acquired facts. Such tasks have been considered to depend on declarative (also called representational or explicit) memory and to require the integrity of medial temporal lobe or diencephalic brain structures that are damaged in amnesia (Cohen 1984; Shimamura, 1989; Squire, 1986). In contrast, intact learning in amnesia is implicit and accessible only through performance. The tasks that can be learned include a heterogeneous collection of skillful behaviors, conditioning tasks, and other cases in which experience changes the facility for operating in the world but without requiring the conscious recollection of any previous event. The learning in these cases is nondeclarative (implicit) and independent of the brain structures damaged in amnesia.

A number of issues continue to be explored concerning the kind of information that is available to declarative and nondeclarative memory. Amnesia provides an especially favorable opportunity for addressing such issues because in amnesia nondeclarative memory can be studied without much likelihood that conscious memory strategies will contaminate task performance. Accordingly, a finding of entirely intact performance in amnesia provides particularly good evidence that a task does not materially depend on declarative memory.

We used this approach to consider what kind of information underlies learned skillful behavior. Acquired skills could potentially depend on both generic information, which is acquired cumulatively across many study trials, and specific information, which is obtained from the particular kinds of study trials that are encountered. The question is whether both kinds of information are nondeclarative, that is, whether amnesic patients can acquire both generic and specific components of skill learning. This question was initially addressed by assessing the ability of amnesic patients to learn to read mirror-reversed word triplets that were either unique or repeated (Cohen & Squire, 1980). With unique word triplets, the amnesic patients improved at a normal rate, but with repeated triplets the normal subjects performed better than the amnesic patients. This finding could be taken to suggest
that information about specific encounters was not available to amnesic patients. However, as others have pointed out (Masson, 1986; Moscovitch, Winocur, & McLachlan, 1986; Nichelli et al., 1989), the same words were always presented together in the same order in each repeated word triplet. Accordingly, normal subjects might have used declarative memory strategies to retrieve the second and third words from the triplet after deciphering the first word. Thus, amnesic patients may have performed worse because they could not use this strategy, not because they were unable to acquire item-specific skills. In a recent study of one amnesic patient, Nichelli et al. (1989) reduced the possible influence of declarative memory by presenting only one mirror-reversed word at a time. The patient improved at reading both unique and repeated words to a similar extent, though it was difficult to determine if the patient's performance was fully normal.

A considerable body of research with normal subjects suggests that specific information is retained as part of skillful behavior. For example, in experiments by Kolers (1976), subjects practiced reading passages of geometrically transformed text (e.g., inverted or mirror-imaged.) Thirteen to 15 months later, subjects read either familiar passages or new passages, both presented in the same typography that had been practiced earlier. Familiar passages were read more quickly than new ones. Kolers suggested that the advantage of familiar over novel passages was due to the retention of text-specific, pattern-analyzing skills.

In similar experiments, Masson (1986) measured reading speed for word triplets that were presented in mirror-reversed form and in alternating small and capital letters. In the study phase, all letters were encountered equally often in both uppercase and lowercase. At test, subjects read faster when letters were presented in the same alternating case pattern that they were in at study than when the letters appeared in a different alternation. Moreover, reading speed was faster in both of these conditions than when subjects read entirely new words. Thus, the skilled performance of these subjects reflected information about the exact visual detail of specific instances that had been studied.

Although the experiments reported by Masson (1986) show that facilitated reading of single words can depend on highly specific information, the evidence for text reading is not so clear. In one experiment, auditory presentation of textual material facilitated reading when the same material was subsequently presented visually in a transformed typography (Kolers, 1975). This finding shows that semantic, conceptual information can contribute to facilitated reading speed. In another study (Tardif & Craik, 1989), subjects read different texts in two unfamiliar typographies (e.g., mirror-reversed or inverted) and in normal typography. One week later, subjects read the old passages and new passages in both the practiced typographies and in a third, unfamiliar typography (e.g., reversed spelling). Passages were read faster if they had been read previously and if the typography had been practiced. In addition, verbatim passages were reread faster than paraphrased passages, which in turn were read faster than new passages. However, there was no additional benefit from rereading a passage in the same typography that it had appeared in during the study session. Tardif and Craik suggested that facilitated rereading of text passages depends on the retention of general pattern-analyzing skills (not on instance-specific pattern-analyzing skills), together with the retention of conceptual information about the text (both gist and specific lexical information). Others have also concluded that semantic, conceptual factors are important in rereading (Carr, Brown, & Charalambous, 1989; Graf & Levy, 1984; Horton, 1985; Levy & Burns, in press; Levy & Kirsner, 1989; Levy, Newell, Snyder, & Timmins, 1986; Masson & Sala, 1978).

