Processing Speed and Adult Age Differences in Activity Memory

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Immediate and delayed recall of performed cognitive activities was examined in 136 adults aged 20 to 85. Hierarchical regression analyses were used to assess the association between perceptual speed and age differences in activity memory. The age-related variance in delayed activity recall was reduced by 52% by the statistical control of perceptual speed, and the age-related variance in immediate activity recall was reduced by 91%. Thus, adult age differences in delayed and immediate activity memory were found to be associated with limitations in perceptual speed. The cognitive effort that is required to perform cognitive activities may tax the processing resources of older adults, prohibiting successful encoding of the activities.

Adult age differences have been found in recall of performed cognitive activities, such as the subscales of the Wechsler Adult Intelligence Scale (WAIS) (Bromley, 1958; Earles, 1996; Kausler & Lichty, 1988). Because memory for performed activities is important for people to function successfully in their environments, it is important to determine the causes of these age differences in activity memory.

One prominent theory that has been proposed to explain some of the age differences in performance on many cognitive tasks is the processing speed theory (Salthouse, 1996). Salthouse (1996) has successfully demonstrated that the age-related variance in cognitive performance is substantially reduced after the statistical

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control of perceptual speed within a hierarchical regression analysis.

Two studies of the relation between processing speed and age differences in activity memory have been conducted (Earles, 1996; Earles & Coon, 1994). Earles and Coon (1994) conducted phone interviews of adults aged 18 to 87 who had participated in a previous study in which they performed a series of cognitive activities. The participants were called 2 to 182 days after their performance of the activities and were asked to describe the activities. Processing speed was found to be associated with approximately 70% of the age-related variance in memory for the activities, suggesting that a decline in the efficiency of effortful processing contributes to age differences in activity memory after a lengthy retention interval.

In order to extend our understanding of the contribution of effortful processing to age differences in activity memory, Earles (1996) compared age differences in memory for performed activities with age differences in memory for descriptions of activities that were not performed. Both younger and older adults remembered performed items better than nonperformed items. However, age differences in memory for both performed and nonperformed items were found to be mediated to a similar extent by perceptual speed. The age-related variance in both types of memory performance was reduced by approximately 75% by the control of perceptual speed. Earles (1996) also found an association between working memory and age differences in activity memory. Thus, limitations in effortful processing capabilities appear to be important to age differences in memory for performed and nonperformed items.

The present study was designed to further establish the link between processing efficiency and adult age differences in activity memory. Age differences in memory for activities were examined after both very long and very short delay intervals, using a large age range of adults. Measures of processing efficiency included measures of motor speed, perceptual speed, and working memory. It was expected that measures of processing efficiency would be found to mediate most of the age differences in activity memory after both a short and a long delay. A reduction in processing efficiency may require older adults to use all of their available capacity for performing a task. Thus, older adults may have little capacity remaining for the simultaneous processing of cues that could later assist retrieval of the activity. This potential lack of effective retrieval cues could become more important as the delay between encoding and retrieval is expanded.

METHOD

Participants

Participants were 136 community-dwelling adults who were paid $10 for their participation. Those participants from the study of Park et al. (1996), who were originally tested in Atlanta, returned 43 to 216 days later to participate in this study. Only 10 participants (4 younger, 5 middle-aged, and 1 older) did not return for the follow-up study.

The sample included 46 younger adults aged 20 to 39, 40 middle-aged adults aged 40 to 59, and 50 older adults aged 60 to 85. Education was rated on a scale of 1 to 7 with 5 equal to some college. Health was rated on a scale of 1 (poor) to 4 (excellent). There was no significant correlation of age with either education level ($r = -.09$) or self-rated health status ($r = -.07$). All age groups rated their health as between good and excellent. A significant increase in Shipley (1986) vocabulary scores was associated with increased age ($r = .28$), and there was also a significant correlation between age and the number of prescription medications participants were currently taking ($r = .35$).

