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Rates of forgetting on three measures of verbal learning using retention intervals ranging from 20 min to 62 days

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Abstract

Previous research has examined age effects in rates of forgetting at short delay intervals of 20–30 min. The present study examined age effects in three verbal memory tasks at longer delay intervals of up to 62 days. Study participants consisted of 371 community-dwelling men and women comprising three age groups 20–39, 40–59, and 60–79 years. Age differences in acquisition and 20-min delayed recall were found on each of the memory tasks (paragraph, word list, and word pairs). However, all age groups showed equivalent rates of forgetting after this short delay interval. When participants were required to retain information for longer delay intervals (i.e., 1–62 days), increasing age was associated with faster rates of forgetting for day 1, but not over longer delay intervals. Age differences in rates of forgetting for longer delay intervals and the facilitating effects of prompted recall are discussed in terms of encoding and storage *versus* retrieval processes. (*JINS*, 2001, *7*, 79–91.)

Keywords: Forgetting, Retention, Learning

INTRODUCTION

Neuropsychological assessment of verbal memory abilities requires that appropriate baseline data exist against which clinical scores can be compared. Ideally, these data should reflect the ability of cognitively intact individuals to acquire and retain information. Critical to this is a determination of how age affects these two processes. A review of the literature (Trahan & Larrabee, 1992) provides overwhelming evidence that increasing age produces a decline in the ability to acquire new information. There is also substantial agreement that older adults obtain lower scores than younger adults on delayed retention tests. This is immediately apparent by reviewing the age-stratified normative tables for any memory test commonly used in clinical practice. These age differences in retention scores *per se* do not necessarily mean that increased age accelerates the rate at which information is forgotten. Alternatively, the lower scores on retention tasks may merely represent a continuation of the lower levels of performance that occurred at the end of acquisition.

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To avoid the problem of comparing rates of forgetting when performance differences exist at the end of training, investigators have used different methods to adjust for acquisition differences. All of these procedures employ the common strategy of calculating the degree to which retention scores change from those obtained on the last acquisition trial. Saving scores, representing the percent of information retained (retention score/acquisition score × 100), are most commonly used. Higher scores show greater retention or less forgetting. Consequently, age produces an accelerated rate of forgetting when the saving scores of older individuals are lower than those obtained by younger persons. The degree of change from acquisition is also measured by the rate at which the scores change between acquisition and retention as shown by the slope of the function when a repeated-measures analysis of variance (ANOVA) is computed using age and time of testing as the two factors. Increased age is assumed to produce an accelerated rate of change when a significant interaction occurs between age and time of testing (i.e., nonparallel slopes) that shows a steeper slope for the older group relative to the younger group.

The majority of studies using these two procedures have reported that younger and older individuals forget visually and verbally presented information at comparable rates. In all of these studies, relatively brief retention intervals (i.e., 10–45 min) and recall measures were used (Cullum et al., 1990; Geffen et al., 1990; Haaland et al., 1983; Measso et al., 1990; Mitrushina & Satz, 1989; Mitrushina et al., 1991; Slamecka & McElree, 1983; Trahan, 1992; Trahan & Larrabee, 1992; Youngjohn & Crook, 1993). Thus, when acquisition differences are controlled, age does not produce an increased rate of forgetting. It appears that most age-associated differences observed on retention scores *per se* reflect those differences between younger and older persons previously observed during acquisition. However, other studies reported that rates of forgetting increased with increasing age for word list (Ivnik et al., 1990; Tombaugh & Schmidt, 1992) and word pairs (Cullum et al., 1990; Tombaugh & Schmidt, 1992; Tsang et al., 1991). It is also noteworthy that one of the few studies to use an extended retention interval (4 weeks) also reported accelerated rates of forgetting for older individuals (Harwood & Naylor, 1969).

Another way to avoid interpretive problems associated with different acquisition levels is to find some method of empirically equating acquisition levels. One approach is to increase the level of learning for the group that normally exhibits a lower level of learning. Huppert and Piercy (1979) have devised such a procedure which has been employed extensively to investigate rates of forgetting across a wide range of neurological impairments. In their initial study, they investigated whether Korsakoff patients exhibited an accelerated rate of forgetting. They used a visual recognition procedure in which 120 colored slides of pictures of common objects were shown during training. In order to equate the amount of learning between the two groups at 10 min, the 1-s exposure duration used for the control patients was increased four to eight times for the Korsakoff patients. Recognition memory was tested at 10 min, 1 day, and 7 days. Each test used a sample of 40 of the original pictures and 40 new pictures. The results from this experiment showed that equivalent rates of forgetting occurred. Application of this basic paradigm to a variety of different neurological impairments has consistently shown that patients with Korsakoff's syndrome and Alzheimer's disease have rates of forgetting comparable to those obtained by cognitively intact controls (Freed et al., 1989; Kopelman, 1985; Martone et al., 1986; Squire, 1981). However, when Huppert and Kopelman (1989) used this procedure to evaluate the effects of normal aging on recognition memory, they found that increasing age produced accelerated rates of forgetting.

Although increasing the stimulus duration has the intuitive appeal of circumventing the problem of differences in initial learning, there is some evidence showing that equating for performance at 10 min does not insure that all individuals learned equally well (Martone et al., 1986). Moreover, some researchers suggest that increasing the stimulus duration may produce other sources of variation (Wickelgren, 1975). Finally, results from other research using a similar procedure have reported that aging does not increase rate of forgetting (Rybarczyk et al., 1987; Spikman et al., 1995). For example, Spikman et al. (1995), using a forced-choice recognition procedure rather than a yes–no recognition paradigm, reported that age did not produce differential rates of forgetting when evaluated over five time periods ranging from immediate testing to 27 weeks.

In summary, two general conclusions can be reached from the preceding review. First, age produces a diminished ability to acquire new information. Second, the age-associated decline in retention scores *per se* probably reflects the differences in acquisition performance rather than accelerated rates of forgetting. Although the majority of data suggest that age does not produce a further reduction in the retention of information over and above that observed for acquisition, there is a sufficient body of contradictory evidence to make it premature to advance such a conclusion at this time. Even if one were to advance such a conclusion, the lack of data over longer retention intervals would limit the generalizability of such a conclusion to retention intervals of less than 1 h. While these short retention intervals may be sufficient for clinical diagnoses, longer retention intervals may show a different picture, one where accelerated rates of forgetting occur for older individuals (Geffen et al., 1990; Rybarczyk et al., 1987; Salthouse, 1991; Trahan & Larrabee, 1992).