If the rereading of text does depend on specific factors related to the particular words in the text, the question arises as to whether these factors are examples of nondeclarative (implicit) memory. One way to address this question is to ask whether amnesic patients would show facilitated reading speed for textual material and whether this effect is text-specific. This question was addressed recently in a study of reading speed involving a mixed group of memory-impaired patients (Moscovitch et al., 1986). At study, subjects read sets of sentences in either normal or inverted typography. At test, which occurred at two retention intervals for each subject (1–2 hr and 2 weeks), subjects were asked to read old and new sentences as rapidly as possible. Both groups read old sentences more quickly than new sentences. However, because control subjects and memory-disordered subjects had different initial reading speeds (i.e., baseline speeds), it was difficult to determine if the two groups improved to a similar degree.

In the present experiments we pursued further the issue studied by Moscovitch et al. (1986)—namely, whether amnesic patients can acquire and retain text-specific reading skills. In the first experiment, we asked whether amnesic patients would improve their reading speed at the same rate as normal subjects. We also asked whether improvement was due to a general skill—for example, an increased speed of reading aloud—or whether improvement was specific to the text that was read. In the second experiment we examined how long facilitated reading speed persists.

### Experiment 1

Amnesic patients and normal subjects read two different stories three times in succession. Facilitated reading speed would be reflected in progressively faster times for successive readings of the first story. If facilitated reading speed is specific to the practiced text, then the first reading of the second story should be slower than the third and final reading of the first story and at about the same speed as the first reading of the first story.

### Method

**Amnesic subjects.** We tested 8 amnesic patients (see Table 1), all of whom have been studied in our laboratory on many occasions during the past few years. Patients were selected who had shown no evidence of slowness on previous tests in which they had participated. We used this selection factor in order to try to equate control subjects and amnesic patients for baseline reading speed.

Four of the patients had alcoholic Korsakoff's syndrome. They had all participated in either a magnetic resonance (MR) imaging
study, which demonstrated marked reductions in the volume of the mammillary nuclei (Squire, Amaral, & Press, 1990), or in a quantitative, computerized tomography (CT) study, which demonstrated reduced thalamic density together with frontal lobe atrophy (Shimamura, Jernigan, & Squire, in press). Of the four other patients, 2 (L.M. and J.L.) have hippocampal pathology identified by MR imaging (Press, Amaral, & Squire, 1989). Patient L.M. became amnesic in 1984 as the result of a respiratory arrest that occurred during an epileptic seizure. J.L. became amnesic gradually during a period of about 2 years (from early 1985 to early 1987); his cognitive status has remained stable since that time. The 2 other amnesic patients (N.A. and M.G.) have diencephalic lesions confirmed by MR imaging (for N.A., Squire, Amaral, & Press, 1989; for M.G., unpublished observations). Patient N.A. became amnesic primarily for verbal material, when he sustained in 1960 a stab wound to the left diencephalic region with a miniature fencing foil (Teuber, Milner, & Vaughan, 1968). Patient M.G. became amnesic in 1986 following a bilateral medial thalamic infarction. The present study was concerned with the overall performance of amnesic patients, and the patients are therefore treated here as a single group.

