Degree of Cognitive Impairment and the Dissociation of Implicit and Explicit Memory

R. ERIC LANDRUM
ROBERT C. RADTKE
Department of Psychology
Southern Illinois University at Carbondale

ABSTRACT. One group of normal elderly adults and two groups of cognitively impaired elderly adults were compared on an implicit and an explicit memory task. Degree of impairment affected explicit memory; the mildly and moderately impaired elderly adults demonstrated significantly reduced recognition performance. Degree of impairment also affected implicit memory priming performance, particularly for low frequency items, as measured by a word completion task. Explicit memory performance declined for both cognitively impaired groups, but implicit memory performance was sensitive to the degree or severity of impairment, causing a decline in performance only in the moderately impaired group.

THE EFFECTS of cognitive and memory impairment on performance in implicit and explicit memory tasks were examined in the present study. An implicit memory task is one in which the subject is unaware that memory is being tested; some task is performed that allows memory to be tested in an incidental fashion. Implicit memory is often studied with a repetition priming paradigm in which items are presented in a study phase, followed by a seemingly unrelated task involving those items. Performance on the task is influenced by the earlier experience, but the relationship between the prior presen-

This article is derived from a master's thesis written by R. Eric Landrum under the direction of Robert C. Radtke at Southern Illinois University at Carbondale. Portions of this report were presented at the 1988 annual meeting of the Midwest Psychological Association.

Requests for reprints should be sent to R. Eric Landrum, who is now at the Department of Psychology, University of Wisconsin-Platteville, Platteville, WI 53818-3099.
tation and performance on the task is not explicitly made known to the subject. Explicit memory tasks are the more traditional tests of memory, such as recognition and recall, in which subjects know they are to retrieve previously presented information.

There is often a marked discrepancy between measures of explicit and implicit memory. A number of variables differentially affect performance on implicit and explicit memory tasks (see Richardson-Klavehn & Bjork, 1988, and Schacter 1987, for reviews). Of major interest in the present study was the fact that these discrepancies are evident in various subject populations. For example, elderly adults perform as well as young adults do when given a word-completion, implicit memory task, but not when tested for recognition memory of previously presented words (e.g., Light & Singh, 1987). Amnesics, by definition, perform poorly on tests of explicit memory, but they perform as well as age-matched normals on implicit memory tasks (Shimamura, 1986).

The cognitive impairment caused by Alzheimer's and other dementias leads to deficits in explicit memory performance (Olton, Gamzu, & Corkin, 1985). The majority of recent studies indicate that such memory deficits are restricted to tests of explicit memory and are not evident in tests of implicit memory (Brandt, Spencer, McSorley, & Folstein, 1986; Knapman & Nissen, 1987; Moscovitch, Winocur, & McLachlan, 1986). For example, Brandt et al. (1986) tested explicit and implicit memory performance in moderately demented patients suffering from Alzheimer's disease. Explicit memory, tested by the free recall of a word list, was severely impaired. When implicit memory was tested with a word association task, however, Alzheimer patients reported previously presented words at the same level of proficiency as that of normal subjects, although neither group was explicitly instructed to provide word associations from the previously presented list.

Nevertheless, some research findings indicate that implicit memory deficits can be found in patients with Alzheimer's disease. Shimamura, Salmon, Squire, and Butters (1987) used a word-stem completion task with patients suffering from Alzheimer's disease, Huntington's disease, or Korsakoff's syndrome. When explicit memory was tested with a recognition task, all three groups demonstrated deficits. Implicit memory performance on the word-stem completion task was significantly lower for the mildly and moderately impaired Alzheimer's patients than for any other group in the study, including those with Huntington's disease, Korsakoff's syndrome, and all appropriate control groups.

The cognitive impairment caused by Alzheimer's disease is typically evidenced by a wide variety of cognitive deficits in addition to impaired explicit memory (Corkin, 1982). The question, then, is whether implicit memory remains intact in the face of generalized cognitive impairment, including impairments in cognitive skills (procedural knowledge), factual knowledge (se-
mantic memory), and language. To the extent that implicit memory relies on these other cognitive processes, we may anticipate a deterioration in implicit memory in cognitively impaired subjects. This result, however, was not found in the majority of the studies we reviewed.