Consequently, the primary purpose of the present experiment was to provide further information on the relationship between age and rates of forgetting when retention intervals varied from 20 min to 62 days. Within this context, one goal was to determine if the practical constraints associated with the clinical administration of memory tests produces a biased set of results which do not adequately reflect the effects which age exerts on the retention of information. That is, are the results obtained using the relatively short retention intervals in clinical applications (e.g., 15–20 min) representative of how age affects retention of information? A second purpose was to investigate whether different types of verbal learning paradigms produced different patterns of forgetting over extended delay intervals. Consequently, three verbal learning tasks (paragraph recall, word-list recall, and word-pair recall) were used. Although prior research has revealed that these types of tests are highly correlated (Schmidt & Tombaugh, 1995; Tombaugh & Schmidt, 1992), other research has indicated that they are not equally sensitive to neurological impairments (Schmidt et al., 1990). One major difference between the three different verbal learning tests used in the present study is the degree to which recall is aided by contextual factors. That is, recall of information contained in the paragraph is facilitated to a greater degree by the context in which discrete bits of information are embedded and the environmental support that it provides than either of the other two tasks. Recall of paired associates also benefits from the contextual association that is built up between the stimulus and response components. Word-list recall contains the least amount of contextual help and places the greatest cognitive load on internal strategies. From research showing that older adults are not as prone to use internal strategies as younger

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adults (Murphy et al., 1981), it is predicted that rates of forgetting will be related to the degree of contextual support provided by the three tasks, with the greatest rates of forgetting occurring for word-list recall. Finally, the present study was interested in investigating whether any difference in rates of forgetting reflects faulty encoding/storage processes or retrieval processes. Of the three tasks, the paragraph and word list contained recall, prompted-recall, and recognition procedures whereas the word pairs contained only recall and recognition procedures. Because recognition is generally assumed to be the most sensitive measure of stored information, accelerated rates of forgetting for older individuals that occurred on both recall and recognition measures would suggest diminished encoding or storage processes. On the other hand, if recognition measures substantially reduced the accelerated rate of forgetting observed with recall measure, retrieval processes would be implicated.

METHOD

Research Participants

Three-hundred-and-seventy-one participants, capable of independent living, were contacted through social groups, places of employment, and word of mouth. They were screened prior to testing in order to exclude those with a known history of neurological disease or major psychiatric illness. All participants scored higher than 28 on the Mini-Mental Status Examination (Folstein et al., 1975) and lower than 12 on the Geriatric Depression Scale (Brink et al., 1982).

Material

Three verbal subtests contained in the Learning and Memory Battery (Schmidt & Tombaugh, 1995; Tombaugh & Schmidt, 1992) were employed. Each test contains multiple learning trials and a 20-min delayed retention test. Each test is described below.

Paragraph

The paragraph test consists of six sentences describing an individual and his daily activities. There are 31 bits of verbal information (each consisting of a single word) to be recalled. The passage is presented twice during the acquisition portion of the test, each presentation being followed by recall and then prompted recall. Prompted recall consists of specific questions about missed information (e.g., "What did he have to eat for breakfast?"). Approximately 20 min after the last acquisition trial, a delayed retention trial is administered. Following recall, prompted recall is administered for incorrect answers. Recognition is used for items not retrieved on either recall or on prompted recall and consists of four-item multiple-choice questions regarding missed material (e.g., "Which of the following did he have for breakfast: toast, muffin, donut, or cereal?").

Word list

The word list consists of 15 unrelated words, such as pistol and dentist. Each word is selected from a more general category, such as weapon or profession. These general categories serve as semantic cues during the prompted-recall phases of the test. To reduce the risk of random guessing resulting in correct responses to these cues, the four words with the highest association to that category (Batting & Montague, 1969) were not included in the list. The word list is presented five times with all 15 words being presented on the first trial. However, only words that are missed on the prior trial are presented on the subsequent four trials (Buschke, 1973). This results in a different set of words being presented on each trial in contrast to the traditional word-list procedure where the same order of words is maintained on each trial. Each presentation is followed by recall and then prompted recall which uses the semantic cues for any word not previously recalled during recall (e.g., "Tell me the word that was a profession."). Finally, a 20-min delayed-recall trial consisting of recall, prompted recall, and recognition is used. Recognition utilized a four-item multiple-choice format (e.g., "Was the profession a doctor, an engineer, a dentist, or a lawyer?"), and is used only for words not recalled during prompted recall.

Word pairs

The word-pair task contained three easy (e.g., east–west) and 11 difficult (e.g., fire–sugar) word pairs. Each of the easy pairs were opposites and possessed a high degree of association through prior learning. Eight of the difficult word pairs consisted of concrete words (Paivio et al., 1968) that were not related to each other in any obvious way. The remaining three difficult pairs consisted of abstract words that also were not related to each other. Four acquisition trials were administered. The entire list is presented on the first trial, but only pairs that are missed on the previous trial are presented on all subsequent trials (Buschke, 1973). Following each presentation, the first word of the pair is presented, and the individual must recall the second word. Again, a 20-min delayed-recall procedure is utilized, first with recall and then with recognition procedures used for incorrect answers. Recognition employed a four-item multiple-choice format (e.g., "Which of the following words went with fire: sugar, smoke, secret, or salt?").

Procedure

After the initial training session, 326 participants were contacted by telephone 1–62 days later and asked to recall the information contained in each of the verbal tests using the same recall, prompted-recall, and recognition procedures described previously. The sequence of tests was as follows: retention for paragraph, word list, and word pairs. Individuals were not told in advance that they would be phoned. Only one person refused to participate in the phone test.

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The remaining 45 participants were administered only the 20-min retention interval. Thus, overall, there were seven retention intervals: 20 min, 1 day, 2–7 days, 8–21 days, 22–35 days, 36–49 days, and 50–62 days.

RESULTS

Demographic Information

The basic demographic data are shown in Table 1. Study participants were divided into the following three age groups: young (20–39 years, $n = 119$), middle-aged (40–59 years, $n = 110$), and older (60–79 years, $n = 142$). All participants took part in the acquisition and 20-min retention trials. For the extended 1–62 day retention trial, each participant was retested by telephone only once. Initially, some attempt at random assignment within each age group was made; however, if participants could not be contacted within the desired time frame, attempts were made to contact them at a later date. Because each person is only included in one extended delayed retention group, cell sizes for these groups are smaller.

There were no significant differences in education among the three age groups overall $F(2,350) = 2.15$, $p > .05$, or within each of the seven extended retention intervals. There were no significant age differences across the seven extended delay intervals within the younger group, $F(6,112) = 0.45$, $p > .05$. However, as Table 1 shows there were some small, nonsystematic age differences across the seven extended delay intervals within the middle-aged group, ($F(6,103) = 3.00$, $p < .05$), and within the older group ($F(6,135) = 3.97$, $p < .01$).