The 8 amnesic patients averaged 62.1 years of age and 12.1 years of education. They had an average Wechsler Adult Intelligence Scale-Revised (WAIS-R) IQ of 107.8. Individual 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 5.5 and 0 respectively (21 segments total; Gilbert, Levec, & Catalano, 1968). Scores on other memory tests appear in Table 2. Note that the scores on the word recall test in Table 2 are above zero because on this test of immediate recall, several items can be retrieved from immediate memory, which is intact in amnesia. In addition, the mean score on the Dementia Rating Scale (Mattis, 1976) was 133 points (maximum = 144, range = 119-143), with most of the points lost on the memory subportion of the test (6.6 points). The average score on the Boston Naming Test was 54.6 (maximum = 60, range = 48-59). Scores for normal subjects on these same tests can be found elsewhere (Janowsky, Shimamura, Kritchevsky, & Squire, 1989; Squire et al., in press).

Healthy control subjects. Five men and 4 women served as a control group for the amnesic patients. All were employees or volunteers at the San Diego Veterans Affairs Medical Center. They

Table 1

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age</th>
<th>Etiology</th>
<th>WAIS-R</th>
<th>WMS-R</th>
</tr>
</thead>
<tbody>
<tr>
<td>V.F.</td>
<td>70</td>
<td>Korsakoff</td>
<td>103</td>
<td>101</td>
</tr>
<tr>
<td>D.M.</td>
<td>55</td>
<td>Korsakoff</td>
<td>101</td>
<td>92</td>
</tr>
<tr>
<td>P.N.</td>
<td>62</td>
<td>Korsakoff</td>
<td>94</td>
<td>81</td>
</tr>
<tr>
<td>R.C.</td>
<td>73</td>
<td>Korsakoff</td>
<td>106</td>
<td>115</td>
</tr>
<tr>
<td>N.A.</td>
<td>51</td>
<td>Penetrating brain injury</td>
<td>120</td>
<td>102</td>
</tr>
<tr>
<td>M.G.</td>
<td>57</td>
<td>Thalamic infarction</td>
<td>111</td>
<td>113</td>
</tr>
<tr>
<td>J.L.</td>
<td>70</td>
<td>Unknown</td>
<td>116</td>
<td>122</td>
</tr>
<tr>
<td>L.M.</td>
<td>59</td>
<td>Anoxia</td>
<td>111</td>
<td>132</td>
</tr>
<tr>
<td>M</td>
<td>62.1</td>
<td></td>
<td>107.8</td>
<td>107</td>
</tr>
</tbody>
</table>

Note. WAIS-R = Wechsler Adult Intelligence Scale-Revised; WMS-R = Wechsler Memory Scale-Revised. The WAIS-R and each of the five indices of the WMS-R yield a mean score of 100 in the normal population with a standard deviation of 15.

Table 2

<table>
<thead>
<tr>
<th>Patients/controls</th>
<th>Diagram recall</th>
<th>Paired associates</th>
<th>Word recall (%)</th>
<th>Word recognition (%)</th>
<th>50 words</th>
<th>50 faces</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V.F.</td>
<td>8</td>
<td>0-0-0</td>
<td>27</td>
<td>91</td>
<td>27</td>
<td>31</td>
</tr>
<tr>
<td>D.M.</td>
<td>0</td>
<td>0-0-2</td>
<td>32</td>
<td>56</td>
<td>24</td>
<td>29</td>
</tr>
<tr>
<td>P.N.</td>
<td>2</td>
<td>1-1-1</td>
<td>29</td>
<td>83</td>
<td>27</td>
<td>38</td>
</tr>
<tr>
<td>R.C.</td>
<td>3</td>
<td>0-0-3</td>
<td>19</td>
<td>85</td>
<td>37</td>
<td>30</td>
</tr>
<tr>
<td>N.A.</td>
<td>17</td>
<td>0-0-2</td>
<td>49</td>
<td>93</td>
<td>34</td>
<td>42</td>
</tr>
<tr>
<td>M.G.</td>
<td>0</td>
<td>0-0-2</td>
<td>33</td>
<td>71</td>
<td>30</td>
<td>34</td>
</tr>
<tr>
<td>J.L.</td>
<td>1</td>
<td>0-0-0</td>
<td>40</td>
<td>93</td>
<td>31</td>
<td>20</td>
</tr>
<tr>
<td>L.M.</td>
<td>11</td>
<td>1-1-3</td>
<td>44</td>
<td>98</td>
<td>30</td>
<td>37</td>
</tr>
<tr>
<td>M</td>
<td>5.2</td>
<td>0.3-0.3-1.6</td>
<td>34</td>
<td>84</td>
<td>30.0</td>
<td>32.6</td>
</tr>
<tr>
<td>Controls (n = 8)</td>
<td>20.6</td>
<td>6.0-7.6-8.9</td>
<td>71</td>
<td>97</td>
<td>41.1</td>
<td>38.1</td>
</tr>
</tbody>
</table>

