Temporal memory over the adult lifespan

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Performances of noncollege student young adults, middle-aged adults, and elderly adults were contrasted on word temporal memory and paired-associate learning tasks. A comparison group of college-student subjects was also evaluated on each task. Significant effects for age variation were found for each task. The age sensitivity for temporal memory conflicts with one of the criteria commonly established for determining the automaticity of a memory task. In addition, moderately high positive correlations were found for each age group between word temporal memory scores and paired-associate learning scores, implying the involvement of effortful processes over the adult lifespan in word temporal memory.

Temporal information has been commonly assumed to be among the memory attributes encoded automatically, that is, with minimal expenditure of cognitive effort (e.g., Hasher & Zacks, 1979; Toglia & Kimble, 1976). In question, however, is the extent to which temporal memory satisfies the criteria established for automaticity. These criteria include both the absence of an effect for practice and the absence of reliable individual differences in performances on successive temporal memory tasks (Hasher & Zacks, 1979, 1984). Zacks, Hasher, Alba, Sanft, and Rose (1984) recently presented evidence that challenges the satisfaction of either of these criteria. An additional criterion of automaticity is the absence of adult age differences in performance on a memory task. However, the evidence for this criterion with respect to temporal memory has thus far been conflicting. Although some researchers have found the absence of an effect for age variation (e.g., Perlmutter, Metzger, Nezworski, & Miller, 1981), others have found significantly lower temporal memory scores for older than for younger adults (e.g., Kausler, Lichty, & Davis, 1985; McCormack, 1982). The primary objective of the present study was to provide a thorough examination of adult age differences in temporal memory proficiency.

The present study differs from earlier studies examining adult age

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differences in temporal memory in several important ways. Two of the departures concern the nature of the subjects employed. First, the primary group of young adults consisted of individuals 20 to 39 years of age who were not currently attending college. Previous tests of adult age differences contrasted college students with elderly adults, thereby confounding student status with age. An additional group of college-student young adults, somewhat younger than the noncollege-student young adults, was also tested to determine the extent to which estimates of age deficits in temporal memory may be exaggerated by the use of college students as the baseline for comparison with older adults. Second, the noncollege subjects were selected from the entire age range of 20 to 79 years. This procedure permitted a regression analysis of the age-temporal memory performance relationship as well as the more traditional analysis of comparing the mean performances of young, middle-aged, and elderly groups of subjects.

Finally, all of our subjects performed on a paired-associate learning task. Paired-associate learning is commonly assumed to require effortful processing (e.g., Hasher & Zacks, 1979). Our interest concerns covariations at different age levels between scores on an effortful task and scores on presumably automatic temporal memory tasks. If temporal memory is guided by automatic processes, then little covariation with performance on an effortful task is to be expected at any age level.

EXPERIMENT

METHOD

Subjects

The noncollege-student subjects consisted of 45 young adults (21 men, 24 women) from 20 to 39 years of age (M = 29.1 years, SD = 6.2), 48 middle-aged adults (19 men, 29 women) from 40 to 59 years of age (M = 50.4 years, SD = 5.8), and 36 elderly adults (18 men, 18 women) from 60 to 79 years of age (M = 67.3 years, SD = 6.0). Means (standard deviations) for years of formal education were 14.4 (2.1), 14.1 (2.7), and 13.3 (2.7) for the young, middle-aged, and elderly groups, respectively. The overall correlation between age and educational level was statistically significant, $r(127) = -.24$, $p < .01$. Means (standard deviation) for a self-reported measure of health status (1 = excellent, 5 = poor) were 1.9 (0.9), 2.0 (0.8), and 1.8 (0.9) for the three age groups. The correlation between age and rated health status was not significant, $r(127) = -.05$. The college-student group (University of Missouri undergraduates) consisted of 11 men and 14 women (M = 19.5 years, SD = 1.9). The mean educational level for this group was 13.2 years, and the mean health rating was 1.9. All noncollege students were paid $10 for their participation in this study, and college-student subjects participated to satisfy a course requirement.

Materials and procedure

The present study was part of a large-scale normative project evaluating adults of different ages in their performances on various cognitive tasks, including the temporal memory task and the paired-associate learning task of present interest. All task materials were presented by means of an Apple IIc computer.

