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Age-Related Effects of Study Time Allocation on Memory Performance in a Verbal and a Spatial Task

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Abstract

Past studies have suggested that study time allocation partially mediates age relations on memory performance in a verbal task. To identify whether this applied to a different material modality, participants ages 20-87 completed a spatial task in addition to a traditional verbal task. In both the verbal and the spatial task, increased age was associated with poorer utilization of study time, suggesting that age differences in study time allocation are qualitatively similar across material modality. Furthermore, age differences in how individuals allocated their study time partially mediated the age relations on memory performance in both tasks, indicating the importance of effective regulation of study time when learning information. Finally, age differences in study time allocation did not appear to be due to differences in awareness of performance. When a subset of participants was asked about their prior performance, awareness of previous performance was not associated with study time allocation on either task. Interestingly, asking participants about their prior performance tended to decrease recall performance. Overall, these results illustrate that how one allocates study time is related to subsequent memory performance in both a verbal and spatial modality, but knowledge about prior performance is not associated with study time utilization, and inquiring about past performance during study may disrupt rather than facilitate learning.

Tulving and Madigan (1970) wrote that “one of the truly unique characteristics of human memory [is] its knowledge of its own knowledge” (p. 477). This knowledge about one’s memory is defined as metamemory. One key question over the last few decades is whether age-related memory declines are related to metamemory deficits. For example, if older adults are less aware of the effectiveness of a particular strategy, implementing a less effective one could contribute to poorer memory performance (Brigham & Pressley, 1988). In light of the hypothesis that some of the age relations on memory may be related to declines in metamemory, the study of metamemory in older adults has become a flourishing area of research.

There are a variety of ways in which one can assess metamemory, and it can be examined before learning, during learning (encoding), and at retrieval (See Nelson & Narens, 1990, for a review). It is especially important to consider whether there are age relations on metamemory at encoding since it may be the case that age differences in metamemory at learning contribute to some extent to age differences in memory performance. Intuitively if individuals incorrectly believe that they have adequately encoded information, then they may not allocate additional resources to try to remember the information (e.g., they may stop rehearsing the information), and as consequence, they might not retrieve this information at a later time.

Some evidence suggests that one type of metamemory measure, study time allocation, is related to memory performance. For instance, recall readiness studies, in which participants study an entire list before declaring when they are ready to take a test, demonstrate that older adults' poorer recall performance may be at least partially due to prematurely terminating study during learning (Murphy, Sanders, Gabriesheski, & Schmitt, 1981; Murphy, Schmitt, Caruso, & Sanders, 1987). When older adults were instructed to study a list a certain amount of time before terminating the study phase (e.g., the minimum amount of time spent studying a list was 30 seconds), they recalled more items than older adults who were allowed to terminate study at any time (Murphy et al., 1981). An inspection of the study times revealed that participants allowed to terminate study at any time spent less time studying each list compared to the other group. Therefore, the results from the recall readiness studies suggest that older adults may terminate study before fully learning the items and this contributes to differences in memory performance.

Furthermore, previous research that has examined how long each item is studied using verbal materials (e.g., word pairs) has provided supporting evidence that there are age differences in study time allocation. When given the opportunity to restudy information before a subsequent memory test, both younger and older adults allocated more study time to previously incorrect word pairs; however, older adults less consistently allocated additional study time to items that they previously failed to recall compared to younger adults (Dunlosky & Connor, 1997; Souchay & Isingrini, 2004). Importantly, regression analyses revealed that when a measure of study time allocation was partialled from a measure of recall performance, the magnitude of the age differences in recall performance was attenuated (Dunlosky & Connor, 1997; Souchay & Isingrini, 2004). These studies suggest that differences in how individuals of different ages utilize study time in a verbal task partially mediate the age relations on memory performance. One goal of the current project was to determine if this finding could be replicated in a verbal task using a continuous age sample, and whether a similar pattern would be evident in a task involving spatial to-be-remembered information.

