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Adult Age Differences in Recall of Performed and Nonperformed Items

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Memory for performed cognitive activities (e.g., psychometric tests of intelligence), for performed brief actions (e.g., hand wave), and for nonperformed items (e.g., written words) was assessed for 102 older and 101 younger adults. Although enactment improved recall, the beneficial effects of enactment were the same for both age groups. In fact, more than 80% of the age-related variance in memory for performed items was shared with memory for nonperformed items. Working memory and perceptual speed were important to the age differences in memory for both types of items. Performed and nonperformed items showed different serial position effects. However, the correlation between memory for the 2 types of items was high, especially for older adults, suggesting that the 2 types of memory share many common processes.

A growing literature examining memory for performed cognitive activities (e.g., psychometric tests of intelligence) and brief actions (e.g., break a stick) suggests that there may be fundamental differences between memory for performed items and memory for verbally presented (i.e., either written or spoken) items. Furthermore, it has been suggested that there are smaller effects of age on memory for performed than nonperformed items (see Kausler & Lichty, 1988). One purpose of the present study was to directly examine the relations between memory for performed and nonperformed items, focusing on the effect of type of material to be remembered on age differences in recall and on possible mechanisms for age differences.

Age Differences in Memory for Performed Items

Many studies have found that memory for both the names of and descriptions of performed cognitive activities (e.g., cognitive tests) is better for younger than for older adults (e.g., Earles & Coon, 1994; Kausler & Hakami, 1983). Many studies have also found significant age differences in recall of briefer, more discrete actions (e.g., stamp foot or break stick) that involve less of a cognitive component and more of a motor component (e.g., Cohen, Sandler, & Schroeder, 1987; Knopf & Neidhardt, 1989; Nyberg, Nilsson, & Bäckman, 1992). Although a few studies have not shown significant age differences (e.g., Bäckman, 1985; Bäckman & Nilsson, 1984, 1985), even these studies have usually found nonsignificant age differences, favoring younger adults, in the recall of brief actions (Kausler & Lichty, 1988).

In the current study, two measures of memory for performed items were obtained from a relatively large sample of younger and older adults. Both brief motor actions and longer cognitive activities were used as the performed items. Activities and actions share many common features. They are both performed by the participant, and both contain information from more than one modality, including a motor component. It was therefore expected that there would be a strong relation between memory for cognitive activities and memory for brief actions. However, actions were hypothesized to be better recalled than activities because they are more distinctive. Actions involve many different objects and movements, whereas each cognitive activity is different; however, the motor component (i.e., writing) is similar in each.

Comparison of Memory for Performed and Nonperformed Items

Memory for performed items may differ in important ways from memory for nonperformed items. Most direct comparisons of performed and nonperformed items have used very brief motor actions as the items to be remembered. One of the most important findings is that memory for these brief actions is usually better than memory for verbal labels of the actions. In other words, enactment improves recall. Recall of brief actions has been found to be significantly better than recall of the same verbal action commands that are not performed (e.g., Bäckman & Nilsson, 1985; Bäckman, Nilsson, & Chalom, 1986; Cohen, 1981; Cohen, Peterson, & Mantini-Atkinson, 1987) and significantly better than memory for words (e.g., Cohen, 1988; Cohen, Sandler, & Schroeder, 1987; Helstrup, 1986; Zimmer, 1991). Thus, enactment does appear to be a very effective orienting task.

The primary evidence for a fundamental qualitative difference, in addition to the quantitative difference, in how people remember performed and nonperformed items has come from research suggesting that several manipulations that affect mem-

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ory for verbally presented items do not have much of an effect on memory for performed items. Manipulations that have been suggested not to affect memory for performed items include levels of processing (Cohen, 1981; Dick, Kean, & Sands, 1989), intentionality (e.g., Kausler & Hakami, 1983; Kausler, Lichty, Hakami, & Freund, 1986), and serial position (e.g., Bäckman & Nilsson, 1984, 1985; Cohen, 1981; Kausler & Hakami, 1983). Each of these manipulations has been found to affect recall of verbal items (see Kausler, 1994).

However, under some conditions, these encoding manipulations can affect memory for performed items. For example, Glover, Timme, Deyloff, and Rogers (1987) found that participants in a rhyming mnemonic condition recalled more brief actions than did participants who paraphrased each action, and both groups recalled more than did a control group. Kausler and Phillips (1989) found that research participants given instructions to memorize cognitive activities, even if it meant sacrificing performance on the activity, recalled significantly more than did participants who were not informed of the upcoming memory test. Finally, unlike other studies of serial position effects, Helstrup (1986) found evidence of a primacy effect for the serial recall of brief actions. Thus, a primacy effect may be found with manipulations, such as serial recall, that encourage people to use strategies such as rehearsal.

Thus, studies of levels of processing, intentionality, and serial position variation have provided some evidence that memory for performed items may be qualitatively different from memory for nonperformed items. However, most of these encoding manipulations can affect memory for performed items under certain conditions.

Because previous research has suggested that memory for performed and nonperformed items may be fundamentally different, it was important to design a study in which the two types of memory and age differences in the two types of memory could be directly compared. The best comparison between memory for performed and nonperformed items is probably between an action or activity that is performed and the identical verbal instructions for that action or activity (e.g., Nyberg et al., 1992). Thus, in the present study, there were measures of memory for action commands and for activity descriptions that were not performed. Because other studies have compared memory for activities and actions with memory for words, a measure of free recall of nouns was also included. It was predicted that recall of performed items would be better than recall of nonperformed items because additional information provided by performance, such as movements and objects, may help one form a more elaborate memory representation and may provide additional pathways for retrieval. It was also predicted that age differences would be smaller for performed than for nonperformed items.