Procedure

Participants in the Park et al. (1996) study performed 23 cognitive activities over a 3-day period. The order of activities for Day 1 was (a) Picture Integration, (b) Picture Naming, (c) Computation Span (Salthouse & Babcock, 1991), (d) Reading Distraction (Connelly, Hasher, & Zacks, 1991), (e) WAIS-R Vocabulary (Wechsler, 1981). The order for Day 2 was (a) Backward Digit Span, (b) Similarities (Wechsler, 1981), (c) Word Naming, (d) Reading Span (Salthouse & Babcock, 1991), (e) Digit-Symbol Substitution (Wechsler, 1981), (f) Stroop (Golden, 1978), (g) Letter Comparison (Salthouse & Babcock, 1991). The order for Day 3 was (a) Count As and Es, (b) Rate Names, (c) Definitions, (d) Stem Completion, (e) Cued Recall, (f) Shipley Vocabulary (Shipley, 1986) (g) Pattern Comparison (Salthouse & Babcock, 1991), (h) Opposites, (i) Free Recall, (j) Remote Associations (Mednick & Mednick, 1967), and (k) Spatial Recall. Detailed descriptions of these tasks can be found in Park et al. (1996).

Participants in the Park et al. (1996) study returned to the laboratory 43 to 216 days after their participation. Upon their return, participants were given unlimited time to write descriptions of the 23 activities that they had previously performed. Participants were then given the names of the activities and were given unlimited time to write descriptions of them. A response was scored as correct if the activity was identifiable from the description written by the participant. The delay interval was varied in order to examine potential age differences in the forgetting of activities.

Participants then performed 13 new activities in the following order: (a) Digit Copy, (b) Number Comparison, (c) Boxes, (d) Series Completion, (e) Word Fluency, (f) Category Fluency, (g) Name Number Association, (h) Alphabet Span, (i) Forward Digit Span, (j) Circle Es, (k) Symbol Digit, (l) Synonyms, (m) Size Judgment Span. Participants were not told that their memory for these tasks would be tested.

Speed Tasks

In the Digit Copy task (Salthouse, 1994), participants received 100 digits from 1 to 9. Each digit was placed in the top of a box, while the bottom of each box was left blank. Participants were given 30 s to copy as many digits as possible from the top of the box to the bottom of the box. In the Number Comparison task (similar to the Number Comparison task developed by Ekstrom, French, Harman, & Derman, 1976), participants were given 60 s to compare pairs of number strings containing 3 to 9 digits and decide if the strings were the same or different.

In the Circle Es task, participants received a list of 135 words. They were given 30 s to circle as many words as possible that contained the letter “e”. In the Boxes task (Salthouse, 1994), participants received a page containing 100 boxes that were missing one side. Participants were given 30 s to make as many boxes as possible by closing the missing side of each box with a line.

In the Word Fluency task, participants were given 30 s in which to write down all the words they could think of that began with the letter “Z.” In the Category Fluency task, participants were given nine category names and were asked to generate eight members of each category.

In the Symbol Digit Substitution task (similar to a task from Wechsler, 1981), participants received a key containing a set of nine symbols, each matched with a digit from 1 to 9. Participants then received a set of symbols and were given 90 s to write the digit that was associated with each symbol.

Memory Tasks

In the Name Number Association task (Salthouse, 1994), participants studied for 60 s a list of 10 first names, each of which was paired with a two-digit number. They then received the names in a different order and were asked to recall the number that went with each name. In the Alphabet Span task, participants heard lists of two to five words that they then had to list in alphabetical order. Participants received one trial at each level.

In the Forward Digit Span task, participants heard lists of 2 to 9 digits. After each digit series, they were asked to recall the digits in the order in which they were presented. There was one trial at each level. In the Size Judgment Span task (Cherry & Park, 1993), participants heard lists of 2 to 5 words that named objects that they then had to list in order of size from smallest to largest. Participants received one trial at each level.

Other Tasks

In the Synonyms task, participants were given six words. For each word they chose which of five words was a synonym of the first word. In the Series Completion task, participants received five series of five two-digit numbers. They were asked to determine what number would come next in each series.

Immediately after performing the last activity, participants were asked to write descriptions of the 13 activities and were then given the names of the activities and were asked to provide descriptions. A response was scored as correct if the activity was identifiable from the description.

RESULTS

For both activity recall measures, the initial free-recall descriptions were used rather than the descriptions given following the provision of the names of the activities. The free-recall measure was used because of the greater possibility of guessing following the provision of the name of the activity.