Utilization of study time was assessed by investigating how long individual items were studied based on previous performance. It was expected that younger adults would demonstrate better recall performance compared to older adults partly due to differentially allocating study time to previously incorrect items relative to previously correct items. Based on previous research (Dunlosky & Connor, 1997; Souchay & Isingrini, 2004) it was hypothesized that increased age would be associated with poorer regulation of study time, as manifested by less consistent allocation of more study time to previously incorrect items relative to previously correct items when given an opportunity to restudy these items in a subsequent study trial. In addition to attempting to replicate previous findings of age-related effects on study time allocation in a task with verbal materials, the current research investigated whether a similar finding is also evident in a nonverbal, spatial task. Although verbal and spatial memory may rely on distinct processes (e.g., Shaw, Helmes, & Mitchell, 2006; Siedlecki, 2007), it was hypothesized that the age relations on study time allocation would be qualitatively similar for both a verbal and a spatial task, and that the process by which participants determine whether an item is learned well enough to terminate study would be similar across the two tasks.

There are at least two reasons why increased age may be associated with poorer allocation of study time. First, older adults may be poorer at effectively regulating their study time. For instance, individuals might prematurely terminate studying items, or they may excessively allocate study time to items that are already well-learned. Second, there may be age differences in the knowledge of the item's status on the previous trial (i.e., Does the participant remember whether an item was recalled or not?), and this may influence how

long a particular item is studied. For example, if an individual incorrectly believes that an item was correctly recalled on the previous test, less study time may be devoted to that item. In fact, there is some evidence that knowledge about past performance may be impaired with increased age (e.g., Koriat, Ben-Zur, & Sheffer, 1988), which may help to explain age differences in study time allocation. That is if older adults incorrectly believe that they recalled an item, then the study time for this item may be equivalent to the study times for items that they actually recalled. The result is that older adults would appear to be less effective at regulating their study time, as evidenced by less consistently allocating more time to previously incorrect items; however, this would be due to differences in awareness of the prior status rather than differences in differentially allocating study time to previously incorrect items.

Typically these two influences, differences in utilization of study time and knowledge about prior performance, are not distinguished (e.g., Souchay & Isingrini, 2004), likely because it is assumed that participants are aware of their prior performance. However, an experiment by Dunlosky and Connor (1997, Experiment 2) partially addressed the issue of whether differences in remembering the status of the items contributed to age-related differences in study time allocation. Even when participants were presented with feedback about the item status (i.e., previously recalled versus previously unrecalled) during the self-paced study trials, older adults were worse at allocating their study time, as indicated by less consistently allocating more time to previously incorrect items. This suggests that age differences in effectively regulating study time is the primary determinant of age differences in study time allocation and that knowledge about prior performance is unlikely to be an important factor. Nevertheless, this is the only experiment that has provided feedback. The current study more directly examined the effects of knowing about the item's status by including a judgment during the study phase about prior test performance. Based on the finding by Koriat et al. (1988) that older adults are poorer at monitoring what they recalled, it is hypothesized that increased age is associated with poorer judgment accuracy, such that older adults may incorrectly believe that they recalled an item on a previous test when they did not, or incorrectly believe that they did not recall an item on the prior test when they actually recalled it. Furthermore, it was also hypothesized that this would contribute to the age relations on study time allocation.

To summarize, the current project determined whether study time allocation is a mediator of the age relations on memory performance. It was hypothesized that increased age would be associated with poorer study time allocation performance in both a verbal task and a spatial task, and that this would partially contribute to lower recall performance with increased age. Further, the second major goal was to assess whether age relations on study time allocation are due to differences in awareness of prior performance. It was predicted that increased age may be associated with deficits in assessing whether an item was correctly recalled on the previous test, and this may result in poorer allocation of study time on a subsequent self-paced study trial.

Method

Participants

Four-hundred-eighty-one participants completed the two tasks in two different sessions separated by 1-14 days as part of a larger scale study. Participants were assigned to one of three conditions, with 118 participants (Probe 1) being asked in List 1 about their prior performance (i.e., when re-presented with an item for study, they were asked if they correctly recalled the item on the previous test), 154 participants (Probe 2) being asked in List 2 about their prior performance, and 143 participants (No Probe) not being asked in either list about their prior performance.

In these sessions participants completed a series of cognitive ability tasks before they were administered the two meta-memory tasks. The sessions lasted two hours, and the meta-memory tasks were always administered at the end of the session. The majority of the participants completed both tasks, but some of the participants did not complete one of the lists or one of the tasks due to time constraints.