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 26.5, a normal score (Kritchevsky, Squire, & Zonzounis, 1988). The paired associate 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-hr recognition test of 50 words or 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 N. A. is not severely impaired on nonverbal memory tests because his brain injury is primarily left unilateral.
Aged 60.9 years of age, had 13.7 years of education, and obtained WAIS-R subtest scores of 22 for Information (compared with 20 for the patients) and 57.6 for Vocabulary (compared with 57.9 for the patients). Immediate and delayed (12 min) recall of a short prose passage averaged 7.0 and 6.4, respectively.

Materials. Excerpts of two short stories from Reader's Digest and Esquire Magazine, each containing about 20 lines of text, were selected as study material (204 or 223 words in length).

Procedure. Subjects were told that they would be asked to read stories several times and that they would then be asked questions about their content. Subjects then read each story aloud three times in succession. The order of the two stories was counterbalanced across subjects. Subjects were told to read the stories as quickly as possible but not so quickly that they would not understand what they were reading. The interval between each reading was just long enough to remind subjects to read as quickly as possible (5-10 s).

After the third reading of the first story, subjects read the second story three times following the same procedure. An interval of about 10-15 s separated the readings of the two stories. The time needed to complete each reading was recorded with a stopwatch. After the three readings of the second story were completed, subjects were given 10, three-alternative, forced-choice questions about the first story followed by 10 similar questions about the second story.

Results

The time required to read each story declined with repeated readings (see Figure 1). Reading speeds appeared to change similarly for amnesic patients and control subjects. The average reading time for both groups was 69.4 s for the first reading of the first story and 63.3 s for the third reading. There was no discernible transfer of reading speed to the second story (for both groups the first reading of the second story averaged 69.7 s; the third reading averaged 64.0 s).

Statistical analysis confirmed these impressions. First, separate two-way analyses of variance showed a significant reduction in reading speeds for both stories: Story 1, F(2, 30) = 10.75, p < .01; Story 2, F(2, 30) = 7.92, p < .01. There was no effect of group (F < 1) and no interaction, F(2, 30) = 2.1, p > .10. Second, a single analysis of variance for the data from each story (Group × Story × Reading Time) showed only the expected effect of repeated reading, F(2, 30) = 10.92, p < .01, and no effect of story (F < 1) or group (F < 1) and no interaction (all Fs < 2.45, ps > .10). Finally, for each group the first reading of the second story was accomplished at about the same speed as the first reading of the first story (t < 1.0) and was significantly slower than the third reading of the first story: For control subjects, t(8) = 3.55, p < .01; for amnesic patients, t(7) = 2.37, p < .05.

Thus, amnesic patients and control subjects both read more rapidly with repeated presentations of each story, but there was no transfer of reading speed from the first to the second story. The control subjects performed much better than the amnesic patients on the questions about story content: Story 1, 90% versus 68.9%; Story 2, 88.9% versus 63.9%; t(15) > 2.8, ps < .01.

Discussion

Amnesic patients improved their reading speed at a normal rate despite impaired declarative memory for the content of what was read. The facilitation was specific to the text that was read. These findings support the idea that facilitated reading speed depends on nondeclarative (implicit) memory.