Explanations of Age Differences

Although memory for activities and actions declines with increases in age during adulthood, it has been hypothesized that memory for these types of items develops very early in life and, therefore, is one of the latest things to decline during adulthood (Bäckman, 1985; Cohen, Sandler, & Schroeder, 1987). The verbal memory system may develop late and degenerate early, but the motor memory system, which is involved in memory for performed items, may develop early and degenerate late (Knopf & Neidhardt, 1989).

In support of this hypothesis, several researchers have found significantly smaller age differences in memory for performed brief actions than for verbal action commands that were not performed (Bäckman, 1985; Bäckman & Nilsson, 1984, 1985; Nyberg et al., 1992). However, Cohen, Sandler, and Schroeder (1987), in two experiments, found no significant interaction between age and brief action versus word recall, and no previous studies have directly compared age differences in memory for performed and nonperformed cognitive activities.

There are two theories, in addition to the differential degeneration of memory systems theory, that are used to explain why age differences may be smaller for recall of performed than nonperformed items. Bäckman (1985) proposed a multimodal encoding hypothesis in which performed items are encoded through the use of many modalities and contain many features (Bäckman, 1985; Bäckman & Nilsson, 1984, 1985; Bäckman et al., 1986). For example, activities and actions often have auditory instructions, visual presentation, and motor or tactual action. Bäckman suggested that these properties of activities and actions may help people to encode these items in an optimal manner that decreases the reliance on self-initiated processing during encoding, thus increasing recall. Older adults are hypothesized to compensate for memory deficits through the task-guided, multisensory encoding of performed items (Bäckman & Nilsson, 1984).

The second theory, the automatic encoding theory (Cohen, 1984, 1989; Kausler & Hakami, 1983), provides an explanation for why age differences may be smaller in memory for performed than nonperformed items that is similar to that proposed by Bäckman (e.g., Bäckman & Nilsson, 1984). In this theory, the performance of a brief action or cognitive activity is hypothesized to control the encoding of that action or activity (Cohen & Bean, 1983). The memory trace of the performed item is automatically transmitted to long-term memory without a conscious attempt by the participant to memorize the item (Cohen, 1984, 1989; Kausler & Hakami, 1983). Memory for performed items, therefore, is suggested to involve task-guided encoding, whereas verbal memory is said to involve person-guided encoding. Because encoding of activities and actions is guided by the performance of the activity or action, less self-initiated processing is required for encoding. Smaller age differences in memory for performed items than in memory for verbal items may occur because there is less reliance on self-initiated processing (Craik & McDowd, 1987).

Both the automaticity of encoding theory and the multimodal encoding theory, therefore, explain the predicted smaller age differences in memory for performed than nonperformed items by suggesting that older adults rely more than younger adults on task-guided encoding. Thus, memory for performed items is predicted to require less effort than memory for nonperformed items. Neither of these theories, however, provides an explanation for why there are age differences in memory for performed items.

Age differences may occur because cognitive effort can improve the encoding of performed items. As mentioned previously, the encoding of activities can be improved by strategic processing under some conditions. Helstrup's (1986) finding of a primacy effect, Kausler and Phillips's (1989) finding of facilitation from intentionality, and Glover et al.'s (1987) finding of facilitation from encoding manipulations provide evidence that some strategic processing of performed items during encoding can facilitate performance. However, under most conditions, encoding strategies do not appear to improve recall (e.g., Bäckman & Nilsson, 1984; Cohen, 1981; Kausler & Hakami, 1983). If activity memory requires less effort than verbal memory, then it may be less related than verbal memory to indexes of processing efficiency such as perceptual speed and working memory. In fact, if the encoding of activities is automatic, it should bypass the limited capacity constraints.

If encoding is automatic, the age differences may occur at retrieval rather than at encoding. Kausler has hypothesized that even though the encoding of actions and activities is automatic, the retrieval of these items is age sensitive because it involves effort and depends on the diminished processing capacity of older adults (Kausler & Hakami, 1983; Kausler & Lichty, 1988). It is, however, difficult to separate the effects of age on encoding from the effects of age on retrieval.

It is likely that changes in processing capacity are responsible for age differences in memory for performed items. One possible explanation for the age differences in memory for performed items is that an age-related deficit in working memory affects encoding or retrieval, or both. Working memory is the ability to simultaneously store and process information (Babcock & Salthouse, 1990), and this ability has been found to decrease with increases in age during adulthood (e.g., Babcock & Salthouse, 1990; Salthouse, 1991; Salthouse & Babcock, 1991). A reduction in working memory capacity may limit the use of strategies during encoding and may limit the complexity or the number of retrieval pathways that can be used during retrieval. Because of greater working memory capacity, younger adults may be better able than older adults to encode contextual information and form integrated structures between context and content information that can later be used at retrieval.

Age has been found to have a much larger effect on the processing component than on the storage component of working memory (Salthouse & Babcock, 1991). These age-related declines in the processing component of working memory may be due to age-related declines in the speed of processing information (Salthouse & Babcock, 1991). There is some evidence that age differences in action and activity memory are related to age differences in perceptual speed. Earles and Coon (1994) found that perceptual speed was associated with 70% of the age-related variance in memory for cognitive activities. This finding is consistent with the finding that perceptual speed is associated with much of the age-related variance in memory for verbal materials (e.g., Salthouse, 1994).