Participants were recruited from the community; none were college students. All had a high school degree, and participants who scored below a 25 on the Mini-Mental Status Exam (MMSE; Folstein, Folstein, & McHugh, 1975), a standard test used to screen for dementia, were excluded from the analyses. Table 1 provides the descriptive characteristics of the sample. The age-adjusted scaled scores for four tests from the Wechsler Adult Intelligence Scale-III (Wechsler, 1997a) and the Wechsler Memory Scale-III (Wechsler, 1997b) are reported to indicate the representativeness of the sample. As shown in the table, increased age was associated with higher functioning on the majority of the tasks, indicating that any age differences observed in the subsequent analyses are not a by-product of the older adult sample being worse on the reference measures.

Materials

For the verbal task 40 Swahili-English translations (e.g., hadithi-story) were selected from the most difficult items in the Swahili-English database (Nelson & Dunlosky, 1994), with the exception of the first two and last two items, which were less difficult. Two lists consisting of 20 translations were constructed to have the same mean level of difficulty. For the spatial task 32 non-objects were selected from the van Diepen and De Graef (1994) line drawing database so that these objects were not easily labeled, making the spatial task a nonverbal task. These non-objects were presented in a 4×4 matrix.

Procedure

The verbal and the spatial task were administered in counterbalanced order across participants on two testing days. Each task was composed of two lists, and participants completed the lists in the same order.

In both the verbal and spatial tasks participants viewed a series of instructions informing them about the purpose of the task along with practice trials to familiarize them with the task. They were told that during the first study phase the computer would control how long the items appeared on the screen, and that they should try to remember these items because they would be given a subsequent memory test. The participants were informed that after they completed the memory test that they would then be re-presented with the same items to study again. They were told that during this second presentation of the items that they would be given some control in determining how long they wanted to study each item. It was explained to them that by pressing the SPACEBAR the next item (Spatial task) or pair of items (Verbal task) would appear on the screen. During the self-paced study trial there was always a prompt at the bottom of the screen informing the participants to press the spacebar to move on to the next item/pair so that participants would not forget which type of study trial they were completing (i.e., computer- vs. self-paced). They were informed that if they did not press the SPACEBAR within 8 seconds that they would automatically be advanced to the next item/pair. Participants were also told not to waste time studying because the time they spent studying also reflected the efficiency of their learning. Following the self-paced study trial, participants completed a recall test. After the second recall test, participants were re-presented with the same items for study in a final self-paced study trial, and following the study trial they completed a final memory test. See Figure 1 for an illustration of the procedure.

For the verbal task, the Swahili word always served as the cue word in the recall tests, and participants provided the English translation. The experimenter typed their responses. Participants were given up to 10 seconds to respond, and they were allowed to pass if they could not remember the translation. For the spatial task, during the recall tests participants were given an empty matrix, and they were shown a non-object at the bottom of the screen. They were asked to click on the cell where they thought the item had appeared, or if they were uncomfortable using the mouse the participants pointed to the cell and the experimenter clicked on the cell for them. If participants did not respond within 10 seconds, they were automatically advanced to the next question.

Participants in the probe conditions were asked during the second and third study trials about their performance on the previous recall test in either List 1 (Probe 1 condition) or List 2 (Probe 2 condition). Specifically, they were re-presented with the items one by one and were asked to make an immediate yes-no judgment as to whether they correctly recalled the item on the previous test. Then they were allowed to re-study the item in a self-paced study trial. Figure 2 depicts an illustration of the procedure for the probe conditions. Note that the diagram contains an example from the verbal task, but the same format was used in the spatial task.

In sum, participants completed six recall test trials – three in the first list and three in the second list – and six study trials, with the first trial always being computer timed followed by two additional self-paced study trials. Some participants were asked about their previous test performance during Study Trials 2 and 3, either in List 1 or List 2, depending on their condition. The presentation of the study material was presented in a fixed order, but the test order was random. The procedure for the verbal and spatial tasks was identical, with only the material modality varying.