Two series of eight tasks each were performed by each subject. The series consisted of alternate forms of the following tasks: a digit symbol test, a number comparison test, a verbal short-term memory test, a spatial short-term memory test, a paper-folding test, an incomplete-picture identification test, and the forementioned paired-associate learning and word temporal memory tests. The use of two temporally separated paired-associate learning tests and word temporal memory tests permitted an analysis of practice effects for each task and of interlist consistency of performance (i.e., reliability) of each task.

Because tasks other than the paired-associate and the temporal memory tasks were not relevant to the present study, they will not be described further (see Salthouse, Kausler, and Saults, in press, for a complete description). The two forms of the paired-associate task each consisted of eight pairs composed of unrelated four-letter, high-frequency nouns. Two alternating study-test trials were given for each list. In the study phase, each word pair was displayed for 2 s; in the test phase, the first word from each pair was displayed alone until the subject named the word that had been paired with it. Different random orders of pairs in the study phase and stimulus words in the test phase were employed for each trial.

Each form of the word temporal memory task consisted of successive 4-s presentations of 16 unrelated words of varying lengths and grammatical form classes. The number of words in our lists was considerably less than the number employed in studies with young adults (e.g., 36 in the study by Zacks et al., 1984). Longer lists were likely to be viewed as "unlearnable" by many older subjects, resulting in negative reactions to the task and a probable floor effect in task scores. Subjects were instructed to pay attention to the order in which the words appeared for the purpose of subsequent reconstruction of that order (i.e., intentional memory). After the last word in the series was presented, a simple arithmetic task was performed for 30 s. The entire set of 16 words was then displayed, and the subjects assigned a number between 1 and 16 to each word to indicate its order of appearance in the previous series.

RESULTS

Temporal memory

Subject scores for temporal memory consisted of the correlations (*r*s) between true order and their reconstructed orders. Means and standard deviations for all age groups on the two tests (List 1 and List 2) of temporal memory are given in Table 1.

A 3 (Age) × 2 (Lists) mixed ANOVA for the noncollege subjects on the word temporal memory task revealed a significant main effect for age, $F(2, 126) = 4.92$, $p < .01$, $MS_e = 0.16$. Scheffé's test indicated a significantly higher mean score for young adults, $p < .05$, relative to both middle-aged and elderly adults, on both List 1 and List 2. However, the difference in means between middle-aged and elderly adults was not significant for either list, ps > .05. A comparable analysis of z-transformations of the individual correlation coefficients yielded essentially the same outcome. The presence of an overall age effect was confirmed further by the significant overall correlation between age and the average temporal memory score for the two lists combined, $r(127) = -.29$, $p < .01$ (intercept and slope values of the regression equation = .739 and −.005, respectively). In addition, the average score of the two lists for college students (.64) did not differ significantly from that of the noncollege-student young adults (.59), $t(68) < 1$, but it was significantly greater than that of either middle-aged adults (.45), $t(71) = 3.11$, $p < .01$, or elderly adults (.40), $t(59) = 3.69$, $p < .01$. Of further interest is the percentage of subjects in each age group having a correlation significantly greater than zero, $p < .05$, on each test of word temporal memory. These percentages for Lists 1 and 2, respectively, were 76.5 and 84.0 for college students, 60.0 and 71.0 for noncollege young adults, 45.8 and 45.8 for middle-aged adults, and 38.9 and 52.8 for elderly adults.

Neither the main effect for lists nor the Age × Lists interaction effect approached significance, Fs(1, 126) and (2, 126) < 1, $MS_e = 0.05$. In addition, the increment in scores from List 1 to List 2 for the college-student subjects (0.06) failed to reach significance, correlated-$t(24) = 1.00$, $p > .10$. The absence of a significant practice effect for college students contrasts with the significant increment over multiple lists reported by Zacks et al. (1984). However, it should

Table 1. Summary statistics for temporal memory scores (correlation coefficients)

	List 1		List 2		Average	
Age group	Mean	*SD*	Mean	*SD*	Mean	*SD*
College students	.61	.22	.67	.28	.64	.20
Noncollege young	.56	.26	.62	.29	.59	.21
Middle-aged	.47	.31	.44	.37	.45	.31
Elderly	.38	.34	.42	.37	.40	.31

be noted that the increment from List 1 to List 2 in the earlier study was only about .05, averaged over the two groups of subjects employed in that study. A clear practice effect emerged in their study only after more than two lists had been administered.