Delayed Activity Recall

A delayed activity free-recall score was computed by counting the number of activities that a participant correctly described from the original set of 23 activities. An item was counted as correct if the activity could be identified from the description. The reliability of this scoring method was assessed in Earles (1996). The current scorer and a second scorer scored 46 items from each of 10 younger and 10 older participants. The scorers had only three disagreements, so there seems to be little concern that the measure is subjective. Therefore, only one rater was used in the current study. The number of items correctly recalled was divided by 23 to get the proportion of activities recalled after the long delay interval.

There was no significant correlation between number of days since testing and any of the other variables. Therefore, the delayed activity recall variable was computed using all 136 participants. Participants recalled an average of 14% ($SD = .11$) of the activities. The variation in delay interval was used because of the possibility that the number of days could be important to age differences in recall. The lack of an effect of delay interval suggests that after 43 days, participants' memory for the activities was relatively stable.

Immediate Activity Recall

The immediate activity free-recall score was computed by counting the number of activities that the participant described from the second set of 13 activities. This score was divided by 13 to get the proportion of activities recalled. Participants recalled an average of 44% ($SD = .22$) of the activities.

Composite Scores

A composite motor-speed score was calculated by taking the average of the z scores for the Boxes and Digit Copy tasks. The correlation between Boxes and Digit Copy was .58. A composite perceptual-speed score was computed by taking the average of the z scores of the Letter Comparison, Pattern Comparison, and Digit Symbol Substitution tasks. The correlation between Letter and Pattern Comparison was .70, between Letter Comparison and Digit Symbol was .71, and between Pattern Comparison and Digit Symbol was .61. A composite working-memory score was computed by taking the average of the z scores of the Computation and Reading Span tasks. The correlation between these two tasks was .49.

Correlations

Correlations were computed among age, delayed activity recall, immediate activity recall, motor speed, perceptual speed, and working memory. These correlations are presented in Table 1. Greater age was associated with significantly slower speed, poorer working memory, and poorer activity memory performance for both delayed and immediate activity memory tests. Slower speed and lower working-memory spans were also associated with poorer activity-memory performance.

Hierarchical Regression Analyses

Hierarchical regression analyses were used to assess the degree of association of motor speed, perceptual speed, and working memory with age differences in activity memory. It was assumed that if the age differences in activity memory were greatly reduced after the control of speed or working memory, then speed or working memory is important to the relation between age and activity memory. The results of these analyses are shown in Table 2.

When delayed activity recall was used as the dependent variable, age was associated with 23% of the variability in performance. The age-related variance was reduced by 22% by the control of motor speed, by 52% by the control of perceptual speed, and by 14% by the control of working memory. The age-related variance was reduced by 53% by the control of motor speed, perceptual speed, and working memory. There was no significant quadratic effect of age, and there were no significant interactions with age.

TABLE 1 Correlation Matrix

		1	2	3	4	5	6
1	Age	-					
2	Delayed activity recall	−.48	-				
3	Immediate activity recall	−.38	.43	-			
4	Motor speed	−.36	.24	.21	-		
5	Perceptual speed	−.62	.36	.46	.53	-	
6	Working memory	−.31	.19	.51	.37	.47	-

Note. All correlations are significant at $p < .05$.

TABLE 2 Hierarchical Regression Analyses (Continued on next page)

	R^2	Change	F	p
Delayed activity recall as the dependent variable				
Age	.233		38.06	< .001
Motor speed	.057		7.49	.007
Age	.238	.181	29.50	< .001
Perceptual speed	.126		18.10	< .001
Age	.238	.112	18.18	< .001
Working memory	.037		4.45	.037
Age	.235	.201	32.49	< .001
Motor speed	.057		7.49	.007
Perceptual speed	.130	.073	10.43	.002
Working memory	.130	.000	.019	.891
Age	.240	.110	17.66	< .001

TABLE 2 Hierarchical Regression Analyses (Continued)

	R^2	Change	F	p
Immediate activity recall as the dependent variable				
Age	.144		21.06	< .001
Motor speed	.046		6.04	.015
Age	.151	.105	15.32	< .001
Perceptual speed	.215		34.24	< .001
Age	.228	.013	2.14	.146
Working memory	.263		44.69	< .001
Age	.318	.054	9.85	.002
Motor speed	.046		6.037	.015
Perceptual speed	.216	.170	26.96	< .001
Working memory	.336	.119	22.13	< .001
Age	.349	.013	2.36	.127

Note. The change in R^2 represents the remaining age-related variance following the control of another variable.