Results

Results from a pilot test suggested that the first items were more likely to be studied for a longer duration relative to items in the other portion of the list, while the last two items were studied for a shorter duration. There is also considerable evidence that individuals are more likely to remember items from the first and last portion of a list compared to the middle portions (e.g., Glanzer & Cunitz, 1966). Therefore, the first two and last two items were excluded from the data analyses.

Since some participants completed the verbal task first and the spatial task second, and vice versa, preliminary analyses were conducted to test for order effects. These analyses did not yield a significant main effect of order or significant Age $\times$ Order interaction in the verbal or spatial tasks, $F_s < 3.70$, $p_s > .05$; therefore, subsequent analyses are collapsed across task order.

Recall Performance

A 3 (Age Group: Young, Middle, Older) $\times$ 3 (Condition: No Probe, Probe 1, Probe 2) $\times$ 2 (List: List 1 vs. List 2) $\times$ 3 (Recall Trial: Trial 1, Trial 2, Trial 3) ANOVA on the proportion of items recalled in the verbal task was performed. The ANOVA yielded a significant main effect of Age Group, $F(2, 406) = 34.54$, $\eta_p^2 = .15$, $p < .001$, with LSD post hoc tests indicating that younger adults ($M = .42$) recalled more translations compared to both middle-aged ($M = .33$) and older adults ($M = .20$), and middle-aged adults recalled more than the older adults. Additionally, there was a main effect of List, $F(1, 406) = 6.43$, $\eta_p^2 = .02$, and Trial, $F(2, 812) = 963.97$, $\eta_p^2 = .70$, $p_s < .05$. There were three significant interactions involving List – List $\times$ Condition, $F(2, 406) = 5.84$, $\eta_p^2 = .03$, List $\times$ Trial, $F(2, 812) = 14.14$, $\eta_p^2 = .03$, and List $\times$ Trial $\times$ Condition, $F(4, 812) = 11.25$, $\eta_p^2 = .05$, $p_s < .05$.

As seen in the upper portion of Figure 3, the interactions were a result of lower performance in the probe conditions when participants were asked about their previous performance on a particular trial in a list. Specifically, there was lower performance on lists that included the probe question, and lower performance on Trials 2 and 3 when the question was present. Finally, there was a significant Age Group $\times$ Trial interaction, $F(4, 812) = 20.56$, $\eta_p^2 = .09$, $p < .01$, with increased age being associated with less improvement across trials.

A similar ANOVA was performed on the proportion of items correctly recalled on the spatial task. Similar to the verbal results, there were significant main effects of Age Group, $F(2, 401) = 23.48$, $\eta_p^2 = .11$, List, $F(1, 401) = 103.73$, $\eta_p^2 = .21$, and Trial, $F(2, 802) = 974.78$, $\eta_p^2 = .71$, p 's $< .001$. Furthermore, unlike the verbal results, in the spatial task there was a main effect of Condition, $F(2, 401) = 5.71$, $\eta_p^2 = .03$, $p < .01$, with Probe 1 condition ($M = .42$) showing poorer performance compared to the No Probe condition ($M = .50$) as indicated by LSD post hoc tests. Likewise, similar to the verbal task, there were significant interactions for List $\times$ Condition, $F(2, 401) = 30.35$, $\eta_p^2 = .13$, List $\times$ Trial $\times$ Condition, $F(4, 802) = 18.85$, $\eta_p^2 = .09$, and Age Group $\times$ Trial, $F(4, 802) = 7.48$, $\eta_p^2 = .04$, p 's $< .05$. There was also a significant Age Group $\times$ Trial $\times$ Condition interaction, $F(8, 802) = 2.21$, $\eta_p^2 = .02$, and an Age Group $\times$ List $\times$ Trial interaction, $F(4, 802) = 2.75$, $\eta_p^2 = .01$, p 's $< .05$. Overall, as was the case with the verbal task, when participants were asked about their prior performance, this resulted in poorer recall performance, suggesting that the probe interfered with their learning. Furthermore, the Age Group $\times$ Trial $\times$ Condition interaction suggests that the probe in the spatial task was more deleterious with increased age.