The results of the present study were expected to confirm previous findings of age differences in memory for performed items, and the effects of age on the nonperformed items were predicted to be larger than the effects of age on performed items. Thus, the task-guided elaboration resulting from performance was expected to benefit older more than younger adults. However, there was also expected to be a strong relation between the age differences in memory for performed and nonperformed items.

In addition to comparing the age differences in memory for performed and nonperformed items, it is also important to begin to explore potential mechanisms for the age differences in memory and to assess whether or not the mechanisms that are responsible for age differences in action and activity memory are similar to those responsible for age differences in verbal memory. It was predicted that age differences in processing speed and working memory would mediate the age differences in memory for both performed and nonperformed items.

Method

Participants

Participants were 102 community-dwelling older adults 50 to 89 years of age and 101 undergraduate students. The older adults were recruited through newspaper advertisements and were paid $10 for their participation. The students either were paid $10 or received extra credit in a psychology course. Participant characteristics are shown in Table 1.

Older adults had significantly more education and scored significantly better than younger adults on a vocabulary test. Younger adults, on the other hand, reported taking significantly fewer medications than did the older adults and had significantly higher health ratings on one of the three self-rated health measures, although the means for both age groups indicated good health.

Materials

Working memory measures. There were two measures of working memory similar to those used by Salthouse and Babcock (1991). In the Reading Span task, participants saw a series of sentences on a computer screen. Each sentence was followed by a question and three possible answers. The participant was asked to answer each question and to simultaneously remember the last word from each sentence. After a series of sentences had been presented, the word *recall* appeared on the screen, and the participant wrote the last word from each sentence. Participants completed two trials each of series containing 1, 2, 3, 4, 5, and 6 sentences. The score was the number of trials in which both the answers to

Table 1
Participant Characteristics

	Younger adults		Older adults		
Characteristic	*M*	*SD*	*M*	*SD*	$t(201)$
Age (years)	20.34	1.71	67.23	7.15	64.10*
Education (years)	14.13	1.41	15.09	2.09	3.84*
Vocabulary[a]	30.66	3.75	34.49	4.34	6.66*
Health rating[b]	4.25	0.74	4.09	0.72	1.51
Health limitations[c]	3.77	0.55	3.53	0.68	2.74*
Health satisfaction[d]	3.21	0.70	3.17	0.75	0.41
Medications[e]	0.32	0.65	1.81	1.19	6.43*

Note. In the younger adult sample, 60.4% of the participants were male; in the older adult sample, 45.1% were male.
[a] Total correct out of 40 on the Shipley Institute of Living vocabulary test. [b] "How would you rate your health on a scale of 1 (*poor*) to 5 (*excellent*)?" [c] "How much do health problems limit your daily activities on a scale of 1 (*a lot*) to 4 (*none*)?" [d] "How satisfied are you with your health on a scale of 1 (*not at all satisfied*) to 4 (*very satisfied*)?" [e] Number of prescription medications currently being taken.
*$p < .01$.

the questions were correct and the words were recalled. The Computation Span task was like the Reading Span task except that participants were presented with series of arithmetic problems that they were to solve while simultaneously remembering the last digit from each problem.

Perceptual speed measures. The perceptual speed measures were the Letter Comparison and the Pattern Comparison tests from Salthouse and Babcock (1991). In the Letter Comparison test, participants inspected pairs of letter strings and decided whether the letter strings were the same or different. If the strings were the same, they wrote an *S* on the line between them; if the strings were different, they wrote a *D*. There was one section with three letters in each string, one with six letter strings, and one with nine letter strings. The participant was given 30 s for each section. The Pattern Comparison test was the same as the Letter Comparison test except that participants compared patterns of three, six, and nine line segments. For both tests, the score was the total number of correctly completed items on all three sections.

Activities and activity descriptions. There were four lists of 12 cognitive activities. Each participant performed two lists and read two lists. For each activity, the participant saw a task title (e.g., Geography Questions) and the instructions for the task (e.g., In this task, please circle the response that best answers each question). For the performed lists, the participant was then given several questions to answer. For the nonperformed (i.e., read) lists, the participant was simultaneously given both the questions and the answers to those questions. In other words, the activity descriptions were exactly like the performed activities except that the answers were provided to the participants rather than generated by them. Half of the adults in each age group performed Lists 1 and 2 and read Lists 3 and 4. The other half performed Lists 3 and 4 and read Lists 1 and 2. Participants were told that they would later be tested for memory of the items. They were given 50 s to perform or read each item. After each list, a distractor task was performed for 30 s so as to minimize recency effects. Participants were then given 6 min to write a description of each of the 12 activities performed or described.

Actions and action commands. There were four lists of 12 brief actions (e.g., tap your foot or cut the paper). Half of the participants in each age group performed Lists 1 and 2 and read Lists 3 and 4, and the other half performed Lists 3 and 4 and read Lists 1 and 2. Participants were told of the upcoming memory test. For the performed actions, the materials needed were provided in envelopes, each envelope containing the object to be used in one action. Half of the actions involved objects (e.g., a toy dog or a clay ball), and half did not. Participants were given 10 s to read each action command or perform each action. After the last action in each list, participants performed a 30-s distractor task and then were given 4 min to write down the items.

Words. There were four lists of 12 concrete nouns taken from Snodgrass and Vanderwart (1980). The nouns were presented one at a time for 3 s each. For half of the participants in each age group, Lists 1 and 2 were used; for the other half, Lists 3 and 4 were used. After each list, participants performed a 30-s distractor task and were then given 3 min to recall the words.

