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Procedural and Declarative Memory Processes: Individuals With and Without Mental Retardation

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Learning and retention of procedural versus declarative memory tasks were examined with 26 young adults with mild mental retardation and 27 school children matched for MA. Results revealed a similar pattern of task performance. Performance of the young adults with mild mental retardation was inferior to that of the control subjects on both types of tasks. However, learning rate and retention over time were comparable, thereby maintaining the control group's consistent advantage throughout all repeated trials. These results are consistent with previous findings for individuals with mental retardation tested on memory and problem-solving tasks. Theoretical implications of this pattern of results for individuals with mild mental retardation were discussed.

Investigators have found that individuals with mental retardation have deficits in various types of memory (for a review see Hale & Borkowski, 1991). Borkowski (1965) suggested that people with low intelligence have a limited memory capacity. Ellis (1963) attributed the memory limitations of individuals with mental retardation to their rapid trace decay. Belmont and Butterfield (1973) and Brown (1974) reported a significant improvement in the memory of individuals with mental retardation after they were taught to employ rehearsal strategies. Turnure and Gudeman (1984) have shown that when given verbal or visual retrieval cues, individuals with mental retardation can improve recall of verbal and visual pair associations. This type of evidence led Byrnes and Spitz (1977) to conclude that

> a major deficiency [exists] in individuals with mental retardation when compared with matched-MA [mental age] individuals without mental retardation on tasks requiring logic, strategy, and foresight. (p. 567)

Thus, whereas individuals without mental retardation tend to lessen the load of memory by using organizational mnemonics, such as chunking and categorization, people with mental retardation do not benefit from such strategies due to their intellectual limitations.

There is a great deal of controversy in the field about memory deficits of this population. For example, is "storage" the primary memory deficit or is memory of individuals with mental retardation qualitatively different from that of those without mental retardation, or is there simply a quantitative deviation along the same performance continuum between those with and without mental retardation? (For a review, see Turnure, 1991.)

Spitz and his colleagues conducted a series of studies to directly measure the ability of individuals with mental retardation to use logical reasoning, foresight, and strategy when confronted with problem-solving tasks (Minsky, Spitz, & Besselieu, 1985; Spitz & Borys, 1984; Spitz & DeRisi, 1978; Spitz & Nadler, 1974; Spitz, Webster, & Borys, 1982; Spitz & Winters, 1977). Overall, they found that people with mental retardation performed significantly below the level of school children without mental retardation who were matched for mental age (MA). After receiving strategy training, however, the subjects with mental retardation improved their performance and maintained their improvement over a period of 9 to 13 weeks. However, Spitz et al. also found that generalization and transfer of these strategies was very limited.

In recent years there has been increased interest in the residual learning capabilities of another group of cognitively impaired individuals, namely, those with amnesia. Corkin (1968) found that people with amnesia can acquire new motor skills. Investigators also found that they retained the ability to learn and remember new cognitive skills, such as solving a visuospatial puzzle like the Tower of Hanoi puzzle (Cohen, Eichenbaum, Deacedo, & Corkin, 1985) or mirror reading (Cohen & Squire, 1980).

Based on these findings of dissociations between preserved and affected memory faculties, Cohen and Squire (1980) suggested that memory is composed of two different systems: the declarative memory system and the procedural memory system. *Declarative memory*, or "knowing that," refers to memory of new facts and events, such as a list of words or pictures. *Procedural memory*, "knowing how," refers to skill learning, such as riding a bicycle or solving the Tower of Hanoi puzzle. For skill learning, it is difficult to identify what is specifically learned. Cohen et al. (1985) described the essence of skill learning, stating that

> with practice, amnesic patients and control participants become better able to derive the solution to the puzzle without necessarily explicitly remembering the puzzle, the component steps of the puzzle, or a set of explicit rules for solving. (p. 68)

Thus, it follows that in amnesia, the declarative memory system has been found to be impaired whereas the procedural memory system is preserved.

It is interesting that the tasks applied by Spitz and others to assess some types of problem-solving ability are the same tasks classically employed as procedural memory tasks. One of the most well-known procedural memory tasks is the Tower of Hanoi puzzle (Cohen et al., 1985), which was also the test most frequently used by Spitz and colleagues to assess depth of search (Byrnes & Spitz, 1977; Minsky et al., 1985; Spitz & Borys, 1984; Spitz et al., 1982). However, it is important to note that there are several differences between the way the Tower of Hanoi puzzle was administered and scored by Spitz and his co-workers when used with individuals who have mental retardation and the way it was used by researchers of amnesia (i.e., Cohen and co-workers). The test that has been administered to people with mental retardation consists of actual pegs and disks, and the required arrangement is always in view. By contrast, in many studies of amnesia, investigators have employed a computerized version of the task, as we did in the present study. In addition, only a solution of seven moves was scored as correct in studies of people with mental retardation, whereas in studies of patients with amnesia, the total number of moves to completion of the puzzle was recorded.