Age, Study Time Utilization, and Recall Performance

Study time utilization was analyzed by computing gamma correlations between study time allocation on a subsequent study trial and prior recall performance (i.e., previously incorrect vs. previously correct). Gamma correlations range from -1 to $+1$, with -1 indicating that an individual consistently allocated study time to previously incorrect items. Importantly, gamma correlations measure the degree of overlap of the two item types – previously incorrect versus previously correct, regardless of the absolute duration of study time. Thus, the absolute values of the study times do not matter, but rather it is the extent to which participants' study time consistently discriminates between the two item types.

To investigate the possibility that lack of awareness of prior performance may influence the study time allocation scores, participants were asked to make judgments on the second and third study trials in either List 1 (Probe 1 Condition) or List 2 (Probe 2 Condition) about whether they believed that they correctly recalled an item on the previous recall trial (e.g., on the second study trial participants answered whether they believed that they correctly recalled an item on Test 1). Participants could be accurate by correctly responding that they recalled an item on the previous test or correctly responding that they did not recall an item on the previous test. They could be inaccurate by incorrectly responding that they recalled an item on the previous test or incorrectly responding that they did not recall an item on the previous test. A monitoring accuracy score was computed such that the sum of the number of correct responses was divided by the sum of the participants' total number of correct and incorrect responses.

To increase the reliability of measures, performance variables were aggregated across trials and lists. For example, Study Time Utilization was calculated by averaging gamma correlations between subsequent study time allocation and previous test performance (i.e., gamma correlations for Recall Trial 1-Study Trial 2 and Recall Trial 2-Study Trial 3 for Lists 1 and 2 were averaged)¹. Furthermore, Recall Performance was computed by averaging the number of items recalled on Trials 2 and Trials 3 across Lists 1 and 2. Therefore, study time utilization and recall performance measures were averaged across four

scores. Monitoring Accuracy scores were collapsed across trials in List 1 (Probe 1 Condition) and List 2 (Probe 2 Condition). There was not a monitoring accuracy score for those in the No probe condition.

Correlations between age, recall performance, study time utilization, and monitoring accuracy by condition are displayed in Table 2 for the verbal (upper portion) and spatial (lower portion) tasks. As shown in the table, increased age was associated with fewer items recalled on both the verbal and spatial tasks across conditions. In addition, increased age was related to less consistently allocating more study time to previously incorrect items, and this finding was consistent across tasks and conditions. Furthermore, better allocation of study time (i.e., study time utilization) was associated with better recall performance on both tasks. While increased age was not associated with poorer monitoring accuracy in the verbal task, nor was monitoring accuracy related to recall performance or study time utilization, there was a tendency for increased age to be associated with poorer monitoring accuracy in the spatial task (Probe 1 condition only), and poorer monitoring accuracy in the spatial task was associated with poorer spatial memory. Importantly, monitoring accuracy and study time utilization were not related in either task, suggesting that monitoring accuracy is not associated with subsequent study time allocation.

Regression analyses were conducted to assess the extent to which study time utilization mediated the age relations on recall. Two values were computed in the regression analyses: 1) The total amount of variance in recall associated with age (R^2 with Age alone), and, 2) the amount of variance associated with age after partialling for study time utilization (R^2 Change). The percentage of reduction in age-related variance in recall when controlling for study time allocation was calculated using the following formula: $[(R^2 \text{ with Age alone} - R^2 \text{ Change})/R^2 \text{ with Age alone}]$. Regression analyses were performed for each condition and task using the aggregated performance variables. Partialling for study time allocation reduced the age-related variance in verbal recall performance by 61.3% in No Probe $[(.173-.067)/.173]$, by 66.3% in Probe 1 $[(.178-.060)/.178]$, and by 77.6% in Probe 2 $[(.210-.047)/.210]$ conditions. Similarly, the age-related variance in spatial recall performance was reduced by 26.0% in No Probe $[(.150-.111)/.150]$, by 69.7% in Probe 1 $[(.152-.046)/.152]$, and by 54.7% in Probe 2 $[(.095-.043)/.095]$ conditions. These results suggest that age differences in how one allocates study time may contribute to some extent to age-related memory declines.