The key to identifying whether implicit memory performance is impaired in Alzheimer individuals may be severity or degree of impairment. If severity is important, a decline in implicit memory performance may serve as a marker for the overall decline of the Alzheimer's patient. Researchers have not directly examined the effect of severity of impairment, and it may be that only more severely impaired adults will show diminished implicit memory. The purpose of the present study was to assess this possibility.

**Method**

**Subjects**

The subjects were 7 normal elderly adults recruited at a luncheon program at a senior citizen center and 14 cognitively impaired elderly adults, 9 of whom were enrolled in an adult day-care program at the same senior center and 5 of whom were nursing home residents. The day-care subjects were described by the program director and staff social workers as memory impaired, and the nursing home residents were variously diagnosed by their physicians as having organic brain syndrome, senile dementia, or Alzheimer's disease. Thus, the cognitively impaired subjects were a heterogeneous group.

For the nursing home residents only, a screening measure was used in which four word-completion problems similar to the implicit-memory test items were presented. Patients were included as subjects only if they could complete at least three of the four word problems. Of 24 individuals tested, only 6 met this criterion; 5 were included in this study.

The Mini-Mental State Exam (MMSE) was given to all subjects as a measure of general cognitive functioning (Folstein, Folstein, & McHugh, 1975). The MMSE consists of the following subscales: Orientation, Registration, Attention, Recall, and Language. Total MMSE scores can range from 0 to 30, with normal elderly subjects typically scoring 25 or above. The MMSE scores of the normal subjects in this study ranged from 26 to 30 ($M = 28.4$, $SD = 1.5$). The cognitively impaired subjects were divided into two groups on the basis of their MMSE scores. Seven mildly impaired subjects had MMSE scores ranging from 20 to 24 ($M = 21.4$, $SD = 1.6$), and 7 moderately impaired subjects had MMSE scores ranging from 10 to 16 ($M = 12.6$, $SD = 2.6$). We refer to the latter group as moderately impaired because we did encounter elderly adults who were incapable of taking the test.

The normal elderly group was composed of 3 men and 4 women; their average age was 73.4 years (range, 67 to 82), and they had an average of 14.1
years of education (range, 8 to 19). The mildly impaired group comprised 1 man and 6 women, who were an average 74.1 years old (range, 63 to 91). The five individuals for whom we could secure education information reported an average of 12.0 years of education (range, 8 to 20). The moderately impaired group was composed of 7 women whose average age was 85.1 years (range, 74 to 92) and who had 10.9 years of education (range, 8 to 16). The three groups did not differ in years of education, but they did differ significantly in age, $F(2, 18) = 5.38$, $MS_e = 56.1$. The moderately impaired subjects were significantly older than the normal subjects, $t(12) = 3.43$, $p < .05$.

**Procedure**

Subjects were tested individually. After data on age, education, and sex were collected, a word list was presented, followed by a word-completion test (to assess implicit memory) and a recognition test (to assess explicit memory). This was followed by the administration of the MMSE.

Two lists were prepared, List A and List B, each consisting of 20 high frequency and 20 low frequency words, each five or six letters in length, and each with the initial two letters different. High frequency words had an average normative frequency (Francis & Kucera, 1982) of 133.05 occurrences, and low frequency words had an average normative frequency of 6.18 occurrences.¹ A word-completion problem was generated for each word: The first two letters of the word were followed by a series of open boxes (3 or 4) to indicate the length of the target word. Each word and word-completion problem was placed on a 10.80 × 14.00 cm white card.

In the word-presentation phase, each subject was presented with a list of 40 words individually displayed on cards. Subjects were instructed to study all the words because they would be asked questions about them later. Each word was presented for approximately 5 s. Three normal, 4 mildly impaired, and 4 moderately impaired subjects were presented with List A; the remaining subjects in each group saw List B. Following the presentation of the words, 40 word-completion problems were presented. Half the problems could be solved to spell high or low frequency words from the presented list, and half

¹Low frequency words were used because there is typically more priming and better recognition memory for low frequency words than for high frequency words (Jacoby & Dallas, 1981). Although we believed such words would enhance the sensitivity of the group comparisons, we were concerned that the cognitively impaired subjects would be unable to generate a sufficient number of low frequency words to demonstrate significant priming. Therefore, we chose to use both high frequency and low frequency words.
Each word-completion problem was displayed for approximately 30 s by the experimenter. Subjects were instructed to say the first word that came to mind that started with the appropriate two letters and that fit the assigned length of the word. The experimenter recorded the responses. No indications were given that there was a relationship between the words presented earlier and the word-completion problems.