The declarative/procedural memory dissociation found among individuals with amnesia may contribute to the understanding of memory processes of individuals with mental retardation. This is particularly so because the tasks employed by researchers to measure procedural memory of individuals with amnesia are the same tasks used by investigators to examine depth of search by individuals with mental retardation.

Several researchers have distinguished between two aspects of memory:

learning rate, which is the increase in the amount of information acquired from trial to trial, and *retention,* which is the amount of information retained after a delay period from the learning episode (Huppert & Piercy, 1982; Squire, 1981). The present study was designed to determine differences in performance of individuals with mental retardation on learning rate and retention on two procedural tasks and two declarative tasks. Our focus was on memory processes per se; therefore, we did not use any interventions such as manipulation of different strategies or training methods (e.g., Minsky et al., 1985), as was done in earlier studies. We believe that such a direct comparison between tasks measuring different memory types will further help to clarify the relation between certain kinds of problem-solving difficulties and different aspects of memory in individuals with mental retardation.

Method

Participants

Subjects were 26 young adults with mild mental retardation (17 males, 9 females) and children matched for MA (but not chronological age [CA]). The young adults were recruited from a special public school for young adults with mental retardation in the central region of Israel. They ranged in age from 16 to 21 years (mean = 18.58, standard deviation [*SD*] = 1.68). Their IQs, which ranged from 54 to 75 (mean = 60.23, *SD* = 4.26), were obtained from administration of the Hebrew adaptation of the Wechsler Intelligence Scale for Children-Revised—WISC-R (Lieblich, Ben Shachar-Segev, & Ninio, 1976). This test is administered to children with mental retardation when they are admitted to school.

We asked teachers to nominate individuals who they believed would be cooperative and could communicate effectively. Of the 37 thus identified, 26 met the following criteria for participation in the experiment: (a) diagnosis of mild mental retardation—IQ range 50 to 75 (American Psychiatric Association, 1994), (b) not currently taking medications known to affect the central nervous system, (c) capable of understanding the task requirements, and (d) capable of completing the Tower of Hanoi puzzle at least once.

The control group consisted of 27 children (16 males, 11 females) matched for MA who were recruited from a public school in the central part of Israel. They ranged in age from 9 to 12 years (mean = 10.70). The formula IQ = (MA/CA) × 100 was used to determine MA (Byrnes & Spitz, 1977). Thus, by transposition (MA = [IQ × CA] divided by 100), an 11.2-year-old would be a match for a young adult with a CA of 16 and an IQ of 70.

Tests and Procedure

Participants were tested individually in two sessions one week apart. To test procedural memory we used the Tower of Hanoi puzzle (Cohen et al., 1985) and Porteus Mazes (Porteus, 1950), and to test declarative memory we employed the Visual Paired Associates, a subtest of the Wechsler Memory Scale-Revised (Wechsler, 1987), and the Rey Auditory Verbal Learning Test (Lezak, 1983).

We administered The Tower of Hanoi puzzle three times: twice in the first session, half an hour apart, and once in the second session, one week later. At the beginning of the first session, participants completed the puzzle four times, then four more times half an hour later, and, finally, four additional times at the second session a week later. The Porteus Mazes were administered twice, once in each session. Each declarative test was administered twice, half an hour apart for the Visual Paired Associates and after a 20-minute delay for the Rey Auditory Verbal Learning Test, as determined by standard administration. For half of the participants from each group, one of the declarative tests (e.g., Rey Auditory Verbal Learning Test) was administered in the first session and the other test (e.g., Visual Paired

Associates), in the second session. For the other half of the participants, the order of tests was reversed.

Tower of Hanoi Puzzle. This task was based upon a computer program written for a PC computer. Participants are seated in front of a computer screen. Three pegs are presented on the screen, numbered from 1 to 3. At the outset, three rings are arranged on the left-most peg, with the largest ring on the bottom and the smallest ring on the top. Participants were told that the goal was to move the three rings from the left-most peg to the right-most peg in the minimum number of steps. They were also told that they could move only one ring at a time, they could not place a large ring on a small ring, and that they could use the middle peg. The optimal solution for three rings requires seven moves. In order to move the rings, one must first press the number (1, 2, or 3) reflecting the original position of the peg to be moved and then press the number of the peg to which one chooses to move the ring. The computer automatically registers the number of moves and the average time per move. At the beginning of the first session, participants completed the puzzle four times, then four more times half an hour later, and, finally, four additional times at the second session a week later.

Porteus Mazes. Ten mazes were presented in order of difficulty, from the simplest (i.e., age 5 level) to the most difficult (i.e., adult level). For this task, participants were asked to mark the path from the starting to the exit point with a pencil. They were also requested not to lift the pencil while solving the maze, not to enter a dead-end alley, and to avoid transection of the lines of the maze. We gave two scores on the task: the number of mazes correctly solved (maximum of 10) and number of errors measured as the total number of entrances to blind alleys (the number of other errors was negligible) (Porteus, 1950). The mazes were presented to the participants to solve once in each session.