Acquisition Performance and 20-min Retention

Table 2 shows the mean scores for three different age groups on the last learning trial and on the 20-min delayed recall trial for all three verbal learning tests. To determine if age exerted any differential effects on the amount of information acquired at the end of acquisition, one-way analyses of variance (ANOVAs) were performed on scores from the last learning trial. The effect of age on amount of information retained during the 20-min retention interval was examined using 3 (age) × 2 (trials) mixed-model ANOVAs. If increasing age did not produce differential effects on retention (i.e., equivalent declines in performance occurred for all age groups), only the main effects due to age and trials should be significant. However, if age did exert a differential effect (i.e., increasing age produces faster decline in performance), then an age × trials interaction should occur. The analyses were performed on recall (R) scores and the sum of recall and recall scores (R+PR) for Paragraph and Word List, and on recall scores for Word Pairs. Because no recognition procedure was administered on the acquisition trials, the analyses could not be performed on R+PR+REC scores.

Paragraph

Inspection of Table 2 shows that increasing age produced lower recall scores on the last acquisition trial. A subsequent ANOVA confirmed this observation [$F(2,368) = 26.42$, $p < .001$]. The results of the 3 (age) × 2 (trials) mixed-model ANOVA revealed a slight but statistically significant age-associated increase in recall scores on the retention trial [Age: $F(2,368) = 33.00$, $p < .001$; Trials: $F(1,368) = 9.51$, $p < .01$]. However, the failure to obtain an age × trial interaction showed that this effect was comparable across the three age groups [Age × Trials: $F(2,368) = 2.31$, $p >.05$].

Although prompted recall increased acquisition performance for all groups, an analysis of the R+PR scores showed that a significant age effect still occurred [$F(2,368) = 14.53$, $p < .001$]. Performance declined by less than a single item on the retention trial with the greatest decrease occurring for the oldest group [Age: $F(2,368) = 18.98$, $p < .001$; Trials: $F(1,368) = 39.74$, $p < .001$; Age × Trials: $F(2,368) = 7.94$, $p < .001$].

Word list

Increasing age resulted in lower recall performance on the last learning trial [$F(2,368) = 31.79$, $p < .001$]. A slight decline in performance from acquisition to the 20-min retention trials was comparable across the three age groups as evidenced by the nonsignificant age × trials interaction [Age: $F(2,368) = 34.60$, $p < .001$; Trials: $F(1,368) = 14.53$, $p < .001$; Age × Trials: $F(2,368) = 0.97$, $p > .05$].

Analysis of R+PR scores failed to yield any statistically significant effects on the last acquisition trial [Age: $F(2,368) = 2.86$, $p > .05$]. On the retention trial, only the trial effect was significant [Age: $F(2,368) = 3.47$, $p > .05$; Trials: $F(1,368) = 19.91$, $p < .001$; Age × Trials: $F(2,368) = 1.12$, $p > .05$].

Word pairs

As previously observed, an age-associated decline in performance occurred on the last acquisition trial [$F(2,368) = 17.95$, $p < .001$]. The three age groups did not differ in performance from acquisition to retention trial [Age: $F(2,368) = 21.46$, $p < .001$; Trials: $F(1,368) = 69.78$, $p < .001$: Age × Trials: $F(2,368) = 2.96$, $p > .05$].

Summary

Overall, age exerted its primary effects on acquisition performance for all three verbal learning tests. These age-associated differences "carried over" and were evident on the 20-min retention trial. The failure to obtain any age × trial interactions for recall measures shows that age did not differentially affect the retention of information over the 20-min retention interval. The only evidence for a differential effect occurred when prompts were used in paragraph re-

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Table 1. Demographics for participants at each extended delay interval

	Delay intervals						
Total sample	20 min[a]	1 day	2–7 days	8–21 days	22–35 days	36–49 days	50–62 days
Young (20–39 years)							
n	15	14	15	13	22	27	13
Age	29.4 (5.8)	31.4 (4.0)	31.0 (3.8)	30.6 (5.5)	32.1 (4.1)	31.2 (5.3)	32.0 (4.5)
Education	12.5 (2.1)	12.2 (0.8)	11.6 (1.2)	13.0 (1.0)	13.6 (1.0)	14.0 (0.9)	14.2 (1.0)
Middle (40–59 years)							
N	15	11	14	21	18	19	12
Age	50.0 (5.7)	50.4 (6.1)	52.9 (4.2)	53.7 (5.8)	50.4 (6.8)	48.3 (5.9)	47.1 (6.1)
Education	12.5 (2.1)	12.2 (1.0)	11.6 (1.0)	12.6 (1.1)	12.6 (1.0)	14.6 (1.0)	14.0 (0.9)
Older (60–79 years)							
n	15	19	28	23	23	18	16
Age	70.4 (6.2)	71.3 (5.9)	21.0 (5.6)	70.6 (5.8)	66.4 (4.1)	66.1 (3.4)	69.1 (6.8)
Education	12.8 (2.8)	11.2 (1.0)	11.2 (1.1)	12.6 (1.5)	13.8 (1.4)	14.2 (1.3)	12.8 (1.7)

[a]Participants tested only at 20-min retention interval are included.

call. Even in this instance, the changes across the three groups were very small (Young = .2, Middle = .4, and Old = 1) and not clinically significant.

Extended Retention Intervals 1–62 Days—Percent Retained

As previously mentioned, interpretation of retention data requires some prior estimate of the amount of information previously acquired. The present analyses used the scores on the last acquisition trial as this reference point. Because age differences occurred in these scores, percent retained scores were used (i.e., the score for each extended retention interval divided by the score on the last acquisition trial $\times$ 100). Figures 1, 2, and 3 show the scores on each of the verbal subtests for the three age categories over the six extended retention intervals (1 day, 2–7 days, 8–21 days, 22–35 days, 36–49 days, and 50–62 days). Percent retained for an independent group that was only tested at 20 min is also included, making a total of seven retention intervals. To determine if age exerted any differential effects on the retention of information, 3 (age) $\times$ 7 (retention intervals) ANOVAs were performed on the percent-retained scores.