Experiment 2

In this experiment, we attempted to measure the time course of forgetting of the text-specific reading skill. One reason for examining forgetting was to construct an additional test of the hypothesis that facilitated reading speed is nondeclarative. If this skill is supported entirely by nondeclarative
(implicit) memory, then amnesic patients and normal subjects should lose the skill at the same rate. A second reason for examining forgetting was that information about the time course of the skill might suggest what kind of process underlies it. After reading text three times in succession, subjects were tested on a fourth occasion either 0 s, 10 min, 2 hr, or 1 day later. The 10-min delay was included to determine if facilitated reading speed persisted beyond the range of immediate memory. The 2-hr delay was included so that the results for facilitated reading speed could be compared to previous results obtained for word priming. Many stem-completion and word-association priming effects have been found to disappear within 2 hr in normal subjects and amnesic patients (Diamond & Roizin, 1984; Graf & Mandler, 1984; Graf, Squire, & Mandler, 1984; Shimamura & Squire, 1984; Squire, Shimamura, & Graf, 1987). Finally, a 1-day delay was included to determine whether facilitated reading speed might be as long-lived as other skills such as mirror reading (Cohen & Squire, 1980; Nichelli et al., 1989) or the ability to resolve random-dot stereograms (Benzing & Squire, 1989).

**Method**

**Subjects.** The same 8 amnesic patients were tested as in Experiment 1. Eight healthy control subjects were also tested, 3 of whom had participated in Experiment 1. All were employees or volunteers at the San Diego Veterans Affairs Medical Center. As a group, the control subjects (5 men and 3 women) averaged 62 years of age, had 13.2 years of education, and obtained WAIS-R subtest scores of 21.5 for Information and 56.1 for Vocabulary. Immediate and delayed (12-min) recall of a short prose passage (Gilbert et al., 1968) averaged 6.6 and 6.1, respectively.

**Materials.** Excerpts of four short stories from Reader's Digest and Esquire Magazine, each containing about 20 lines of text, were selected for study material (211, 218, 230, or 233 words in length). The stories and the subject matter were different from the stories used in Experiment 1.

**Procedure.** Subjects were asked to read a story three times in succession following the same procedure that was used in Experiment 1. As in Experiment 1, subjects were told that they should read aloud as rapidly as possible but not so rapidly that they would not understand what they were reading. In this experiment, a fourth reading was scheduled at one of four different delays after the third reading: immediately, 10 min, 2 hr, or 1 day. All subjects participated in all four delay conditions, which were given on different days, separated by at least 1 day. The stories and the delays were counterbalanced such that all of the stories were used in all four delay conditions and the four delays occurred in a different order for each subject. Thus, on each of four different occasions, subjects read a story three times in succession and then read the same story again after a delay (0 s, 10 min, 2 hr, or 1 day later). After the final (delayed) reading of each story was completed, subjects were given a written test consisting of 10, three-alternative, forced-choice questions about the content of the story. To determine baseline guessing rates for the content of the four stories, the multiple-choice tests were administered to 6 subjects who had not read any of the stories. Their mean scores for the four stories were close to the expected score of 33.3% for a three-alternative test (38.3%, 36.7%, 33.3%, and 40.0%).

**Results**

The measure of reading speed for the first three readings was obtained by averaging the times for all four stories (see Figure 2). For both groups, reading times decreased with repeated presentations of the stories (from 79.9 s to 67.0 s for the amnesic patients and from 78.9 s to 73.3 s for the control subjects, $F(2, 28) = 24.2, p < .001$). There was no effect of group ($F < 1.0$), but amnesic patients improved at a more rapid rate than control subjects as reflected in the significant Group x Repetition interaction, $F(2, 28) = 3.71, p < .05$.

The time required to complete the fourth reading, which was scheduled at a variable delay after the third reading, provided information about how long facilitated reading speed persisted. The amnesic patients and control subjects performed similarly across these four delay intervals. An analysis of variance (Group x Delay) revealed an effect of delay interval, indicating that reading speed gradually slowed across the four delays, $F(3, 42) = 211.2, p < .001$. There was no effect of group ($F < 1.0$) and no interaction ($F < 1$). Thus,
both amnesic patients and control subjects increased their reading speed across three repetitions of the same text. As time passed after the third repetition, reading speed gradually slowed at the same rate in both groups.