Visual Paired Associates. This subtest consists of a set of 6 different colors paired with 6 nonsense shapes. Each card (10 cm × 14 cm) contains one pair. The same set is repeated three consecutive times, each time in different order, thus totaling 18 cards. Following each set of 6 cards, 6 testing cards are presented, each card comprising only a shape. At this time, participants are shown a folder with 8 different colors and are asked to point to the color pair of the given test card shape. One more matching test trial is repeated half an hour after completion of the first three consecutive trials. In order to test for delayed memory, we presented only the test cards in the fourth trial. The Visual Paired Associates subtest was administered to half of the participants in the first session and to the other half in the second session.

Rey Auditory Verbal Learning Test. The Hebrew version of the test (Vakil & Blachstein, 1993) was administered in standard fashion (Lezak, 1983). The test consists of 15 common nouns that are read to participants five consecutive times (Trials 1 to 5). After each trial, subjects are asked to recall as many words as possible. In Trial 6, an interference list of 15 new common nouns is presented, followed by free recall of these new nouns. In Trial 7, participants are again asked to recall the first list. Twenty minutes later participants are once again asked to recall the first list (Trial 8). They are then requested to identify the 15 words from the first list out of 50 words (that also include the 15 words in the second list and 20 new common nouns) (Trial 9). In the first session the Visual Paired Associates test was administered to half of the participants, who were then given the Rey Auditory Verbal Learning Test in the second session. This order was reversed for the other half of the participants.

Testing Order

The first session contained (a) the four trials of the Tower of Hanoi puzzle, then

(b) a declarative test (i.e., either the three trials of the Visual Paired Associates or the first seven trials of the Rey Auditory Verbal Learning Test), (c) the 10 Porteus Mazes, (d) four trials of the Tower of Hanoi puzzle, and, finally, (e) the declarative task (i.e., either the fourth trial of the Visual Paired Associates or Trials 8 and 9 of the Rey Auditory Verbal Learning Test). The second session started with (a) the four trials of the Tower of Hanoi puzzle, followed by (b) a declarative test (i.e., the one not presented in first session), then (c) Porteus Mazes, and finally (d) the second part of the declarative test.

Results

Tower of Hanoi Puzzle

The task was administered in three testing periods (immediate, half an hour later, and a week later). There were four learning trials in each period. Two separate dependent measures, which were automatically generated by the computer program, were employed to analyze the data: number of moves for completion and the average time per move. The average time per move measure is preferable to the measure of total time to complete the puzzle because the latter is confounded with the first measure—the number of moves (i.e., the more moves, the longer it takes to solve the puzzle).

Number of Moves. The number of moves required to complete the Tower of Hanoi puzzle was analyzed in three alternatives ways, each using different measures: (a) mean number of moves, (b) median number of moves in each testing period, and (c) number of times (out of the 4 learning trials) the puzzle was completed in the minimum number of moves (i.e., 7).

First, the number of moves required by the two groups to complete the puzzle was analyzed for the four repeated trials in the three testing periods (see Table 1). The results were submitted to a mixed design analysis of variance to determine the effect of Group (young adults with mental retardation, control) × Learning Trials (1 to 4) × Testing Period (immediate, half an hour, one week). The first factor was between-subjects and the last two, within-subjects. The three main effects reached significance. The subjects with mental retardation needed more moves overall to complete the puzzle, $F(1, 51) = 17.10$, $p < .001$. Overall, there was a significant learning effect from trial to trial, $F(3, 153) = 5.15$, $p <. 002$, and there was improvement over the testing periods, $F(2, 102) = 8.03$, $p < .001$. The Group × Testing Periods and the Group × Testing Periods × Learning Trials interactions did not reach significance; however, there was a tendency towards significance, $F(2, 102) = 2.87$, $p = .061$, and $F(6, 306) = 1.86$, $p = .087$, respectively. Table 1 shows this tendency, as both groups began with similar performance and then diverged over the testing period.

Table 1
Mean Number (and *SD*) of Moves on Puzzles by Group, Trial, and Testing Period

Testing period/ Group[a]	Learning trial: First Mean	*SD*	Second Mean	*SD*	Third Mean	*SD*	Fourth Mean	*SD*	Mean	*SD*
First										
Control	10.67	5.13	10.41	5.32	8.82	3.24	8.59	3.04	9.62	2.74
YAMR	10.73	2.81	10.46	2.90	11.08	3.48	10.58	4.03	10.71	1.74
Second										
Control	8.41	2.56	8.15	5.32	7.82	1.92	7.96	2.18	8.08	1.76
YAMR	11.35	3.83	9.00	2.42	9.19	2.93	8.89	2.90	9.61	2.03
Third										
Control	8.30	2.11	7.78	2.10	7.67	1.57	7.22	0.58	7.74	1.14
YAMR	10.54	2.79	10.92	4.21	10.89	3.48	9.46	4.50	10.45	2.94

[a]*N* = 27 control subjects, 26 young adults with mental retardation (YAMR).