Paragraph

Figure 1 shows a general decline in recall performance for all ages over the seven retention intervals. Overall, the oldest group tended to recall a lower percentage of information than the two younger groups. Although it appeared that the performance of the oldest group declined at a faster rate during the first seven days, this interaction was marginally significant [Age: $F(2,350) = 16.49$, $p < .001$; Retention: $F(6,350) = 71.50$, $p < .001$; Age $\times$ Retention: $F(12,350) = 1.57$, $p < .10$]. Inspection of the data in Figure 1 suggests

Table 2. Mean (SD) score for the last acquisition trial and 20-min delay trial for three verbal learning tests[a]

	Age Groups					
	Young (20–39 years)		Middle (40–59 years)		Old (60–79 years)	
Test/trial	Last acquisition	20-min	Last acquisition	20-min	Last acquisition	20-min
Paragraph (max = 31)						
R	24.4 (4.6)	25.1 (4.7)	22.2 (5.4)	22.9 (5.1)	19.7 (5.7)	19.6 (6.0)
R+PR	27.9 (3.2)	27.7 (3.5)	27.0 (4.1)	26.6 (3.8)	25.2 (4.7)	24.2 (5.0)
Word List (max = 15)						
R	13.1 (1.8)	12.9 (2.0)	12.3 (1.8)	12.1 (2.3)	11.2 (2.3)	10.0 (2.9)
R+PR	14.6 (0.8)	14.5 (0.9)	14.5 (0.9)	14.3 (1.2)	14.4 (0.9)	14.1 (1.4)
Word Pairs (max = 14)						
R	12.4 (2.3)	12.0 (2.3)	11.7 (2.2)	11.1 (2.2)	10.3 (2.9)	9.7 (3.0)

[a]R: Recall. PR: Prompted Recall.

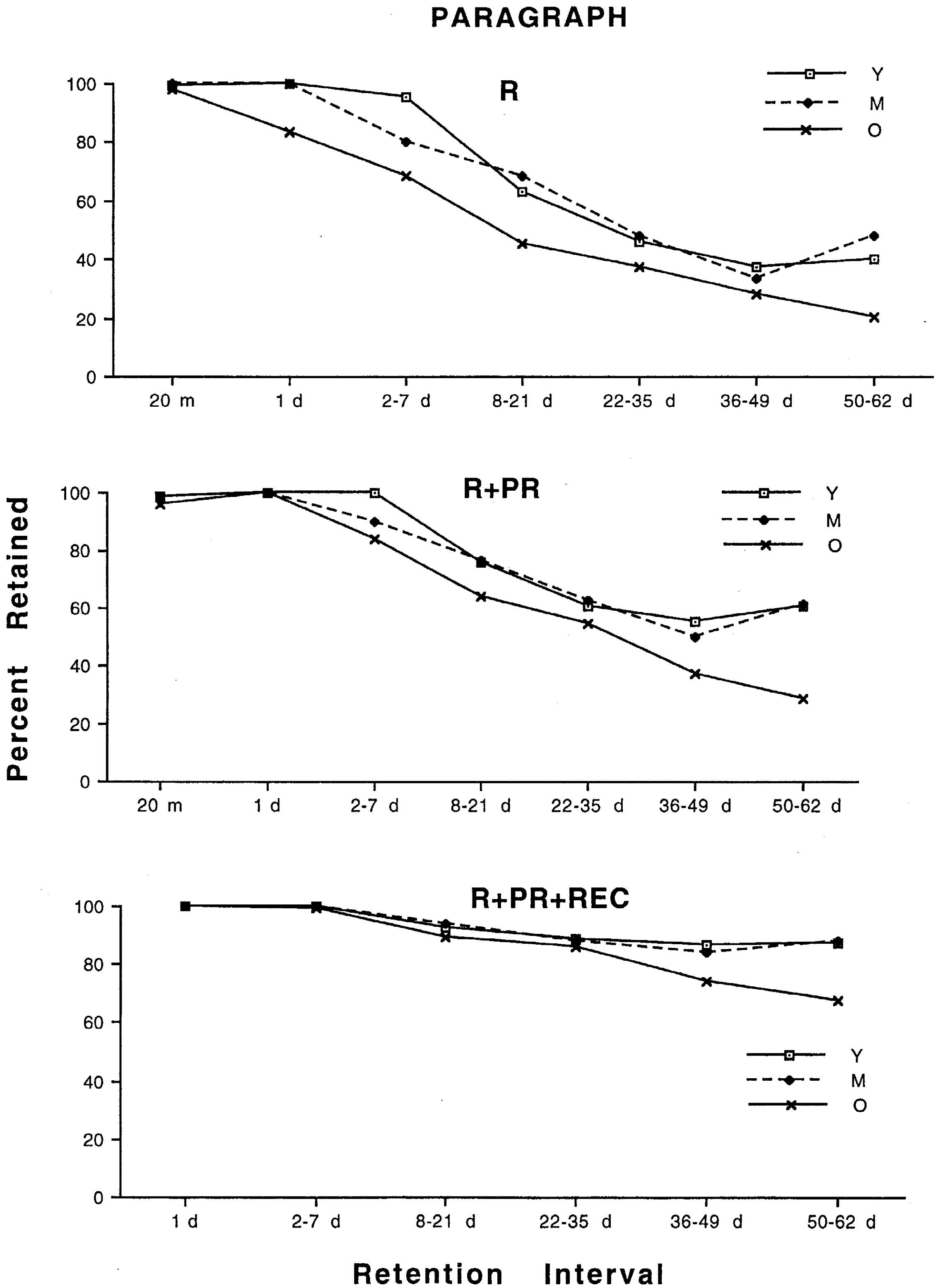

Fig. 1. Percent of paragraph recalled over extended retention intervals (20 min–62 days) for three age groups (20–39, 40–59, and 60–79 years). R: recall; PR: prompted recall; and REC: recognition.

that the marginally significant interaction was attributable to the parallel decrease in performance for the three age groups over the last five intervals which masks the interaction that occurred during the first two intervals by increasing the mean-squared-error term in the overall *F* test. Consequently, an ANOVA was performed over the first two intervals. The results of the analysis clearly show that the rate of decline was significantly faster for the oldest group