Distractor task. A distractor task was performed for 30 s after each list of items had been presented and before recall. In this task, participants saw a word and a block of color on a computer screen and were asked to press the *z* key if the word named the color and the / key if the word did not name the color. Thus, this task had a verbal, a visual, and a motor component.

Procedure

Participants were tested in groups of 3 or fewer. They came to the campus laboratory for a single session lasting approximately 2 to 2.5 hr. The tasks were presented by a Macintosh IIci computer in two sets. The order of Set 1 was action commands, activity descriptions, words, activities, and actions. The participants then received a 5-min break. The order of Set 2 was actions, activities, words, activity descriptions, and action commands. After completing the memory tests, participants received the Letter Comparison and Pattern Comparison tests, followed by the Reading Span and Computation Span tests. They then took the Shipley (1986) vocabulary test and filled out the demographics questionnaire.

Results

Reliability of Measures

Estimates of interrater reliability were obtained for the cognitive activity and activity description recall measures. Ten percent of the protocols were scored by a second rater. There were two tests of activity recall and two tests of activity description recall for each of 20 participants, and there were 12 items in each list. Thus, there were 960 decisions to be made about whether or not a participant recalled a particular item. The raters had only three disagreements. Thus, as was found by Earles and Coon (1994), the interrater reliability was high. Because there appeared to be little cause for concern about the possible subjectivity of the activity measures, only one rater was used to evaluate participants' responses.

The reliabilities of all measures were estimated in an attempt to ensure that possible differential effects of age on memory for performed and nonperformed items would not be due to the use of unreliable measures. Low reliabilities limit the size of the possible correlations among different memory measures and age. Reliabilities of the working memory and perceptual speed measures have been estimated by Salthouse and Babcock (1991). The estimated reliabilities were .86 for Reading Span, .84 for Computation Span, and .94 for Letter Comparison and Pattern Comparison. Reliabilities of the memory measures were estimated by calculating the correlation between the first and second administrations of each type of test and boosting this correlation by the Spearman–Brown formula. The overall reliabilities of the memory measures, as well as the reliabilities within each age group, can be found in Table 2. The overall reliabilities of the measures used in this study were moderate to high. In fact, the overall reliabilities were somewhat higher for performed than for nonperformed memory measures. Thus, there was adequate reliable variability in all of the memory measures to enable the examination of the relations between the memory measures and other variables, including age.

Differences in Memorability

For each memory measure, the score was the sum of performance on the two administrations of the test. Because of the

Table 2
Reliability Estimates

Measure	Overall	Younger adults	Older adults
Action commands	.69	.64	.54
Actions	.82	.61	.75
Activity descriptions	.75	.75	.58
Activities	.87	.67	.83
Words	.73	.41	.67

Table 3
Task Performance by Age Group

Measure	Younger adults *M*	Younger adults *SD*	Older adults *M*	Older adults *SD*	*t*(201)
Actions	20.72	2.20	15.07	5.34	9.85*
Action commands	15.88	3.85	10.85	4.33	8.75*
Activities	16.13	3.37	9.77	5.13	10.44*
Activity descriptions	15.13	4.84	8.59	5.20	9.27*
Words	16.44	3.41	10.06	4.77	10.94*
Letter comparison	46.46	8.06	33.25	7.43	12.07*
Pattern comparison	66.74	8.33	49.63	8.71	14.23*
Reading span	7.90	2.56	4.00	3.23	9.52*
Computation span	9.23	3.57	4.63	4.65	7.90*

Note. One participant lacked a letter comparison score, and 1 lacked a pattern comparison score, because of failure to follow instructions.
*$p < .01$.

large number of comparisons to be made, the alpha level was set at $p < .01$. An analysis of variance (ANOVA) revealed that recall of Lists 1 and 2 was not significantly different from recall of Lists 3 and 4 for any of the memory measures, all $Fs(1, 201) < 1.28$. The data were therefore collapsed across this variable.

A 2 (age) × 5 (item type) ANOVA revealed that younger adults recalled significantly more than did older adults, $F(1, 201) = 154.25$, $MSE = 59.08$, $p < .01$, and that some types of items were recalled significantly better than other types, $F(4, 804) = 123.48$, $MSE = 8.94$, $p < .01$. There was, however, no significant interaction between age and item type, $F(4, 804) = 2.31$, $MSE = 8.94$, $p = .06$.

Average performances on all measures for each age group and *t* tests comparing younger and older adults on all of the individual memory measures are presented in Table 3. The effects of enactment were the same for both age groups. Performed brief actions were recalled significantly better than verbal action commands, $t(202) = 16.31$, $p < .01$, and cognitive activities were recalled significantly better than activity descriptions, $t(202) = 9.75$, $p < .01$. Also, brief actions were recalled significantly better than cognitive activities, $t(202) = 7.62$, $p < .01$. In fact, both older and younger adults recalled brief actions significantly better than any of the other materials.

An analysis was also conducted to examine the effects of the use of an external object on memory for actions. A 2 (object presence: object vs. no object) × 2 (age: younger vs. older) ANOVA revealed a significant interaction of age and object presence, $F(1, 201) = 15.60$, $MSE = 2.20$, $p < .01$. However, this interaction was probably due to a ceiling effect for the younger adults when external objects were used. The younger adults recalled significantly more of the 12 actions that involved an object ($M = 10.99$, $SD = 1.01$) than of the 12 actions that did not involve an object ($M = 9.73$, $SD = 1.67$), $F(1, 100) = 58.43$, $MSE = 1.37$, $p < .01$. The older adults also recalled significantly more actions with objects ($M = 8.75$, $SD = 2.91$) than without objects ($M = 6.32$, $SD = 2.97$), $F(1, 101) = 98.57$, $MSE = 3.03$, $p < .01$, but the difference was larger for the older than for the younger adults.