Following the word-completion task, a recognition-memory task was given for the words just tested in the word-completion problems. Subjects were presented with a list of presented and nonpresented words and were asked to circle the words they had seen in the word presentation portion of the experiment. Only half of the presented words were tested in the word-completion and recognition tests. We did attempt to examine long-term retention of implicit and explicit memory by testing the other half of the words 48 hrs after presentation, but many subjects were unable to complete the second day of testing. Following Tulving, Schacter, and Stark (1982), the recognition test covered the same presented and nonpresented items that had just been tested in the word-completion task.

Results

The level of significance for all statistical tests was set at .05. The word-completion data for the three groups are presented in Figure 1 and Table 1. Implicit memory, or priming, was measured by the difference between the proportion of presented and control target words given as solutions to the problems. Analysis of the target solutions (displayed in Figure 1) yielded significant effects for type of word (presented vs. control), $F(1, 18) = 34.72, MS_e = 0.86$, and for group, $F(2, 18) = 3.58, MS_e = 2.12$. The word effect indicated significant priming, with more presented words (.20) than nonpresented control words (.08) given as problem solutions. The group effect indicated that the normal (.18) and mildly impaired (.16) groups gave more target words as solutions to both presented and control problems than did the moderately impaired group (.08).

Table 1 presents the proportion of times subjects responded to the word-completion problems with words other than those preselected by us. The majority (.75) of the subjects’ responses were nontarget word solutions. Analysis of nontarget solutions revealed a significant effect for word, presented (.70) vs. control (.80), $F(1, 18) = 11.57, MS_e = 1.99$, and for frequency, $F(1, 18) = 13.69, MS_e = 1.13$. Of special interest was the fact that there were no significant differences between groups, $F < 1$. The analysis of the proportion of times subjects did not supply any solution word for the problems (the proportion of blanks) revealed no significant main effects or inter-
actions. The major conclusion from these analyses is that subjects did not differ in their ability to provide solutions to the problems.

The apparent interaction between group and word, displayed in Figure 1, was not significant, $F(2, 18) = 2.51$. Nevertheless, there did appear to be less priming for the moderately impaired group than for the other two groups, particularly for low frequency targets (see Table 1). Although the triple interaction with frequency was not significant, $F < 1$, we analyzed high and low frequency items separately. The analysis of high frequency targets yielded no differential priming between groups, $F < 1$. The analysis of low frequency targets indicated a significant Word $\times$ Group interaction, $F(2, 18) = 4.15$, $MS_e = .44$, indicating less priming in the moderately impaired group. Target word frequency was significant, $F(1, 18) = 31.71$, $MS_e = 0.87$, with high frequency words (.22) given as problem solutions more often than low fre-
TABLE 1
Mean Proportion of Priming, Nontarget, and Blank Responses for Word-Completion Problems

<table>
<thead>
<tr>
<th>Response</th>
<th>Normal</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Priming*</td>
<td>.16</td>
<td>.17</td>
<td>.16</td>
<td>.12</td>
<td>.09</td>
<td>.03</td>
</tr>
<tr>
<td>Nontargets*</td>
<td>.71</td>
<td>.79</td>
<td>.66</td>
<td>.73</td>
<td>.76</td>
<td>.86</td>
</tr>
<tr>
<td>Blanks*</td>
<td>.05</td>
<td>.09</td>
<td>.12</td>
<td>.17</td>
<td>.09</td>
<td>.12</td>
</tr>
</tbody>
</table>

*Priming is the difference between presented and control items. *Nontargets are responses that were not in the selected pool of target or control word responses. *Blanks are the items to which the subject made no response at all.

Frequency words (.08). Priming in all three groups was significantly greater than zero, $t(6) = 3.16$, 4.80, and 4.38, for the normal, mildly impaired, and moderately impaired groups, respectively.