To determine how long facilitated reading speed persisted after the third reading, we compared the time required for each fourth reading (at the 0-s, 10-min, 2-hr, or 1-day delay) to the time required for the first reading (averaged across all four stories). In these comparisons, facilitated reading speed would be demonstrated by finding a significantly shorter reading time for the fourth compared to the time required to read the story for the first time. Reading times for the fourth reading were significantly faster in the 0-s delay condition: amnesic patients, \( t(7) = 4.36, p < .01 \); control subjects, \( t(7) = 3.6, p < .01 \). They were also significantly faster in the 10-min delay condition: amnesic patients, \( t(7) = 4.6, p < .01 \); healthy control subjects, \( t(7) = 2.54, p < .05 \). After delays of 2 hr or 1 day, reading speeds had returned to about the level that was observed during the first reading (for both groups, \( p > .10 \)). These comparisons indicate that facilitated reading speed produced by reading a short passage three times in succession persisted for at least 10 min and was not detectable after 2 hr.

This conclusion is also supported by comparing the times required for each fourth reading to the times required for the third reading. At the 0-s and 10-min delays, during the time that the facilitation persisted, the reading speeds for both groups were similar to the times recorded for the third reading (average difference = 0.1 s). In contrast, after the 2-hr and 1-day delays, reading times were slower (though not always significantly so) than for the third reading of each story (average difference = 5.92 s): amnesic patients, 2-hr delay, \( t(7) = 2.06, p = .08 \); 1-day delay, \( t(7) = 6.41, p < .001 \); control subjects, 2-hr delay, \( t(7) = 3.37, p < .05 \); 1-day delay, \( t(7) = 1.67, p = .14 \).

Despite the fact that amnesic patients and control subjects benefited similarly from their exposure to the text as measured by reading speed, the amnesic patients performed more poorly than the control subjects on the questions about story content (73.4% vs. 89.4%); \( t(14) = 3.58, p < .01 \). Questionnaire performance did not differ as a function of delay interval; a two-way analysis of variance showed an effect of group, \( F(1, 14) = 11.9, p < .01 \), but not of delay (\( F < 1 \)). This finding probably reflects the fact that the questionnaire was always given after the fourth reading. Thus, subjects always had the opportunity to read the story just prior to answering questions about it.

Discussion

This experiment demonstrated that facilitated reading speed persisted at least 10 min and disappeared within 2 hr. Because 10 min is outside the range of immediate memory, the effect cannot be attributed to the fact that immediate memory is preserved in amnesia. The finding that facilitated reading speed was lost at the same rate in both amnesic patients and normal subjects provides strong evidence that the facilitation does not depend materially on declarative (explicit) memory.

General Discussion

The two experiments reported here show that, with repeated reading of the same text, amnesic patients improve their reading speed at least as much as normal subjects. The facilitation was not due simply to an improved ability to read out loud but was specific to the text that was read. In both normal subjects and amnesic patients, the effect persisted for at least 10 min and then disappeared within 2 hr. Finally, for the amnesic patients, improved text reading occurred despite a marked impairment in the ability to recollect what was read.

In Experiment 2, facilitated reading speed developed more quickly in amnesic patients than in control subjects. It is not entirely clear how to interpret this finding because it was not observed in Experiment 1. One possibility is that this effect, when it occurs, is due to the fact that all subjects are subsequently asked questions about the stories. The control subjects may sometimes slow down in order to assure better comprehension and retention of the stories, whereas the amnesic patients may forget that memory for the stories will be tested. In any case, the effect was not a reliable one.