Second, the median number of moves required for each participant to solve the puzzle in each testing period was analyzed (see Table 2). A mixed-design analysis of variance was conducted to analyze the effects of group and testing periods. As was the case with the mean number of moves, only the main effects reached significance: $F(1, 51) = 13.73$, $p < .001$, and $F(2, 102) = 6.65$, $p < .002$, for group and testing periods, respectively. These results indicate that the control group required fewer moves overall than did the mentally retarded group to complete the puzzle and that the number of moves required to complete the puzzle decreased from one testing period to another. The nonsignificant interaction between the main effects should be interpreted cautiously because it is a negative finding (i.e., it fails to reject the null hypothesis). Thus, these results do not provide evidence against the claim that the decrease in number of moves over testing periods was similar for both groups.

Table 2
Means and *SD*s of the Median Number of Moves Required by the Groups to Complete the Puzzle and Puzzles Completed in Minimum Number of Moves

	Testing period					
	First		Second		Third	
Puzzle/Group[a]	Mean	*SD*	Mean	*SD*	Mean	*SD*
Median moves						
Control	8.87	2.28	7.93	1.67	7.48	1.01
YAMR	10.35	1.70	9.17	2.49	9.40	3.03
Puzzles completed in minimum number of moves						
Control	1.96	1.37	2.70	1.49	3.00	1.21
YAMR	0.81	1.20	1.62	1.44	1.23	3.03

[a]$N = 27$ for control subjects, 26 young adults with mental retardation (YAMR).

Third, the number of puzzles completed in the minimum number of moves (i.e., 7) in each testing period was analyzed (see Table 2). Consistent with the previous two analyses of number of moves, the main effects reached significance, but the interactions between them did not. Overall, the control group completed puzzles in the minimum number of moves more often than did the mentally retarded group, $F(1, 51) = 18.95$, $p < .001$, and the number of puzzles completed in minimum moves increased from one testing period to the other, $F(2, 102) = 10.86$, $p < .001$. Also as found in earlier analyses, the nonsignificant interaction between the main effects is a negative finding and should, therefore, be interpreted cautiously. Thus, we did not find evidence against the claim that the number of puzzles completed in minimum moves increased from one testing period to the other and was similar for both groups.

Average Time Per Move. Table 3 presents the mean average time per move (and *SD*) required by the two groups to complete the puzzle for the four repeated trials in the three testing periods. Again, all three main effects reached significance. That is, average time per move was longer for the mentally retarded group, $F(1, 51) = 13.03$, $p < .001$, there was a significant overall decrease in average time per move from trial to trial, $F(3, 153) = 31.01$, $p < .001$, and there was a reduction in average time per move over testing periods, $F(2, 102) = 39.51$, $p < .001$. Two of the interactions did reach significance. As can be seen in Table 3, the significant Group × Testing Periods interaction, $F(2, 102) = 4.28$, $p < .02$, indicates that over the testing periods, subjects in the mentally retarded group reduced the average time per move more than did those in the control group. The significant Learning × Testing Periods interaction, $F(6, 306) = 3.14$, $p < .005$, suggests that the reduction in average time per move from trial to trial was steeper in the first as compared to the third period.

Porteus Mazes

This task was administered twice in the first session and once a week later. Two separate dependent measures were employed to analyze the data: number of mazes correctly solved and number of errors (i.e., entrances to blind alley).

Table 3
Mean of Average Time Per Move (in Seconds and *SD*) Required to Complete the Puzzle

Testing period/ Group[a]	Learning trial: First Mean	*SD*	Second Mean	*SD*	Third Mean	*SD*	Fourth Mean	*SD*	Mean	*SD*
First										
Control	6.37	2.58	4.95	1.93	4.11	1.77	3.91	1.58	4.84	1.62
YAMR	8.78	4.75	7.59	4.64	6.69	3.00	6.14	3.09	7.30	3.46
Second										
Control	4.04	2.06	3.24	1.14	3.26	1.36	3.11	1.28	3.41	1.27
YAMR	5.15	2.56	5.24	4.49	4.42	2.26	4.79	2.91	4.90	2.04
Third										
Control	4.11	2.08	2.76	1.03	2.60	1.07	2.48	0.78	2.99	1.12
YAMR	4.27	2.42	3.61	2.05	3.45	2.02	2.98	1.76	3.58	1.88

[a] N = 27 control subjects, 26 young adults with mental retardation (YAMR).