Interlist correlations (i.e., reliability coefficients) for word temporal memory scores were $r(23) = .28$, $p > .05$, for college students; $r(43) = .20$, $p > .05$, for noncollege young adults; $r(46) = .64$, $p < .01$, for middle-aged adults; and $r(34) = .55$, $p < .01$, for elderly adults. The surprisingly higher consistency in performance over lists for our older than for our younger subjects may be attributable to the greater interindividual variability of scores in the former groups (see Table 1). It should be noted that for the college student in the study by Zacks et al. (1984), interlist consistency in performance was apparent only between Lists 2 and 3 and Lists 3 and 4.

It is conceivable that our temporal memory scores reflected largely primacy and recency effects. That is, initial and terminal items may have been ordered correctly, with other items being assigned fairly random-to-ordinal positions. Given the brevity of the list, such effects would have greatly inflated the temporal memory scores. If true, the age differences in our scores may have resulted only from age differences in the recall of primacy and recency items. To test this possibility, an additional analysis was conducted for only the middle 12 items of the list (i.e., eliminating the first 2 and the last 2 items). For these midlist items, the correlation coefficients between true and reconstructed order, averaged over the two lists, were .42 for noncollege young adults, .29 for middle-aged adults, and .25 for elderly adults. Thus, the magnitude of covariation between true and reconstructed order was reduced substantially at each age level by the elimination of primacy and recency items (compare with the values in Table 1). Most important, however, the correlation between age and the average temporal memory score for the combined lists remained significant, $r(127) = -.24$, $p < .01$. Thus, the age-related deficit in temporal memory appears to be relatively independent of potential age differences in primacy and recency effects.

Paired-associate learning

Paired-associate learning scores consisted of the percentages of correct responses on Trials 1 and 2 for both List 1 and List 2. Means and standard deviations for all groups on each score are given in Table 2.

These scores were subjected to a 3 (Age) × 2 (Lists) × 2 (Trials) mixed ANOVA for the noncollege subjects. The main effect for age approached significance, $F(2, 126) = 2.94$, $p < .10$, $MS_e = 1988.68$.

For the regression analysis, age variation was related separately to scores on Trials 1 and 2, averaged in each case over lists. The correlation was significant for Trial 2, $r(127) = -.30, p < .01$ (regression intercept and slope values = 68.35 and −.461, respectively), but not for Trial 1, $r(127) = -.15, p > .05$. In addition, the difference in mean scores between college students and noncollege young adults was significant for Trial 2, averaged over lists, $t(68) = 3.10, p < .01$, and approached significance for Trial 1, $t(68) = 1.90, p < .10$.

The main effects for lists and trials were significant, $F(1, 126) = 3.96, p < .05, MS_e = 381.40$, and $F(1, 126) = 230.00, p < .0001, MS_e = 230.93$, respectively. The Age × Lists interaction effect was clearly not significant, $F(2, 126) < 1$, suggesting the presence of nonspecific positive transfer for all age groups. However, this null interaction effect needs to be considered in light of the significant Age × Lists × Trials interaction effect, $F(12, 126) = 3.30, p < .05, MS_e = 140.27$. From Table 2 it may be seen that nonspecific transfer was apparent mainly for Trial 1 and then only for college students and noncollege students in the 20–39 and 40–59 age groups. That is, little, if any, nonspecific transfer was present for our elderly subjects on either trial. The Age × Trials interaction effect was significant, $F(2, 126) = 4.91, p < .01$. Scheffé's test revealed a significantly higher mean score for the young adults relative to the elderly adults on Trial 2, $p < .05$. However, none of the other group comparisons for Trial 2 attained significance, nor did any of the age comparisons for Trial 1. The Lists × Trials interaction effect was also significant, $F(1, 26) = 11.81, p < .001$, reflecting the greater increment in scores from Trial 1 to Trial 2 for List 1 than for List 2.

Finally, interlist reliability coefficients were significant for all four groups on both Trial 1 and Trial 2. For Trial 1 the values were $r(23) = .42, p < .05$, for college students; $r(43) = .53, p < .01$, for noncollege

Table 2. Percentage correct responses for paired-associate learning

	List 1				List 2			
	Trial 1		Trial 2		Trial 1		Trial 2	
Age group	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*
College students	35.00	25.52	70.50	27.69	45.50	29.29	76.50	24.82
Noncollege young	24.17	22.99	55.28	26.85	35.28	25.04	54.44	29.93
Middle-aged	17.45	19.42	44.27	27.16	26.82	23.91	43.23	27.28
Elderly	23.96	25.42	38.19	31.04	24.65	25.26	39.58	29.50

young adults; $r(46) = .62$, $p < .01$, for middle-aged adults; and $r(34) = .76$, $p < .01$, for elderly adults. Comparable values for Trial 2 were .54, $p < .01$; .42, $p < .01$; .65, $p < .01$; and .80, $p < .01$.