In their study of mirror-reading, Cohen and Squire (1980) found that although amnesic patients learned the general pattern-analyzing skill of reading mirror-reversed word triplets, amnesic patients did not improve as much as normal subjects at reading repeated triplets. One possibility is that the mirror-reading of repeated words depends on declarative (explicit) memory. In this view, the advantage that amnesic patients were able to demonstrate for repeated words compared to unique words was due to the fact that the patients had some residual declarative memory ability (see Shimamura & Squire, 1988, for an illustration of the explanatory usefulness of residual memory abilities in amnesia). Another possibility is that amnesic patients did acquire item-specific skills for reading the repeated words but could not obtain a normal performance score because they were unable to use the declarative (explicit) memory strategies available to normal subjects (e.g., normal subjects could have recalled the second and third words of each triplet after reading the first word). The second possibility seems the likely one in light of the present findings of intact text-specific reading skills in amnesia. It is also consistent with the results reported recently for a single amnesic patient who showed good day-to-day retention of an item-specific mirror-reading skill when the opportunity to use declarative memory was reduced (Nichelli et al., 1989).

The declarative–procedural distinction was originally applied to amnesia as a way to understand what kinds of memory tasks were failed and what kinds were performed well (Cohen, 1984; Cohen & Squire, 1980; Squire, 1982). Nichelli et al. (1989) suggested that the declarative–procedural distinction cannot accommodate the finding of intact item-specific effects in amnesia. However, such findings are fully consistent with the declarative–procedural distinction if skills (procedures) are recognized to depend importantly on item-specific information. Indeed, much of the recent experimental literature concerning the acquisition of skilled behavior in normal subjects emphasizes the importance of the specific encounters that cumulate in skilled performance (Jacoby, 1983; Jacoby & Brooks, 1984; Kofers, 1976; Masson, 1986;
Moscovitch et al., 1986). Amnesic patients can acquire many skills normally (Brooks & Baddeley, 1976; Cohen & Squire, 1980; Nissen & Bullemer, 1987; Squire & Frambah), 1990). What appears to limit their success is not whether the skill reflects multiple exposures to repeated (as opposed to unique) items but whether normal subjects can additionally benefit by engaging declarative memory strategies.

More recently, we used the term nondeclarative (Squire & Zola-Morgan, 1988) to refer to the kind of learning that amnesic patients can accomplish, recognizing that what is spared includes not only the sort of skillful behavior that fits the term procedural, but also other kinds of implicit (unconscious) memory abilities such as priming and classical conditioning. These memory abilities are all experience-dependent and proceed without declarative knowledge of previously acquired facts or events.

Tardif and Craik (1989) found that facilitated reading speed persisted for at least 1 week in their normal college-age subjects, whereas our effect disappeared within 2 hr. Our results cannot be directly compared to theirs because their subjects always reread in transformed typography, whereas our subjects studied and reread in normal typography. These methodological differences might be important in determining the longevity of the effect. Alternatively, it is possible that the effect does not persist as long in older subjects (mean age in our study = 61 years) as in college students.

The text-specific reading skill demonstrated in the present experiment is also less long-lived than other perceptual skills such as mirror-reading (which was still evident after 3 months, Cohen & Squire, 1980) or the ability to perceive stereoscopic depth (which was weakly evident after 7 days, Benzing & Squire, 1989). The longevity of the effect may depend on the amount of practice. In the present study, subjects read each text only three times. In contrast, the mirror-reading skill was acquired during 150 trials given over a period of 3 consecutive days, and the ability to perceive stereoscopic depth was acquired during 10 trials on 2 consecutive days. Thus, additional practice reading the same text might help to maintain a specific reading skill.

The longevity we found for text-specific reading skill is similar to the longevity found for word-completion priming and word-association priming, which have frequently been found to disappear within 2 hr (Diamond & Roizin, 1984; Graf & Mandler, 1984; Graf et al., 1984; Shimamura & Squire, 1984; Squire et al., 1987; for examples of priming effects that appear to last longer, see Jacoby, 1983; Jacoby & Dallas, 1981; Light, Singh, & Capps, 1986; Tulving, Schacter, & Stark, 1982). Word-completion priming was assessed by accuracy rather than speed, so comparisons between word priming and reading speed effects should be made cautiously. Nevertheless, the fact that text-specific reading skills and word priming have similar time courses raises the possibility that priming may be partly responsible for the effect. Thus, facilitated reading of normal text may depend importantly on the priming of words and associations in the text.