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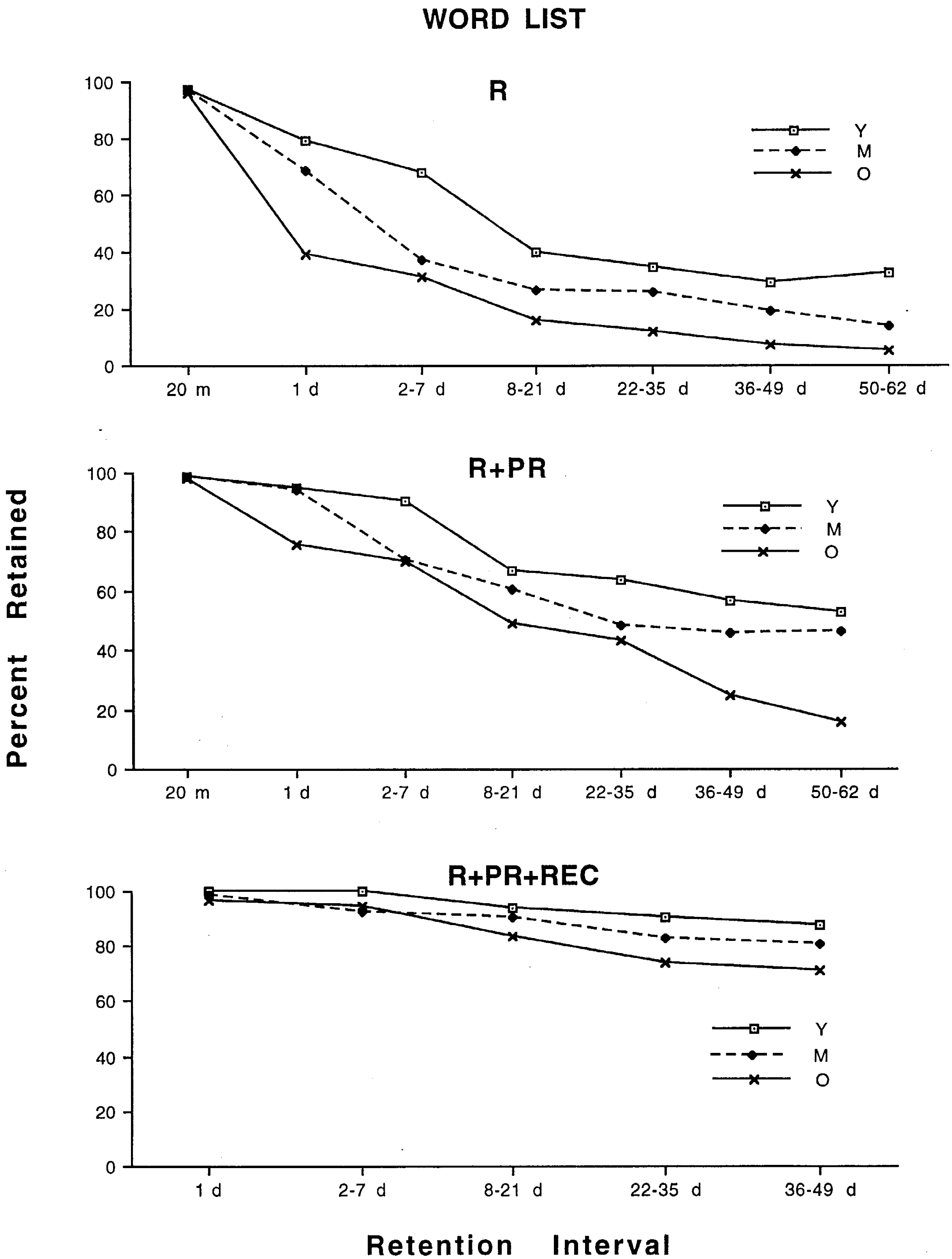

Fig. 2. Percent of word-list recalled over extended retention intervals (20 min–62 days) for three age groups (20–39, 40–59, and 60–79 years). R: recall; PR: prompted recall; and REC: recognition.

[Age: $F(2,83) = 4.30$, $p < .02$; Retention: $F(1,83) = 4.04$, $p < .05$; Age × Retention: $F(2,83) = 5.03$, $p < .01$].

As seen in Figure 1, the effects of age are decreased with increasing number of retrieval cues, particularly during the first 3 weeks. It should also be noted that a significant interaction occurred, primarily because of the faster rate of decline that occurred for the oldest group during the last two retention intervals [R+PR: Age: $F(2,350) = 23.74$, $p <$

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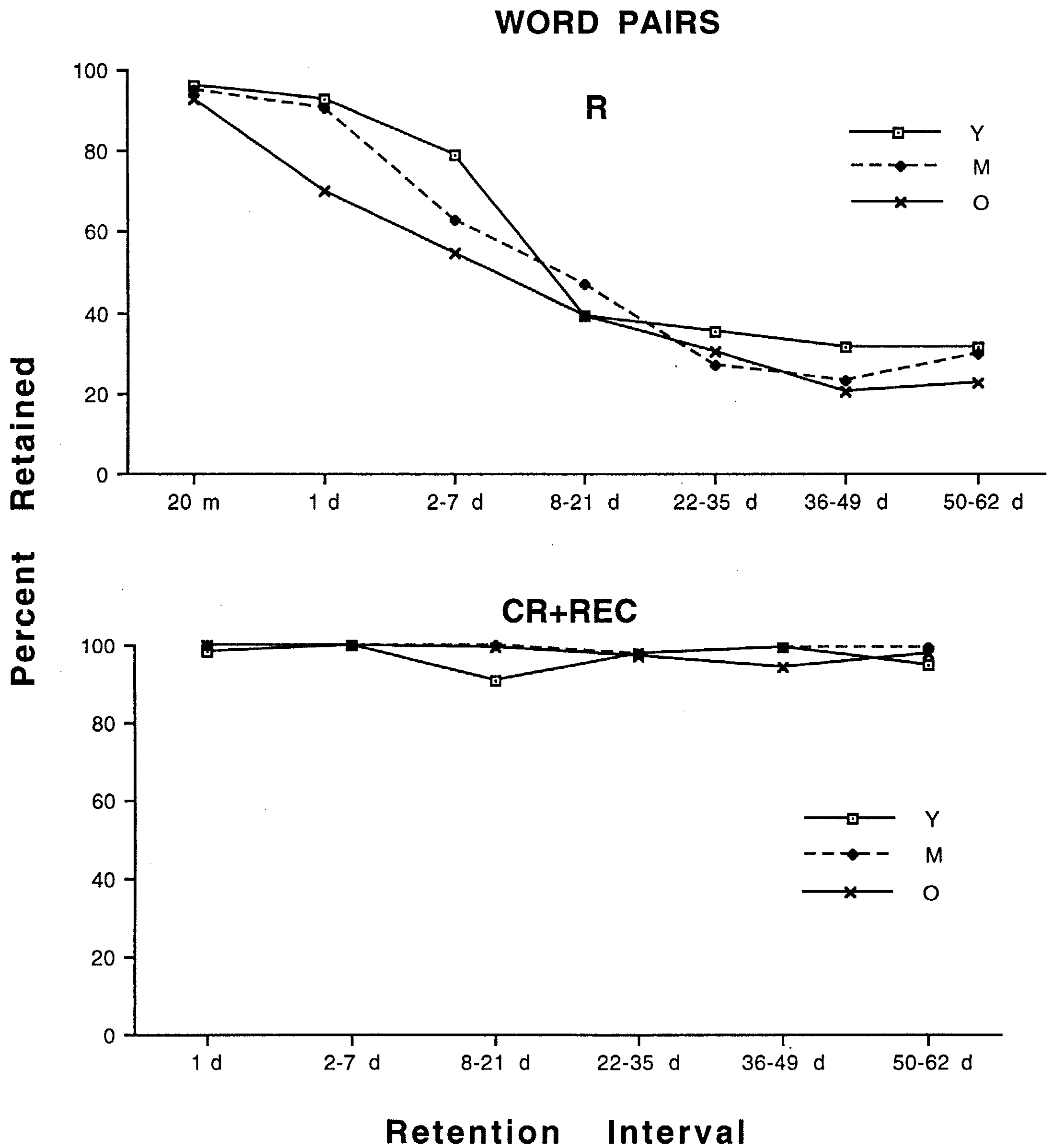

Fig. 3. Percent of word-pairs recalled over extended retention intervals (20 min–62 days) for three age groups (20–39, 40–59, and 60–79 years). R: recall; and REC: recognition.