Number of Mazes Completed. Table 4 presents the mean number (and *SD*) of mazes completed by the two groups in the two testing sessions. The results were submitted to a mixed-design analysis of variance to analyze the effect of group (mentally retarded, control) by testing Session (immediate, one week later). The former is a between-subjects factor, and the latter is a within-subjects factor. The only factor that reached significance was group main effect, $F(1, 51) = 13.73$, $p < .001$, suggesting that the young adults with mental retardation completed fewer mazes overall than did the control subjects. As can be seen in Table 4, although both groups completed more mazes in the second session than in the first session, this change was not significant.

Number of Errors. Because the subjects in the mentally retarded group solved fewer mazes than did those in the control group, a direct comparison of the total number of errors made by the two groups would not be accurate. Examination of the results indicates that the first four mazes were solved by all participants; therefore, we analyzed the number of errors made in these mazes. Table 4 shows the mean number of errors (and *SD*s) made by the two groups in solving the first four mazes in the two testing sessions. Analysis of the same variables listed earlier indicated that the only significant main effect was testing session (i.e., both groups made fewer errors in the second testing session, $F[1, 48] = 11.91$, $p < .001$).

Visual Paired Associates

Table 5 presents the mean number of correct answers (and *SD*s) given by the two groups on the four Visual Paired Associates task trials. As described earlier, participants were tested on the correct matching of colors to six nonsense shapes. The learning procedure was repeated three times consecutively. Half an hour later, participants were exposed only to the shapes and were asked to point to the

Table 4
Mean Number and *SDs* of Completed Mazes and Number of Errors on First Four Mazes by Group and Testing Session

Group[a]	Completed mazes: First test session Mean	*SD*	Completed mazes: Second test session Mean	*SD*	No. of errors on first 4 mazes: First test session Mean	*SD*	No. of errors on first 4 mazes: Second test session Mean	*SD*
Control	7.41	1.05	7.48	.89	1.65	1.65	.92	1.26
YAMR	5.89	1.84	6.15	1.78	2.67	3.37	1.79	2.41

[a] N = 27 control subjects, 26 young adults with mental retardation (YAMR).

Table 5
Mean Number and *SD*s of Correct Answers Made by Group and Trial on the Visual Paired Associates Task

	Trial 1		Trial 2		Trial 3		Trial 4	
Group	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*
Control[a]	3.33	1.73	4.41	1.37	5.00	1.07	5.11	1.34
YAMR[b]	2.15	1.16	2.92	1.62	3.73	1.89	3.50	1.86

[a]$N = 27$. [b]$N = 26$.

matching color. Thus, two separate analyses were conducted: the first three trials were regarded as a measure of learning and the fourth trial was compared to the third trial as a measure of retention over time.

Learning. The results were submitted to a mixed-design analysis of variance to analyze the effect of Group (mentally retarded, control) × Learning Trials (1 to 3). The former effect is a between-subjects factor, and the latter is a within-subjects factor. Both main effects reached significance, but the interaction did not. Subjects in the control group learned more pairs overall than did those in the mentally retarded group, $F(1, 51) = 15.25, p < .001$. Overall, there was a significant increase in number of pairs learned from trial to trial, $F(2, 102) = 30.70, p < .001$. As with the procedural tasks, the nonsignificant interaction between the main effects, $F(2, 102) = .28, p = .75$, should be interpreted cautiously because it fails to reject the null hypothesis. Inspection of individual data suggests that the nonsignificant interaction is not due to a ceiling effect for the control group because only 11 out of 27 control participants reached the maximum score of 6 in the third learning trial as compared to 8 out of 26 for the participants with mental retardation.

Retention. Both groups were compared for performance on the fourth trial relative to the third trial as a retention measure. The group main effect (i.e., control subjects better then subjects with mental retardation) was the only factor to reach significance, $F(1, 51) = 13.37, p < .001$.

Rey Auditory Verbal Learning Test

One of the advantages of this test is that many memory measures can be extracted from it, such as immediate recall, retention, learning rate, and recognition (Lezak, 1983; Vakil & Blachstein, 1993). Table 6 presents the mean number (and *SD*s) of words recalled in the 8 trials of the Rey Auditory Verbal Learning Test and the number of words correctly recognized on Trial 9 by group. In the present study we compared groups primarily on the learning and retention measures of this test.

Learning. We used a mixed-design analysis of variance on the first five trials of the test. The group effect is a between-subjects factor and learning trials is the within-subjects factor. The two main effects reached significance, but the interaction did not. Overall, participants in the control group recalled more words than did those in the mentally retarded group, $F(1, 51) = 8.87, p < .004$. There was also a significant increase in the number of words recalled from the first to the fifth trial, $F(4, 204) = 139.45, p < .001$. Once again, the nonsignificant interaction between the main effects, $F(4, 104) = .68, p = .61$, should be interpreted cautiously because it is a negative finding. As before, inspection of the individual data suggests that the nonsignificant interaction is not due to a ceiling effect for the control group because only 3 out of the 27 control participants reached the maximum score of 15 words on the fifth learning trial as compared to 1 out of 26 participants with mental retardation.