Serial Position Effects

Primacy effects were determined by comparing recall of the first four items with recall of the middle four items in each list. A 2 (position: first four items vs. middle four items) × 2 (age: young vs. old) × 5 (item type) ANOVA showed significant main effects of age, $F(1, 201) = 158.91$, $MSE = 14.08$, $p < .01$, and position, $F(1, 201) = 204.28$, $MSE = 1.87$, $p < .01$. There was, however, a significant interaction of position and item type, $F(4, 804) = 107.21$, $MSE = 2.04$, $p < .01$. There was a significant position effect for all measures except for the measure of memory for performed actions. Thus, the brief action measure showed a different serial position curve than did the other materials. There was no significant Age × Position interaction, $F(1, 202) = 2.89$, $MSE = 1.87$, $p > .01$, and no significant three-way interaction, $F(4, 804) = 3.27$, $MSE = 2.04$, $p > .01$. Serial position effects for each memory measure are shown in Figure 1.

Recency effects were determined by comparing recall of the last four items with recall of the middle four items on each list. A 2 (position: last four items vs. middle four items) × 2 (age) × 5 (item type) ANOVA revealed a significant main effect of age, $F(1, 201) = 137.55$, $MSE = 12.87$, $p < .01$, and a significant position effect, $F(1, 201) = 90.45$, $MSE = 1.93$, $p < .01$. There was also a significant interaction between position and item type, $F(4, 804) = 134.93$, $MSE = 1.97$, $p < .01$. There was a significant position effect only on the measures of cognitive activity and activity description memory. There was no significant interaction of age and position, $F(1, 201) = 1.36$, $MSE = 1.93$, $p > .01$, and there was no significant three-way interaction, $F(4, 804) = 1.36$, $MSE = 1.97$, $p > .01$. Recency effects are shown in Figure 1. The distractor task may not have been as effective for the activity and activity description recall tests because it was shorter than a single activity or activity description.

Correlational Analyses

Correlational analyses were conducted to examine the relations among measures. The correlations among the measures within each age group are presented in Table 4. For both younger and older adults, the memory measures were all significantly correlated with one another. These correlations between memory measures were even higher for the older than for the younger adults. Thus, participants who did well on tasks involving performed items also did well on tasks involving nonperformed items. The two measures of working memory were significantly related for both age groups, as were the two measures of perceptual speed. Overall, although the correlations were not high, faster speed was associated with better memory performance for both younger and older adults. Better working memory was also associated with better memory performance, especially for older adults. There was, however, very little overall relation between speed and working memory measures.

Hierarchical Regression Analyses

The effects of age on memory performance were of primary interest. Therefore, hierarchical regression analyses were used to assess the amount of age-related variance in the memory measures that was associated with speed and working memory.

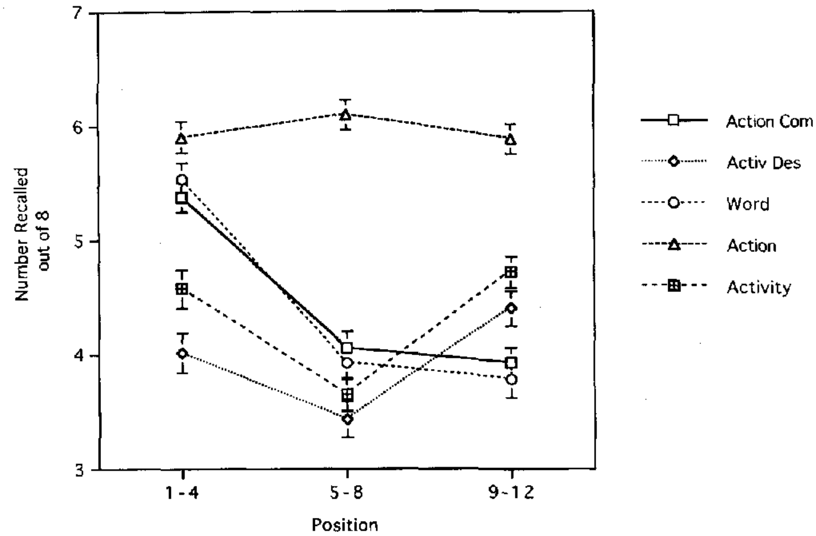

Figure 1. Serial position curves: average number of items recalled in primacy (1–4), middle (5–8), and recency (9–12) positions for each memory test with standard errors. Action Com = action commands; Active Des = activity descriptions.

It was assumed that if the age-related variance in recall was greatly reduced by the control of speed or working memory, then speed or working memory is important to the relation between age and recall. The results of the hierarchical regression analyses must be accepted with caution because the age-related variance was probably inflated by the lack of middle-aged participants. However, one can still look at the partitioning of the age-related variance if one realizes that the absolute amount of age-related variance was probably inflated.