.001; Retention: $F(6,350) = 94.18$, $p < .001$; Age × Retention: $F(12,350) = 2.10$, $p < .05$; R+PR+REC: Age: $F(2,308) = 13.5$, $p < .001$; Retention: $F(5,308) = 44.4$, $p < .001$; Age × Retention: $F(10,308) = 4.69$, $p < .001$].

Word list

Figure 2 shows that percent of information retained progressively declined over successive retention intervals with increasing age producing consistently lower performance [Age: $F(2,350) = 49.71$, $p < .001$; Retention: $F(6,350) = 94.73$, $p < .001$; Age × Retention: $F(12,350) = 1.99$, $p < .05$]. The significant age × retention interaction appeared to be attributable to the faster decline of the oldest group on Day 1. This observation was substantiated by a subsequent ANOVA [Age: $F(2,83) = 11.44$, $p < .001$; Retention: $F(1,83) = 71.33$, $p < .001$; Age × Retention: $F(2,83) = 6.13$, $p < .01$].

As seen in Figure 2, prompted recall and recognition reduced the magnitude of the differences among groups [R+PR: Age: $F(2,350) = 34.92$, $p < .001$; Retention: $F(6,350) = 64.53$, $p < .001$; Age × Retention: $F(12,350) = 1.91$, $p < .05$; R+PR+REC: Age: $F(2,306) = 20.9$, $p < .001$; Retention: $F(5,306) = 19.2$, $p < .001$; Age × Retention: $F(10,306) = 1.45$, $p > .05$].

Word pairs

Figure 3 shows results similar to those observed with the other two verbal tests. Percent recalled scores progressively declined over the seven retention intervals with the oldest

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group showing the fastest rate of decline during the first seven days [Age: $F(2,350) = 10.40$, $p < .001$; Retention: $F(6,350) = 127.54$, $p < .001$; Age $\times$ Retention: $F(12,350) = 2.25$, $p < .01$]. An ANOVA performed over the first two intervals showed the same type of interaction that was reported previously for the other two verbal learning tests [Age: $F(2,83) = 9.70$, $p < .001$; Retention: $F(1,83) = 20.19$, $p < .001$; Age $\times$ Retention: $F(2,83) = 4.67$, $p < .02$]. The R+REC measure shows similar effects but with greatly reduced magnitude [Age: $F(2,304) = 5.75$, $p < .01$; Retention: $F(5,304) = 3.38$, $p < .01$; Age $\times$ Retention: $F(10,304) = 3.92$, $p < .001$].

Extended Retention Intervals 1–62 Days—Empirical Adjustment of Baseline Performance

The previous analyses revealed that while age did not affect percent of information retained at 20 min, it progressively decreased performance at extended retention intervals with older participants recalling differentially less information during the first few days. The following section explores the degree to which performance was independent of how well the person performed during the short retention trial. If age effects are independent of these performance levels (i.e., high *vs*. low scores), then parallel effects of age should be observed during the extended interval regardless of the level of performance during the 20-min retention test. In order to test this hypothesis, recall performance at 20 min was divided into three levels representing the highest, middle, and lowest performance percentiles (i.e., 67–100, 34–66, and 0–33). The effects of age were then evaluated within each level. In essence, this approach represents another attempt to control for different levels of performance by empirically equating the level of performance across the three age groups using the 20-min scores as baseline.

To insure that no age-associated differences existed at the 20-min baseline condition, separate one-way ANOVAs were computed on the scores at each performance level. Generally, no statistically significant age effects occurred within the three performance levels for Paragraph, Word List, or Word Pairs. Small but statistically significant age effects were found, however, for the high baseline level for Paragraph [$F(2,100) = 3.52$, $p < .05$] and for the medium baseline level for Word List [$F(2,136) = 3.18$, $p < .05$].

Due to a reduced number of participants at various retention intervals, the data were collapsed over all retention scores. Scores for each age group for the three different levels of baseline performance are shown in Figure 4.

Paragraph

An examination of Figure 4 suggests that recall scores generally decline as a function of age. However, one-way ANOVAs showed this decline was only significant within the low and high baseline-performance levels [Low: $F(2,86) = 4.03$, $p < .05$; Middle: $F(2,110) = 0.53$, $p > .05$; High: $F(2,100) = 5.73$, $p < .01$]. Follow-up analyses using Tukey's HSD showed a significant difference occurred between the youngest and oldest groups for the low baseline condition while the two younger groups scored significantly higher than the oldest group for the high-performance group.

The same general age-associated decline in performance occurred for the R+PR condition [Low: $F(2,86) = 4.03$, $p < .05$; Middle: $F(2,110) = 0.05$, $p > .05$; High: $F(2,100) = 6.05$, $p < .01$] and for the R+PR+REC condition [Low: $F(2,86) = 4.93$, $p < .01$; Middle: $F(2,110) = 0.96$, $p > .05$; High: $F(2,100) = 13.69$, $p < .001$]. Follow-up analyses showed the same results as found with the recall measure.

Word list

Inspection of Figure 4 shows that within each baseline level of performance, recall scores declined as a function of age [Low: $F(2,80) = 10.29$, $p < .001$; Middle: $F(2,136) = 5.43$, $p < .01$; High: $F(2,93) = 12.55$, $p < .001$]. Follow-up analyses using Tukey's HSD indicated that in the low baseline-performance condition the youngest age group performed significantly better than the two older age groups. In the middle-performance condition, the only significant difference was between the youngest and oldest groups. In the high-performance condition, all three age groups differed significantly from each other.

For R+PR scores, the age effect was only statistically significant in the high baseline-performance condition, although there was a trend in the low-performance condition [Low: $F(2,80) = 2.94$, $p < .06$; Middle: $F(2,136) = 1.62$, $p > .05$; High: $F(2,93) = 6.43$, $p < .01$]. Follow-up analyses indicate that in the high-performance condition the oldest age group scored significantly lower than the two younger age groups. Similar results were found for R+PR+REC [Low: $F(2,80) = 1.10$, $p > .05$; Middle: $F(2,136) = 1.06$, $p > .05$; High: $F(2,93) = 7.84$, $p < .001$]. Follow-up analyses indicate that in the high-performance condition the youngest group scored significantly higher than the two older age groups.