Table 6
Mean Number and *SD*s of Words Recalled on the Rey Auditory Verbal Learning Test (AVLT)

	Control group (n = 27)		YAMR[b] (n = 26)	
Trial of AVLT[a]	Mean	*SD*	Mean	*SD*
1	5.96	1.40	4.81	1.60
2	8.41	2.45	6.73	2.60
3	10.15	2.03	8.19	2.97
4	11.67	2.18	9.77	2.88
5	11.82	2.32	10.35	2.86
6	5.70	1.46	5.12	1.84
7	10.19	2.86	8.50	3.54
8	10.30	2.58	9.12	3.57
9	14.33	.73	13.62	1.70

[a]First 8 trials were number of words recalled and Trial 9 was number of words correctly recognized. [b]Young adults with mental retardation.

Retention. We measured retention by comparing the number of words recalled on the fifth trial to the number of words recalled 20 minutes later on the eighth trial. As can be seen in Table 6, participants recalled fewer words overall on the eighth, as compared to the fifth trial, $F(1, 51) = 28.47$, $p < .001$. Although there was a tendency for the control subjects to recall more words than did subjects with mental retardation, this advantage was not significant. The Group × Delay interaction was also not significant.

Retrieval Efficiency. A common way to derive a retrieval efficiency measure from the Rey Auditory Verbal Learning Test is by comparing the number of words (after a 20-minute delay) recalled in Trial 8 to the number of words correctly recognized in Trial 9 (Vakil & Blachstein, 1993). Similar to the findings on the previous measure, although there was a tendency for the control participants to remember more words than did the participants with mental retardation, this advantage was not significant. Overall, fewer words were recalled on Trial 8 as compared to the number of words recognized on Trial 9, $F(1, 51) = 131.83$, $p < .001$. The interaction between these two factors was not significant. When we employed a t test to compare the number of words correctly recognized (i.e., Trial 9), we found that both groups were significantly different from one another, $t(26) = 3.73$, $p < .001$.

Intercorrelations Between the Different Measures

Pearson product-moment correlations between the scores of the different tasks were calculated for both groups. The measures from each task submitted to the analysis were (a) baseline performance (i.e., first trial), (b) last trial following training, (c) learning measure (the difference between the two previous measures), (d) delayed measure (the difference between the last trial—that is, the second measure and the delayed trial), and (e) the sum of all the learning trials. Tables 7 and 8 present the correlations for the control and mentally retarded groups, respectively. Not surprisingly, there was a strong relation between performance on the different measures within each task. There was also a strong relation between performance on the two procedural tasks and, to a lesser degree, between the two declarative tasks for the control group. However, there was no relation between performance on these tasks for the participants in the mentally retarded group. With the exception of a significant correlation between the delay measure of the Visual Paired Associates task and a few measures of the Porteus Maze task, most of the other significant correlations occurred only among the different scores for the same task.

Finally, we conducted two types of analyses to assess the relation between severity of mental retardation, as reflected by IQs, and the different memory measures. First, we determined Pearson product-moment correlations between the memory scores used previously and IQs. None of the correlations reached significance. Second, the mentally retarded group was divided into two subgroups, above and below IQ of 60, which was the median score in our sample. In a series of t tests in which the two subgroups were

Table 7

Intercorrelations Between the Scores of the Different Tasks for the Control Group (n = 27)

Measure[a]	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1 R Trial 1	.36	-.25	-.16	.62***	-.11	.28	.26	-.23	-.03	.34	-.04	.29	.05	.40*	-.30	-.02	.23	-.27	.04	.07	.30
2 R Trial 5	—	.81***	.19	.84***	.14	.51**	.16	-.21	.35	.05	-.09	.13	.12	-.03	-.25	.11	-.29	-.17	-.34	.18	-.16
3 R learn		—	.29	.49**	.21	.35	.01	-.07	.38*	-.17	-.06	-.05	.10	-.28	-.24	.13	-.44*	-.01	-.37	.15	-.34
4 R delay			—	-.01	.30	.24	-.14	.04	.45*	-.35	-.40*	-.31	-.34	-.30	-.35	.23	-.15	.19	.04	.20	-.23
5 R total				—	.02	.28	.14	-.17	.11	.16	-.01	.13	.12	.16	-.09	-.04	-.13	-.24	-.29	.04	.01
6 V Trial 1					—	.17	-.83***	-.16	.79***	.31	.03	.39*	.23	.18	-.10	.03	.33	.06	.20	.01	.30
7 V Trial 3						—	.42*	.04	.64***	.03	-.27	.15	-.08	-.17	-.34	.14	-.13	-.06	-.14	.17	-.09
8 V learn							—	.17	-.36	-.27	-.18	-.27	-.26	-.26	-.10	.05	-.38	-.09	-.27	.09	-.33
9 V delay								—	.02	-.18	-.17	-.25	-.32	-.21	-.05	-.03	-.14	-.09	-.02	-.01	-.18
10 V total									—	.21	-.11	.33	.04	.01	-.19	.06	.19	-.03	.16	.07	.15
11 T moves Session 1										—	.66***	.91***	.59***	.88***	.55**	-.03	.42*	.09	.02	-.07	.55**
12 T time Session 1											—	.57**	.75***	.55**	.86***	-.21	.41*	-.14	.24	-.19	.39*
13 T moves learn												—	.60***	.68***	.39*	.02	.39*	-.01	.01	.02	.52**
14 T time learn													—	.45*	.34	-.35	.10	-.14	-.02	-.35	.15
15 T total moves														—	.51**	-.03	.35	.11	.06	-.07	.43*
16 T total time															—	-.08	.56**	-.08	.32	-.06	.54**
17 P completed session 1																—	-.24	.53**	-.19	.96***	-.20
18 P errors session 1																	—	-.26	.70***	-.17	.88***
19 P completed learn																		—	-.34	.26	-.12
20 P errors learn																			—	-.07	.28
21 P completed total																				—	-.18
22 P errors total																					—