The results of the hierarchical regression analyses for each memory measure are shown in Table 5. A composite speed measure was computed by taking the average of the z scores for Letter Comparison and Pattern Comparison, and a composite working memory score was computed by taking the average of the z scores for Reading Span and Computation Span. The age-related variance in the three verbal memory tasks was reduced by between 70% and 84% by the control of perceptual speed and by between 66% and 76% by the control of working memory. For the two performed memory tasks, the age-related variance was reduced by between 74% and 83% by the control of speed and by between 66% and 71% by the control of working memory. There were no significant interactions of age and speed. However, a small amount of the variance in all of the memory measures was associated with the interaction of age and working memory. Although the interaction was significant at $p < .01$ only for performed actions, the pattern was the same for all five memory measures. The effect of working memory on memory performance was greater for older than for younger adults.

Hierarchical regression analyses were also conducted to examine the relations between memory for performed and nonperformed items. When performance on the verbal action com-

Table 4
Correlation Matrices for Measures for Younger and Older Adults

Measure	1	2	3	4	5	6	7	8	9
1. Action commands	—	.52	.69	.63	.49	.26	.34	.41	.28
2. Activity descriptions	.50	—	.55	.62	.66	.21	.16	.50	.39
3. Words	.50	.40	—	.58	.55	.19	.16	.41	.28
4. Actions	.39	.36	.37	—	.62	.31	.29	.40	.34
5. Activities	.49	.55	.33	.45	—	.23	.17	.27	.35
6. Letter comparison	.23	.33	.23	.25	.23	—	.64	.18	.22
7. Pattern comparison	.18	.20	.12	.25	.11	.52	—	.12	.20
8. Reading span	.04	.23	.20	.18	.23	.15	.12	—	.47
9. Computation span	.04	.06	.10	−.08	.07	.10	.17	.34	—

Note. Correlations for the younger adults are below the diagonal, and those for the older adults are above the diagonal. Correlations of .26 or higher are significant at $p < .01$. Correlations of .19 or higher are significant at $p < .05$.

Table 5
Hierarchical Regression Analyses for Memory Measures

Variable	R^2	R^2 change	F	p	% age-related variance[a]
			Verbal action commands		
Age	.307		89.12	<.001	
Speed	.302		86.26	<.001	
Age	.350	.048	14.47	<.001	84
WM	.237		62.37	<.001	
Age	.341	.104	31.49	<.001	66
Age × WM	.354	.014	4.20	.042	
			Performed actions		
Age	.358		111.89	<.001	
Speed	.340		102.65	<.001	
Age	.401	.061	20.16	<.001	83
WM	.311		90.59	<.001	
Age	.415	.104	35.46	<.001	71
Age × WM	.438	.024	8.43	.004	
Action commands	.455		166.75	<.001	
Age	.527	.072	30.25	<.001	80
Age × Action Commands	.583	.056	26.70	<.001	
			Activity descriptions		
Age	.338		102.71	<.001	
Speed	.293		82.40	<.001	
Age	.359	.066	20.53	<.001	80
WM	.331		99.47	<.001	
Age	.414	.082	28.10	<.001	76
Age × WM	.423	.010	3.35	.069	
			Activities		
Age	.384		125.41	<.001	
Speed	.297		83.98	<.001	
Age	.396	.099	32.44	<.001	74
WM	.298		85.37	<.001	
Age	.427	.129	44.98	<.001	66
Age × WM	.431	.004	1.46	.228	
Activity descriptions	.543		236.85	<.001	
Age	.600	.057	28.22	<.001	85
Age × Activity Descriptions	.614	.014	7.18	.008	
			Words		
Age	.414		141.70	<.001	
Speed	.304		86.90	<.001	
Age	.429	.125	43.52	<.001	70
WM	.320		94.57	<.001	
Age	.459	.139	51.44	<.001	66
Age × WM	.465	.006	2.33	.129	

Note. WM = working memory.
[a] Percentage reduction in age-related variance after control of measure.

mand task was controlled, the age-related variance in brief action memory was reduced by approximately 80%, suggesting a strong relation between the age-related variance in the two memory measures. The same pattern was present for activities and activity descriptions. When memory performance on the activity description task was controlled, the age-related variance in cognitive activity memory was reduced by 85%. For both actions and activities, a significant interaction suggested that the relationship between verbal and activity memory was greater for older than for younger adults.

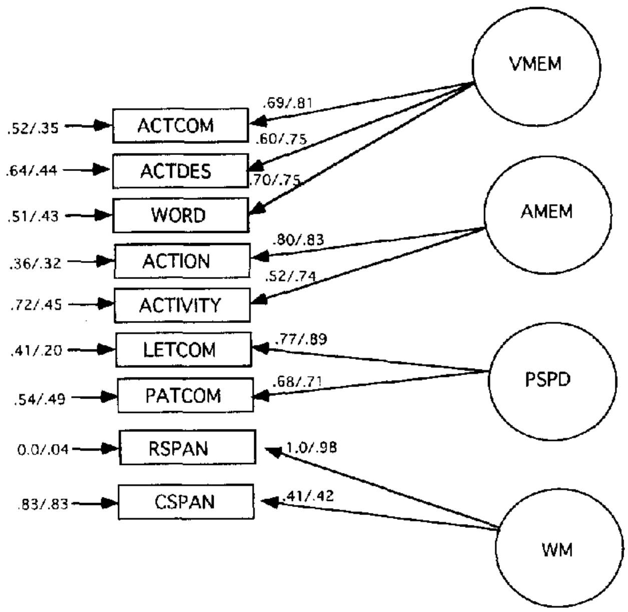

Figure 2. Confirmatory factor analysis with four factors. The within-group, completely standardized solution is shown. All loadings are significant at $p < .01$. The data are presented in the form young/old. The correlation between activity descriptions (ACTDES) and activity was −.07/−.02. The correlation between action commands (ACTCOM) and action was .25/.16. The common metric completely standardized loadings were as follows: ACTCOM, .76; ACTDES, .69; words, .73; actions, .82; activities, .69; Letter Comparison (LETCOM), .83; Pattern Comparison (PATCOM), .70; Reading Span (RSPAN), .99; and Computation Span (CSPAN), .41. VMEM = verbal memory; AMEM = activity memory; PSPD = perceptual speed; WM = working memory.