Explicit memory was measured by the recognition memory test, and the proportion of recognition responses are presented in Table 2. The analysis revealed a significant effect for word (presented vs. control), $F(1, 18) = 30.35$, $MS_e = 3.39$, and a significant Group x Word interaction, $F(2, 18) = 11.08$, $MS_e = 3.39$. Presented items were more likely to be recognized than were nonpresented items, and this effect differed for the three groups. A test of simple group effects indicated that the groups differed significantly on the number of hits (presented words), $F(2, 18) = 21.30$, $MS_e = 3.39$. Using Scheffé's criterion for pairwise comparisons, we found that normal subjects' recognition hits were significantly higher than the recognition hits of either the mildly or moderately impaired subjects. The difference between the mildly and moderately impaired groups was not significant. The groups did not differ in the number of false alarms, $F < 1$. The normal subjects had

TABLE 2
Mean Proportion of Hits and False Alarms in Recognition Task

<table>
<thead>
<tr>
<th>Response</th>
<th>Normal</th>
<th>Mildly impaired</th>
<th>Moderately impaired</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hits*</td>
<td>.579</td>
<td>.300</td>
<td>.129</td>
</tr>
<tr>
<td>False alarms*</td>
<td>.100</td>
<td>.143</td>
<td>.100</td>
</tr>
</tbody>
</table>

*Hits are the number of presented items identified as presented. *False alarms are the number of nonpresented items identified as presented.
significantly more hits than false alarms, $t(6) = 5.10$. The mildly and moderately impaired subjects' number of hits did not differ significantly from the number of false alarms, $t(6) = 2.21$ and $1.08$, respectively. Thus, recognition memory performance declined across the three groups to chance, or guessing, levels of responding for the moderately impaired group.

Because the recognition test was done with the same words that served as presented and control targets in the word-completion problems, we examined recognition performance conditional on having produced or not produced the target word as a solution to the word-completion problem. The recognition hits were similar when previous problem solutions were held constant, $F(2, 18) = 1.63, p > .20$, for the interaction between conditional recognition and groups. Average recognition scores given prior solution were .72, .43, and .11, and for nonsolved problems they were .53, .26, and .11, for the normal, mildly impaired, and moderately impaired groups, respectively. Thus the recognition differences cannot be attributed to any differences in word-completion performance.

MMSE scores were correlated with explicit and implicit memory scores derived from each subject's recognition and word-completion data. The explicit memory score was the number of hits minus the number of false alarms, and the implicit memory score was the number of presented target solutions minus the number of control word solutions. The correlations of MMSE total scores with priming ($r = .49$) and recognition ($r = .74$) were both significant. Age correlated significantly with recognition ($r = -.61$) but not with priming ($r = -.40$). Education did not correlate significantly with either recognition or priming.

Discussion

The major question was whether or not a discrepancy between implicit and explicit memory would be evident in cognitively impaired elderly adults and whether degree of impairment would influence such a discrepancy. That is, would implicit memory as well as explicit memory be impaired in the more severely impaired groups? Our conclusion is that such discrepancies are sensitive to both the type of memory test used (implicit, explicit) and the type of material used (high frequency words, low frequency words).

Explicit memory and, to a lesser extent, implicit memory were affected by the severity or degree of impairment. Explicit memory performance was diminished for both mildly and moderately impaired subjects, in accord with previous findings (e.g., Brandt et al., 1986; Shimamura et al., 1987).

The pattern of results found here for implicit memory performance may help to explain earlier contradictory findings. The implicit memory performance of mildly impaired subjects was similar to that of the normal subjects, replicating Brandt et al. (1986) and others. Moderately impaired subjects
showed significant declines in implicit memory performance (word-stem completion), particularly for low frequency words. This finding also replicates previous work (Shimamura et al., 1987).

The critical factor of severity of impairment is also evidenced in the correlations of MMSE scores with both priming and recognition. The MMSE-recognition correlation was .74, indicating a strong positive relationship. A similar positive relationship (.49) existed between MMSE score and priming (implicit memory), though the relationship was not as great. These differences help account for the differential sensitivity of implicit memory tests to varying levels of cognitive impairment. In other words, implicit memory performance is not influenced as much as explicit memory performance by the level of cognitive functioning.

There was a significant age difference between the three groups in this experiment, with the most impaired group being older than the other two groups. We were interested in degree of cognitive impairment, however, regardless of the source of that impairment. The cognitive impairment of the subjects in this study derived from various etiologies, some of which may have been age related. The age difference, therefore, is not critical to the major conclusions of the study.

Thus, implicit and explicit memory were similarly affected in individuals with severe cognitive impairments; both implicit and explicit memory were diminished compared to normal subjects. When impairment was mild, however, implicit memory performance remained intact despite impairment of explicit memory.

REFERENCES


Received October 16, 1989