[a]R = Rey Auditory Verbal Learning Test, V = Visual Paired Associates task, T = Tower of Hanoi puzzle, P = Porteus Mazes, learn = last trial–first trial, delay = delayed trial–last trial, total = sum of the learning trials.

*$p < .05$. **$p < .01$. ***$p < .001$.

Table 8
Intercorrelations Between the Scores of the Different Tasks for the Mentally Retarded Group (n = 26)

Measure[a]	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1 R Trial 1	.46*	-.11	-.03	.64***	.21	.17	.04	.08	.23	.39*	.09	.00	.10	.40*	.03	.11	.03	.14	-.16	.09	.08
2 R Trial 5	—	.83***	-.02	.90***	.25	.29	.16	.33	.28	.22	-.07	.10	.00	.19	-.06	-.13	.10	.06	.00	-.15	.11
3 R learn		—	.00	.61***	.15	.22	.15	.32	.17	.00	-.14	.11	-.06	-.04	-.08	-.22	.09	-.02	.11	-.22	.07
4 R delay			—	-.02	-.35	-.25	-.04	.11	-.33	-.09	.32	-.35	.18	.26	.37	-.11	.30	-.24	.37	-.06	.24
5 R total				—	.27	.31	.17	.12	.33	.40*	.04	.09	.05	.38*	.09	-.14	.00	.05	-.07	-.16	.02
6 V Trial 1					—	.50**	-.13	.19	.75***	.13	.11	-.01	-.02	.13	.22	-.09	-.30	.17	-.34	-.13	-.26
7 V Trial 3						—	.79***	.45*	.91***	.26	-.01	.15	-.06	.12	.19	.03	-.09	.16	.11	-.01	-.14
8 V learn							—	.38	.52**	.21	-.09	.18	-.06	.04	.05	.09	.17	.06	.36	.08	.03
9 V delay								—	.35	.03	-.17	.00	-.23	.14	-.05	-.32	.58**	-.07	.58**	-.32	.52**
10 V total									—	.27	.04	.16	-.04	.10	.23	-.04	-.18	.16	-.06	-.07	-.20
11 T moves Session 1										—	.14	.27	.19	.68***	.10	-.15	.25	-.05	.14	-.15	.26
12 T time Session 1											—	-.35	.86***	.34	.82***	-.17	-.03	.01	-.13	-.19	.00
13 T moves learn												—	-.15	-.44*	-.36	-.02	.11	-.07	.26	.00	.06
14 T time learn													—	.19	.45*	.04	-.08	-.02	-.10	.05	-.07
15 T total moves														—	.38*	-.24	.30	.01	.11	-.25	.33
16 T total time															—	-.27	.02	.07	-.05	-.30	.04
17 P completed Session 1																—	-.63***	.29	-.41*	.97***	-.64***
18 P errors Session 1																	—	.04	.74***	-.67***	.98***
19 P completed learn																		—	-.02	.07	.05
20 P errors learn																			—	-.42*	.59**
21 P completed total																				—	-.68***
22 P errors total																					—

[a]R = Rey Auditory Verbal Learning Test, V = Visual Paired Associates task, T = Tower of Hanoi puzzle, P = Porteus Mazes, learn = last trial–first trial, delay = delayed trial–last trial, total = sum of the learning trials.
*$p < .05$. **$p < .01$. ***$p < .001$.

compared on the same memory scores as used previously, the two subgroups differed significantly on only one comparison. Participants with IQs above 60 completed an average of .62 more Porteus Mazes in the second testing session than in the first, whereas those with the lower IQs completed an average of only .08 more mazes in the second testing session. This difference between the groups was significant, $t(24) = 2.31$, $p < .03$.