Confirmatory Factor Analysis

A confirmatory factor analysis was conducted to examine the relations among constructs for younger and older adults. The analysis, conducted with four factors (activity memory, verbal memory, perceptual speed, and working memory), used LISREL 8 (Jöreskog & Sörbom, 1993). The chi-square value, degrees of freedom, p value, and comparative fit index (CFI) are presented for each model. The CFI, developed by Bentler (1990), emphasizes the fit of the relations between factors. Maximum-likelihood estimates were derived via the covariance matrix. Variances and covariances among all factors were estimated, as were the residual variances of the indicators. However, no covariances were allowed between residuals. The loading of one indicator of each factor was fixed at one (i.e., action command memory, action memory, Letter Comparison, and Reading Span). An analysis of the two age groups allowing separate estimation of factor loadings, factor covariances, and residual variances for each age group had a satisfactory fit, $\chi^2(42, N = 203) = 63.39$, $p = .018$, CFI = .96. However, the residual variance of the Reading Span indicator for younger adults was negative. This problem may have been due to the high performance of the younger adults on the Computation Span measure and the low performance on the working memory measures by the older adults. The residual variance of the Reading Span measure for the younger adults was thus fixed to zero. Also, because of measurement similarities, residual covariances were estimated for activity recall and activity description recall and for action recall and action command recall. The fit of this model was quite good, $\chi^2(39, N = 203) = 51.33$, $p = .089$, CFI = .98.

When the factor loadings were forced to be equal for the two age groups, there was no significant change in fit, $\chi^2(44, N = 203) = 64.92$, $p = .022$, CFI = .96. The difference in chi-square was 13.59 with 5 degrees of freedom, which was not significant at $p < .01$. The coefficients for these models are shown in Figure 2, and the correlations between factors are shown in Table 6. When the covariances between factors were forced to be equal for the two age groups, there was a significant decrease in fit, $\chi^2(50, N = 203) = 97.11$, $p < .001$, CFI = .91. Thus, separate models were needed for the older and the younger adults. As can be seen in Table 6, activity and verbal memory were highly correlated, suggesting a strong relation between the two types of memory. Also, the relations between working memory and memory performance and between activity memory and verbal memory were higher for the older than for the younger adults.

Discussion

When memory for performed items was directly compared with memory for nonperformed items, enactment was found to improve recall. Enactment improved recall of brief motor actions, as was found by Bäckman and Nilsson (1985) and Cohen (1981), as well as recall of longer cognitive activities. Performed brief actions were, in fact, recalled better than any of the other materials.

Previous suggestions, however, that there are smaller age differences in memory for performed than verbal items (i.e., Bäckman, 1985; Bäckman & Nilsson, 1984, 1985; Nyberg et al., 1992) were not supported by the present results. Bäckman (1985) and Bäckman and Nilsson (1984, 1985) found no age differences in action recall, a result that has been disputed by the results of other studies (e.g., Cohen, Sandler, & Schroeder, 1987; Kausler & Lichty, 1988; Nyberg et al., 1992). This unusual lack of an age difference in action recall is probably responsible for the interaction between age and item type found by Bäckman (1985) and Bäckman and Nilsson (1984, 1985).

The Nyberg et al. (1992) study that found a significant interaction between age and item type (i.e., actions, verbal action

Table 6
Correlations Among Latent Factors for Younger and Older Adults

Factor	1	2	3	4
1. Verbal memory	—	.95	.35	.59
2. Activity memory	.80	—	.41	.43
3. Perceptual speed	.45	.41	—	.20
4. Working memory	.21	.25	.19	—

Note. Correlations for the younger adults are below the diagonal, and correlations for the older adults are above the diagonal. Correlations larger than .21 are significant at $p < .01$. Correlations larger than .19 are significant at $p < .05$.

commands, and words) was more similar in design to the current study. In that study, there were two lists of 12 items of each type, and a within-subject design was used. The items used were the same as those used in Bäckman and Nilsson (1984). Nyberg et al. found a significant effect of age on action recall, but there was also a significant interaction of age and item type. The primary difference between the current study and the Nyberg et al. (1992) study is in the level of action recall by the younger adults. In the current study, younger adults recalled 86% of the actions, whereas, in the Nyberg et al. study, they recalled only 66%. Recall by older adults was very similar across studies. The studies used different presentation times (i.e., the current study used 10 s, and the Nyberg et al. study used 5 s) and different items. The results of the current study were the same when Lists 1 and 2 or Lists 3 and 4 were performed; thus, the particular items are probably not the cause of a lack of interaction. Also, the power to detect a significant interaction in the current study was quite adequate. Item duration may be an important variable in determining differential effects of age on memory for performed and nonperformed items. However, Kausler et al. (1986) found no effects of task duration on age differences in activity recall.

The results of the current study suggest that the extra information provided to the participant through enactment is equally beneficial for younger and older adults. Thus, the task-guided encoding of activities does not appear to help older adults more than younger adults. Perhaps performing the action not only facilitates memory but also discourages the use of other strategies by younger adults.