When immediate activity recall was used as the dependent variable, age was associated with 14% of the variability in performance. The age-related variance was reduced by 27% by the control of motor speed, by 91% by the control of perceptual speed, and by 63% by the control of working memory. The age-related variance was reduced by 91% by the control of motor speed, perceptual speed, and working memory. There was no significant quadratic effect of age, and there were no significant interactions with age.

DISCUSSION

This study, in addition to those of Earles (1996) and Earles and Coon (1994), provides evidence that the efficiency with which one processes information is important to age differences in activity memory. As has been found for memory of other types of items (e.g., Earles, 1996; Park et al., 1996; Salthouse, 1994, 1996), control of perceptual speed greatly reduced the age-related variance in memory performance. A decrease in processing efficiency could reduce the ability of the participant to perform the task and simultaneously attend to memory cues that would assist retrieval. For example, the cognitive effort required by the performance of an activity may prevent slower participants from integrating each new activity with activities that have previously been performed.

As was found in Earles and Coon (1994), a significant portion of the age differences in delayed activity memory was not associated with perceptual speed. In contrast, perceptual speed was associated with 91% of the age-related variance in immediate activity memory. Further studies on long-term retention, however, need to be conducted. Interpretation of the results of the current study is limited because of the use of different activities with different lengths in the two activity-memory measures, because of the use of fewer activities in the immediate measure, and because the immediate activity-memory measure always followed the delayed activity-memory measure, allowing for the possibility of practice effects or of participants guessing that they would be asked to recall the second list.

Now that it has been established that limited processing resources contribute to age differences in activity memory, it is important to determine how decreased processing efficiency influences activity memory. An age-related decrease in processing speed could hinder activity memory because all available resources are used for performance of the activity, and none remain for the processing of potential memory cues. This should mean that memory for more cognitively demanding tasks is more dependent on processing resources than is memory for less cognitively demanding tasks.

REFERENCES

Bromley, D. B. (1958). Some effects of age on short term learning and remembering. *Journal of Gerontology*, *13*, 398–406.

Cherry, K. E., & Park, D. C. (1993). Individual difference and contextual variables influence spatial memory in younger and older adults. *Psychology and Aging*, *8*, 517–526.

Connelly, S. L., Hasher, L., & Zacks, R. T. (1991). Age and reading: The impact of distraction. *Psychology and Aging*, *5*, 533–541.

Earles, J. L. (1996). Adult age differences in recall of performed and nonperformed items. *Psychology and Aging*, *11*, 638–648.

Earles, J. L., & Coon, V. E. (1994). Adult age differences in long term memory for performed activities. *Journals of Gerontology: Psychological Sciences*, *49*, P32–P34.

Ekstrom, R. B., French, J. W., Harman, H. H., & Derman, D. (1976). *Manual for kit of factor-referenced cognitive tests*. Princeton, NJ: Educational Testing Service.

Golden, C. J. (1978). *Stroop color and word test*. Wood Date, IL: Stoeley Company.

Kausler, D. H., & Lichty, W. (1988). Memory for activities: Rehearsal independence and aging. In M. L. Howe & C. J. Brainerd (Eds.), *Cognitive development in adulthood: Progress in cognitive development research* (pp. 93–131). New York: Springer-Verlag.

Mednick, S. A., & Mednick, M. T. (1967). *Examiner's manual: Remote Associates Test*. Boston: Houghton, Mifflin.

Park, D. C., Smith, A. D., Lautenshlager, G., Earles, J., Frieske, D., Zwahr, M., and Gaines, C. (1996). Mediators of long-term memory performance across the life span. *Psychology and Aging*, *11*, 621–637.

Salthouse, T. A. (1994). The nature of the influence of speed on adult age differences in cognition. *Developmental Psychology*, *30*, 240–259.

Salthouse, T. A. (1996). The processing-speed theory of adult age differences in cognition. *Psychological Review*, *103*, 403–428.

Salthouse, T. A., & Babcock, R. L. (1991). Decomposing adult age differences in working memory. *Developmental Psychology*, *27*, 763–776.

Shipley, W. C. (1986). *Shipley Institute of Living Scale*. Los Angeles: Western Psychological Services.

Wechsler, D. (1981). *Manual for the Wechsler Adult Intelligence Scale- Revised.* New York: The Psychological Corporation.