Word pairs

Significant age effects were found at both the low and middle baseline levels of performance [Low: $F(2,83) = 3.48$, $p < .05$; Middle: $F(2,114) = 3.82$, $p < .05$; High: $F(2,112) = 1.64$, $p > .05$]. Follow-up analyses using Tukey's HSD showed that there was a significant difference between the youngest and oldest age groups at the low baseline level and between the middle and oldest age groups at the middle baseline level. For R+REC, the effects of age were observed only for the middle baseline-performance level where a slight but statistically significant decrease in performance occurred for the middle-age group relative to the older group [Low: $F(2,83) = 0.95$, $p > .05$; Middle: $F(2,114) = 4.24$, $p < .05$; High: $F(2,112) = 0.53$, $p > .05$]. For R+REC at the middle baseline performance the significant differences in performance were found between the middle and oldest age groups.

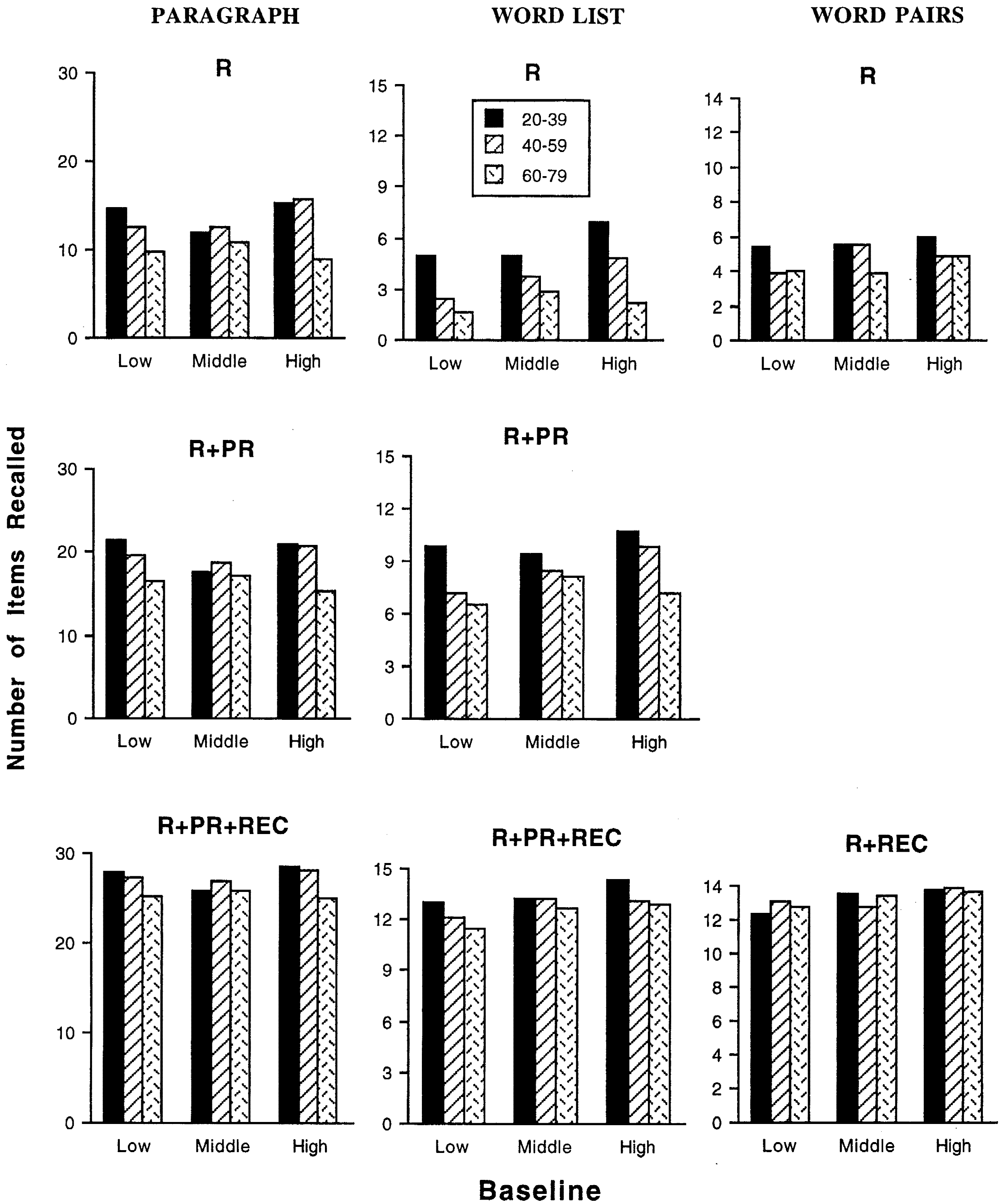

Fig. 4. Number of items recalled on three baseline conditions for paragraph, word list and word pairs as a function of age (20–39, 40–59, and 60–79 years). R: recall; PR: prompted recall; and REC: recognition.

DISCUSSION

Age was found to have a highly consistent effect on three different verbal learning tasks. In each case, lower performance was associated with increasing age when recall measures were employed. Prompted-recall procedures were found to reduce or eliminate these age-associated effects. Overall, these results are not particularly surprising and contribute to an ever increasing body of literature showing that one of the major effects of aging is an increased difficulty

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acquiring and/or recalling new information. Several authors have suggested that much of this difficulty is due to inadequate encoding strategies or inefficient retrieval processes due, in part, to the preferential effects that aging has on frontal lobe functioning (Albert, 1988; Craik et al., 1995; Mitrushina & Satz, 1989; Shimamura et al., 1991). Certainly the facilitating effects provided by prompted recall supports this contention and suggests that much, but probably not all, of the difficulty that older adults have in recalling information is due to some type of retrieval deficit that is partly compensated for by prompts that aid in the recovery of previously stored information.

The effects that age has on the retention of information show a similar pattern across the three verbal learning tests. However, the degree to which this pattern exists depends upon a number of factors including the amount of time that has elapsed after the information was learned, the precise type of verbal learning test employed, and the extent to which recall is facilitated by prompts.