As might be expected by the lack of differential age effects, the age differences in memory for performed items do not appear to be independent of those in memory for nonperformed items. When memory for nonperformed items was controlled, the age-related variance in memory for actions was reduced by approximately 80%, and the age-related variance in memory for cognitive activities was reduced by 85%. Although there was still a significant amount of age-related variance in memory for performed items, the amount was small. Almost all of the age-related variance was shared by the performed and nonperformed memory measures, so memory for performed and nonperformed items did not appear to be distinct with respect to age-related influences. In fact, a large association was found between memory types, suggesting that memory for performed items and memory for nonperformed items may share many common processes.

There was some evidence that activity memory and verbal memory may be even more closely related for older than for younger adults. The confirmatory factor analysis revealed correlations between latent performed and nonperformed memory factors of .95 for older adults and .80 for younger adults. Also, in the hierarchical regression analysis, there was a significant interaction of age and memory for nonperformed items when predicting memory for performed items that suggested that memory for nonperformed items may be a better predictor of memory for performed items for older than for younger adults.

Although differential effects of age on memory for performed and nonperformed items were not found, age differences were found in memory for cognitive activities and brief actions, replicating previous findings (e.g., Cohen, Sandler, & Schroeder, 1987; Earles & Coon, 1994; Kausler & Hakami, 1983; Nyberg et al., 1992). As predicted, both perceptual speed and working memory do appear to be important to age differences in memory for both performed and nonperformed items. Speed was associated with between 70% and 84% of the age-related variance in memory for performed and nonperformed items. This association with a measure of processing efficiency suggests that effort in some components of remembering that require processing resources is involved in memory for performed items as well as in memory for nonperformed items. Thus, as Hultsch, Hertzog, and Dixon (1990) found for memory for words and text; Lindenberger, Mayr, and Kliegl (1993) found for a memory composite; and Salthouse (1994) found for associative memory, a decline in the speed of processing appears to be related to age differences in memory for performed items.

Working memory also appears to be important to the relation between age and memory for both nonperformed items and performed items. In fact, working memory was more closely related to memory for both performed and nonperformed items for older than for younger adults. A decrease in working memory may mean that older adults are not as able as younger adults to integrate information in memory because they cannot store and process information simultaneously. Also, the effects of working memory on age differences in memory for performed items may be due to the necessity of integrating information from different modalities.

It is not yet clear how processing efficiency is related to memory for performed items. For example, the effects of processing efficiency may act at encoding, retrieval, or both. One way to begin to separate encoding and retrieval effects is to look at age differences in recognition of performed and nonperformed items, because recognition may require less effort at retrieval than does free recall. Although limited by ceiling effects, several studies have found very small age differences in the recognition of performed items (e.g., Kausler & Wiley, 1990; Lichty, Kausler, & Martinez, 1986). Thus, the use of recognition tests may help distinguish between the effects of age on memory for performed and nonperformed items. There may be larger age differences in recognition of nonperformed than of performed items.

There is limited evidence in the present study that the effortful processing of performed items may be centered at retrieval rather than at encoding. The major difference, other than level of recall, between memory for performed and nonperformed items was the lack of a primacy effect in memory for performed brief actions. The primacy effect may be lacking for action recall because the encoding of actions is not dependent on rehearsal, as suggested by Bäckman and Nilsson (1984) and Cohen (1981). Alternatively, the performance of the action may have taken all of the available presentation time, and there may not have been any time remaining to use a rehearsal strategy. There was a primacy effect for all other memory tests, including performed activities. The finding of a primacy effect for activities was unexpected and differs from previous findings (e.g., Kausler & Hakami, 1983; Kausler, Lichty, & Davis, 1985). Participants in this study may have been more likely to use a strategy for activity recall than those in other studies because of the large number of memory tests given to each participant.

Whether the performed items are cognitive activities or brief motor actions does influence memory. In addition to the differences in serial position curves, motor actions were recalled much better than cognitive activities by both younger and older adults. Because the presentation rate for the activities was longer than the presentation rate for the actions, activities may have been expected to be better recalled than actions. However, the performance of actions requires the use of more distinctive materials. Also, the motor component is different in each action, whereas, with cognitive activities, the motor component always involves writing answers. Lichty et al. (1986) also found higher recall of activities that had a distinctive motor component. Thus, actions may be better recalled than activities because there is more information from more modalities, and therefore actions are more distinctive than are activities. This result provides some evidence that multimodal encoding may be important for producing beneficial effects of enactment on memory performance, as suggested by Bäckman (Bäckman, 1985; Bäckman & Nilsson, 1984, 1985; Bäckman et al., 1986). Further evidence of the benefits of multimodal encoding was provided by the finding of better memory for actions that involved external objects than for actions that did not involve external objects. External objects increase the amount of information provided by the action. However, this finding contrasts with that of Nyberg, Nilsson, and Bäckman (1991), who found better recall of actions without objects than of actions with objects.

In summary, the results of this study suggest that memory for performed items is closely related to memory for nonperformed items, especially for older adults. Although enactment was found to improve recall, performance of an activity appears to be an equally useful orienting task for both older and younger adults. The attention of the participant is directed to each task by performance of an activity, much as the attention of each person may be directed to verbal items by directed encoding manipulations such as forming sentences with to-be-remembered words. Older adults did not, however, remember performed items as well as did younger adults, and this age difference was related to age differences in processing efficiency.

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