Intertask correlations

Listed in Table 3 are the intertask correlations among temporal memory scores (averages over the two lists) and paired-associate learning scores for both Trial 1 and Trial 2 (averaged over lists). It may be seen that there was substantial covariation between performances on the temporal memory and paired-associate tasks for each age group. In fact, the correlations are nearly the same order of magnitude as the correlations reflecting consistency across lists for the same tasks.

DISCUSSION

The present results indicate that temporal memory involves age-sensitive processes. Thus, another commonly postulated criterion for the automaticity of temporal memory has failed to be satisfied. In addition, our results are in agreement with those obtained earlier by Zacks et al. (1984) in demonstrating some degree of consistency in individual performances on successive word temporal memory tasks, and they also demonstrate that such consistency is not restricted to young adults. As noted earlier, the absence of such consistency is commonly postulated to be a criterion of automaticity.

This pattern of results suggests that temporal memory is an effortful form of episodic memory for adults of all ages. Further support for this conclusion comes from the substantial covariation between temporal memory scores and paired-associate learning scores at each age level, given the common assumption that paired-associate learning is an effortful form of memory. The effortful nature of remembering the order of words should not be surprising. There is an obvious commonality between this form of memory and the traditional serial learning of a list of words. In fact, theories of serial learning frequently

Table 3. Intertask correlations between word temporal memory and paired-associate learning (PA)

Age group	PA Trial 1	PA Trial 2
College students	.51**	.43*
Noncollege young	.41**	.44**
Middle-aged	.57**	.64**
Elderly	.58**	.57**

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

identify memory for temporal order as a component process, along with the availability for recall of the individual words (see Crowder, 1976). Serial learning is generally viewed as requiring effortful processes, and is characterized by pronounced age differences in rate of acquisition (see Kausler, 1982).

A caveat is in order regarding the modest, but significant, correlation between age and educational level within our combined group of noncollege subjects. Conceivably, the age difference for our various memory tasks could be the consequence of this uncontrolled variation in educational level, rather than the consequence of aging per se. However, it is unlikely that the age difference in education accounted for more than a negligible amount of the variation in memory performance scores. This is apparent from the fact that only two of the six correlations between educational level and the memory scores of interest in this study were significant: $r(127) = .19$, $p < .05$, with temporal memory scores on List 2; and $r(127) = .26$, $p < .01$, with paired-associate scores on Trial 2 of List 2. The correlations with temporal memory scores on List 1 and with the three other paired-associate scores ranged in value from .04 to .17. Even more important, the significant correlations between age and temporal memory scores and age with paired-associate scores remained significant after partialling out the effects of educational variation.

Notes

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References

Crowder, R. G. (1976). *Principles of learning and memory.* Hillsdale, NJ: Erlbaum.

Hasher, L., & Zacks, R. T. (1979). Automatic and effortful processes in memory. *Journal of Experimental Psychology: General, 108,* 356–388.

Hasher, L., & Zacks, R. T. (1984). Automaticity processing of fundamental information: The case of frequency of occurrence. *American Psychologist, 39,* 1372–1388.

Kausler, D. H. (1982). *Experimental psychology and human aging.* New York: Wiley.

Kausler, D. H., Licht, W., & Davis, R. T. (1985). Temporal memory for performed activities: Intentionality and adult age differences. *Developmental Psychology, 21,* 1132–1138.

McCormack, P. D. (1982). Temporal coding and study-phase retrieval in young and elderly adults. *Bulletin of the Psychonomic Society, 20,* 242–244.

Perlmutter, M., Metzger, R., Nezworski, T., & Miller, K. (1981). Spatial and temporal memory in 20 and 60 year olds. *Journal of Gerontology, 36,* 59–65.

Salthouse, T. A., Kausler, D. H., & Saults, J. S. (in press). Investigation of student status, background variables, and the feasibility of standard tasks in cognitive aging research. *Psychology and Aging.*

Toglia, M. P., & Kimble, G. A. (1976). Recall and use of serial position information. *Journal of Experimental Psychology: Human Learning and Memory, 2,* 431–445.

Zacks, R. T., Hasher, L., Alba, J. W., Sanft, H., & Rose, K. C. (1984). Is temporal order encoded automatically? *Memory & Cognition, 12,* 387–394.