When only a short, 20-min retention interval was used, as frequently occurs in a clinical situation, the effects of age on the recall of information previously learned in the three verbal tasks were generally small in magnitude. The general failure to obtain an interaction between age and retention shows that the scores from all age groups had a similar rate of change. Further confirmatory evidence was provided in that all age groups showed equivalent percent-retention scores. These results suggest that age produces a significant difference in the amount of information acquired at the end of the learning trials and that any age-associated effects observed at the 20-min delay interval primarily reflect the level of performance that occurred previously, at the end of acquisition. Stated somewhat differently, when the effects of acquisition differences are controlled, rates of forgetting over the 20-min retention interval are equivalent across age groups. Although similar conclusions have been advanced by others (Albert, 1988; Craik et al., 1995; Cullum et al., 1990; Mitrushina et al., 1991; Slamecka & McElree, 1983; Trahan & Larrabee, 1992; Youngjohn & Crook, 1993), the results from longer retention intervals, as discussed below, indicate that this conclusion should be restricted to brief retention intervals.

When individuals were required to retain information longer than for 20 min, a somewhat different picture emerged. In general, increasing age produced a greater decline in performance when retention was tested within the first day after the information had been acquired. The most pronounced effect occurred during the first 24 h where the performance of the oldest group declined faster than that of the other two groups. The age-associated differences that occurred for recall on the first day were generally maintained throughout extended retention. The relatively consistent differences among the three age groups over the remaining 61 days indicate that increasing age exerts its primary effect some time during the first 24 h and does not further differentially decrease recall with the additional passage of time. One important implication of these data is that it is unwise to base any conclusion about the effects of age on retention of information when only a single retention interval is employed.

Evidence that the rate of forgetting is faster for older than younger individuals is also provided by the analyses of the raw scores when they were divided into three different levels of baseline performance. This procedure has the net effect of empirically equating levels of acquisition performance within three restricted band widths. If age is the critical variable in determining the rate of forgetting, rather than the degree to which individuals initially learned the material, then its effects should be observed regardless of whether the individual fell in the highest, middle, or lowest third of the 20-min delayed recall baseline performance. If, on the other hand, the results were related to factors such as ceiling effects that might have occurred with the younger but not the older individuals, then different functional relationships among ages should occur between the different baseline conditions. The data in Figure 4 clearly show this latter explanation was not the case, for within each baseline level performance declined in a similar manner as a function of age. These results are impressive given that the analyses for the low baseline condition compared the "lower" functioning younger and middle aged adults against average older adults, and the analyses for the high baseline compared the "higher" functioning older adults against the average younger and middle aged adults. That is, when the baseline levels were divided into the three levels of performance, the low baseline-level scores represented the average performance of the older adults and the below-average performance of the younger adults. On the other hand, the high baseline scores were more representative of the average younger person and the above-average performance of the older adults. More precise interpretation of these data is hampered by the fact they were collapsed over all retention intervals making it impossible to determine the relative contribution of different temporal intervals.

Overall, the effects of age in all analyses were most pronounced on recall measures. Increased environmental support in the form of prompts and recognition stimuli substantially decreased the magnitude of the effect. Thus, as seen with the relatively brief retention intervals, the diminished recall scores appear to reflect some type of a deficiency in retrieval processes. The size of this effect increased substantially over the first 24 h post-acquisition. This suggests that during acquisition older adults were less efficient in encoding information than younger individuals so that the information was less accessible for recall after a 24-h interval. However, under relatively brief retention intervals, the age-associated differences did not occur. Moreover, the effectiveness of the encoding processes appeared to vary among the three verbal learning tasks. The age-associated differences were the greatest on word list—a task which probably afforded the least amount of associative context and where individuals had to use the greatest number of spontaneous encoding strategies—and least on paragraph and word pairs where the learning context provided a more associative structure. The relative differences in rates of forgetting on the three verbal learning measures cautions against making general statements about the relationship between age and rate of forgetting when the results are restricted to a single verbal learning test.

Previous research has shown that younger individuals are more likely to spontaneously use verbal or visual mediators in the acquisition of new information while older individuals are more likely to employ rote learning (Hulicka & Grossman, 1967; Hultsch, 1971; Murphy et al., 1981; Perlmutter & Mitchell, 1982; Ratner et al., 1987; Rowe & Schnore, 1971). The difference in these approaches would facilitate greater retention by younger persons because mediated learning is more resistant to forgetting than material rotely learned (Kausler, 1982). It is also possible that the encoding processes of the younger adults made the information more resistant to interference effects at longer retention intervals despite the greater demand on retrieval processes.

Several factors indicated that interference effects due to competing verbal stimuli were kept at a minimum during the 20-min retention interval: (1) all individuals had been informed at the beginning of the test session they would be tested for retention of information, (2) nonverbal (i.e., visual or numeric) stimuli were employed as filler tasks during the retention interval, and (3) the brief retention test occurred under virtually the same environmental conditions as the acquisition. However, a different state of affairs existed for the longer term retention tests: (1) rehearsal of information during the longer retention intervals was reduced, if not eliminated, because individuals were not informed about the longer retention tests; (2) no control was exerted over the type of stimuli to which participants may have been exposed during the retention interval; and (3) the retention tests occurred in a different environment than the initial learning trials. All of these conditions offered greater opportunity for interference effects to reduce the ability of older adults to spontaneously retrieve information. However, when reliance on retrieval processes was reduced by prompted recall and recognition, older adults were able to demonstrate that they had retained the originally learned information to a level comparable to that of younger adults. There is, however, some evidence from examining Figures 2–4 suggesting that prompted recall and recognition no longer bestowed their benefits after retention intervals of about 6 or 7 weeks. This is particularly evident for performance on paragraph and word list.

Thus, it may be tentatively advanced that as time from the initial learning increases, older individuals, in addition to their diminished retrieval processes, also fail to retain as much verbal information as do younger adults because of deterioration in longer term storage. Although additional research is needed to substantiate this contention, some experimental support is available. Some supporting evidence is available from two prior studies that have used verbal learning paradigms with retention interval longer than 20 or 30 min. Wilmer (1960) reported that 24-h recall of seven nonsense paired associates was less for older individuals. Harwood and Naylor (1969) found that after 4 weeks older individuals recalled (percent retained) fewer names of pictures than younger persons. In addition, Huppert and Kopelman (1989), using pictures in a visual recognition paradigm that matched for performance level at 10 min, found older individuals exhibited a faster rate of forgetting than younger individuals at 24 h and 1 week.

Finally, the results from the present experiment indicate that the use of retention intervals longer than 20–30 min might also have clinical utility in detecting subtle changes in memory. That is, brief delays, such as the 20-min retention interval used in the present experiment, have proved to be extremely useful in clinical diagnosis where obvious and rapid decline in forgetting occurs such as in Alzheimer's disease. The age-associated decline in recall manifested on Day 1 of the present study suggests that clinical assessment over longer retention intervals may increase the diagnostic sensitivity for memory loss in the early stages of Alzheimer's disease or in cases involving minor head injury.

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