Discussion

Other investigators have viewed memory deficits observed in individuals with mental retardation as secondary to their limited processing abilities, which prevent them from benefiting from the organization of items or their logical relations (Byrnes & Spitz, 1977; Hale & Borkowski, 1991). This view has been supported by results of studies in which investigators directly measured the logical reasoning and a strategic approach to problem solving by individuals with mental retardation (Minsky et al., 1985; Spitz & Borys, 1984; Spitz & DeRisi, 1978; Spitz & Nadler, 1974; Spitz & Winters, 1977). These researchers found quite consistently that individuals with mental retardation have difficulties in processing such tasks. When guided, such individuals can use and retain some suggested strategies, but they have very limited ability to generalize and apply the solution to other tasks. This may be the explanation for the slightly different pattern of intercorrelations we observed in the present study between the young adults with mental retardation and the control group. Individuals in the control group may have exhibited a stronger relation between the procedural tasks because they applied a broader and more abstract strategy that generalized beyond the specific task. By contrast, the young adults with mental retardation may not have shown the same relation in their scores on the different tasks because of lack of generalization; that is, they coped with each task as if it were unique, thus applying very specific strategies suited only for that particular task.

It is interesting that a number of the common tasks (e.g., the Tower of Hanoi puzzle) employed to analyze depth of search are also frequently used as procedural memory tasks in studies about amnesia. Nonetheless, depth of search has not previously been compared directly to memory per se. The present study is the first in which memory terminology (i.e., declarative and procedural memory) has been applied to individuals with mental retardation.

Our purpose in the present study, then, was to compare a group of young adults with mild mental retardation to a group of MA-matched school children on their performance on learning and retention of procedural versus declarative memory tasks. The results revealed a similar pattern of performance for the procedural and declarative memory tasks, despite administration differences between the tasks (e.g., number of learning trials). Specifically, initial performance level of subjects in the mentally retarded group was inferior compared to the MA-matched subjects in the control group. However, learning rate and retention over time were comparable in both groups, thereby maintaining the control group's consistent advantage over the young adults with mental retardation throughout all repeated trials. Declarative task results are congruent with results of other studies in the literature concerning the learning and memory abilities of people with mental retardation. As summarized by Spitz and Borys (1984):

> Retarded and nonretarded groups usually differ in acquisition level—as measured by immediate recall—but not in the slope of retention over short intervals. (p. 333)

Procedural task results in the current study may reflect two cognitive processes that have been demonstrated as being dissociative in individuals with mental retardation. The mentally retarded group's inferior initial performance level, as compared to the MA-matched control group, is consistent with previous reports of the poor problem-solving ability of young adults with mental retardation. The typical learning rate and retention over time of the same tasks displayed by participants with mental retardation in the present study reflects a different cognitive process (i.e., procedural learning). In addition to the theoretical implications of the dissociation found in the present study, there are also therapeutic implications: Specifically, young adults with mental retardation can still benefit from practice and retain what they have learned over time, even for tasks in which their initial performance is poor. We observed an interesting pattern of results in which young adults with mental retardation demonstrated variability (i.e., *SD*) over time and trials generally increased, whereas the control group's variability decreased. This pattern of results implies subgroup separation in the sample of young adults with mental retardation. In future research, more may be learned about these cognitive processes, as subgroup analyses are refined.

We note that the mentally retarded group was compared to a control group matched for MA but not for CA. The finding that the groups were not significantly different in their learning rate and retention over time indicates that these components of memory are associated with MA. However, although groups were matched on MA, they were still different in overall level of performance on the declarative and procedural memory tasks, indicating that these types of tasks are associated less with MA than are the previous components of memory. An additional control group matched on CA with the mentally retarded group might have helped to produce more conclusive results about this issue.

The similarity in performance pattern by the two groups on the procedural and declarative tasks contrasts with findings concerning individuals with amnesia. When procedural and declarative memory abilities of individuals with amnesia are compared, their procedural memory is consistently found to be intact whereas their declarative memory is impaired as compared to that of individuals without amnesia (Cohen et al., 1985; Cohen & Squire, 1980; Corkin, 1968). The diagnostic value of these findings is obvious, but can these findings add to our understanding of the nature of memory processes in individuals with mental retardation?

In the present study, memory performance of the mentally retarded group was parallel to that of the control group, although at a consistently lower level, on all memory tasks. Furthermore, this pattern was consistent, whether the memory measure was learning rate or retention. These results are interpreted as supporting the argument that unlike persons with amnesia, those with mental retardation have memory abilities that show only a quantitative deviation from memory performance of individuals without mental retardation. By contrast, memory of individuals with amnesia reflects a qualitative difference from that of control subjects because they are impaired on one type of task (i.e., declarative memory) as compared to control subjects, but perform equally well on another type of task (i.e., procedural memory). Turnure (1991) reached a similar conclusion in his review of the literature on memory and mental retardation. Further research along these lines is required in order to identify which components of the different cognitive processes are more compromised in young adults with mental retardation and which ones are less compromised. As demonstrated in the present study, such findings are of theoretical, therapeutic, and diagnostic value.

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