This idea is also consistent with previous findings showing faster rereading of verbatim rather than paraphrased text and faster reading when the first presentation is visual rather than auditory (Kolers, 1975; Masson, 1984). The fact that it is advantageous to see the specific words that will later be read suggested to Kolers (1975) that subjects carry out detailed graphemic analyses "of the words as patterns on the page rather than of the words as meanings" (p. 296). Such a view could include two possible kinds of analyses: Words could be treated as lexical items or as neutral objects with particular surface features, that is, as typographical objects consisting of characteristic angles and curves.

Recent studies of visual processing of single words using positron emission tomography (PET) have identified a left posterior word-form area, which is activated both by real words and pronounceable pseudowords (Petersen, Fox, Snyder, & Raichle, 1989). In contrast, presentation of letter strings (nonpronounceable pseudowords) or nonletter shapes activates bilaterally a posterior, more lateral area. It is possible that facilitated rereading of same-word text involves nonlexical systems of the kind activated by nonpronounceable letter strings or nonletter shapes (e.g., to the extent that factors like type font or case influence rereading, Jacoby & Hayman, 1987; Masson, 1986; but see Carr et al., 1989). Alternatively, we propose that facilitated rereading depends importantly on perceptual priming within the word-form area, that is, on perceptual priming of lexical information. Perceptual priming has been proposed previously to operate on a presemantic, word-form system (Schacter, in press) and to facilitate the identification of previously encountered words. Note that if perceptual priming is an important factor in facilitated rereading, then text-specific effects are not due entirely to semantic, conceptual factors as has sometimes been suggested (Carr et al., 1989; Tardif & Craik, 1989).

In addition to perceptual priming, semantic priming may also contribute to text rereading (for this distinction, see Gabrieli, in press; Schacter, in press; Tulving & Schacter, 1990). Perceptual priming is modality bound: for example, it was reduced in both normal subjects and amnesic patients when study and test phases were in different modalities (Graf, Shimamura, & Squire, 1985; Jacoby & Dallas, 1981). Semantic priming operates at the level of meaning and facilitates associations between presented words and semantically related words (Shimamura & Squire, 1984; Schacter, 1985). Perceptual priming could explain why rereading is better when the same words are re-presented than when paraphrased text is presented and why visual—visual testing is more advantageous than auditory—visual testing. Semantic priming could explain why text rereading is facilitated by auditory presentation of the same text and by visually presented, paraphrased text (also see Levy & Kirsner, 1989, for a multiple-factor view of text reading).

It is important to note that these considerations of the factors underlying text-specific reading skills do not require or assume that all of the conceptual and linguistic information available in text is reflected in the reading skill. Word-association priming in amnesic patients occurs only for preexisting, unitized associations (Schacter, 1985; Shimamura & Squire, 1984). Priming of new associations as measured by word completion (Graf & Schacter, 1985) is weak or absent in amnesia, and an essential component of the phenomenon appears to depend on declarative memory (Cermak, Bleich, & Blackford, 1988; Mayes & Gooding, 1989; Shimamura &
Squire, 1989). Finally, although the formation of new associations between previously unrelated words has been reported to facilitate rereading (Moscovitch et al., 1986), this effect has been difficult to replicate (Mussen & Squire, in press).

In summary, amnesic patients showed intact retention of text-specific information as measured by reading speed. This effect was relatively short-lasting—disappearing within 2 hr in both amnesic patients and normal subjects. The time course of the effect is similar to the time course of word-completion and word-association priming effects. Previous research has suggested that facilitated reading speed depends significantly on semantic, conceptual information about the text (i.e., gist and lexical information). The possible contribution of non-lexical, visual-feature information has also been considered previously. We have pointed out in addition the possible importance of perceptual priming within a presemantic, word-form system. Whatever the nature of the information responsible for text-specific effects (i.e., perceptual, semantic, or both), this information can be supported by nondeclarative (implicit) memory.

References


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