In addition to examining study time allocation as a mediator of the age relations on memory, regression analyses were also conducted for the probe conditions to assess whether monitoring accuracy was a mediator of the age relation on study time utilization. With the exception of Probe 2 condition in the spatial task (25.5% reduction), monitoring accuracy did not appear to be a mediator of the age relations on study time allocation (Less than 1% reduction for Spatial Probe 1 and Verbal Probe 1 and Verbal Probe 2 conditions). Therefore, age differences in monitoring accuracy do not appear to be largely related to age differences in study time.

Discussion

The current project investigated whether there were age differences in study time allocation, and if so, whether those differences might be contributing to age differences in memory. A primary goal of the current project was to assess whether age differences in how one

¹Participants who used the 8 second maximum on 75% of the study trials were removed from the analyses since these participants were not regulating their study time (i.e., they relied on the computer pacing). This resulted in the removal of six participants from the verbal task and zero participants from the spatial task.

allocated study time to previously incorrect and previously correct items when given an opportunity to restudy these items (i.e., study time utilization) would contribute to the age relations on recall performance. This was investigated using both a verbal and a spatial task to evaluate whether age relations on study time allocation were modality specific. Furthermore, a secondary aim was to assess whether age differences in monitoring one's prior test performance contributed to the age relations on study time allocation.

Regarding the primary goal, consistent with previous research (Dunlosky & Connor, 1997; Souchay & Isingrini, 2004), the correlational analyses revealed that increased age was characterized by poorer utilization of study time in a verbal task, with increased age associated with less consistent allocation of more study time to previously incorrect items. Furthermore, although prior research has only examined study time allocation in verbal tasks, this pattern was also found in a spatial task. Although there is some evidence that verbal and nonverbal memory may rely on different processes (Shaw et al., 2006; Siedlecki, 2007), these results suggest that study time allocation may be independent of task type, possibly because effectively utilizing study time relies on similar processes and brain regions regardless of the material modality. Specifically, monitoring and controlling the contents of one's memory has been shown to rely on the prefrontal cortex (See Shimamura, 2008, for a review), an area that experiences shrinkage with increased age (Raz, et al., 2005; Resnick, Pham, Kraut, Zonderman, & Davatzikos, 2003). It is therefore tempting to speculate that older adults are less effective at allocating study time because the regions responsible for carrying out meta-memorial processes decline with age.

With respect to the secondary aim, the results suggest that increased age was not associated with poorer monitoring accuracy of prior performance on the verbal task, although there were age differences in monitoring accuracy in the spatial task. However, it should be noted that in neither tasks was monitoring accuracy correlated with study time utilization. Overall, these results are consistent with Dunlosky and Connor's (1997) finding that increased age is associated with poorer utilization of study time, but that this is not because they are unaware of their prior test performance. Interestingly, the monitoring probe appeared to interrupt learning, as indicated by poorer performance on recall trials following study trials with probes. Therefore, explicitly having individuals make a decision about their prior performance may disrupt learning when they are restudying information.

While age differences in knowledge about prior performance do not appear to be related to age-related declines in study time allocation, it is possible that age differences in study time allocation may be due to differences in beliefs about memory. There is much evidence to suggest that older adults believe they have less control over their memory (e.g., Berry & West, 1993), and studies from an educational setting suggest that individuals who believe that they will do poorly on a task may be less likely to plan strategies that will enhance performance (Zimmerman & Martinez-Pons, 1990). More recently Price, Hertzog, and Dunlosky (2010) found that older adults chose to restudy easier items, suggesting that they might have believed that they could not master the more difficult items. Therefore, differences in beliefs and strategies may contribute to the age relations on study time.

Although the reason(s) for why increased age is associated with poorer study time allocation is not evident in the current project, the results clearly show that how one allocates study time based on prior performance is related to subsequent performance in both a verbal and a spatial task, with study time allocation partially mediating the age relations on recall performance. However, these age relations on study time allocation do not appear to be due to differences in awareness of prior performance. Given the relationship between study time allocation and memory performance it is important to understand just what it is about a person and the learning situation that contributes to being able to successfully allocate study

time. This information will be useful not only for research targeting potential aging interventions, but also for the educational field in general.

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Figure 1.
Schematic diagram of multiple study-test trials procedure for Lists 1 and 2.

Figure 2.
Diagram of the probe procedure to examine awareness of prior performance (monitoring accuracy).

Figure 3.
Proportion of items recalled in a verbal and a spatial task by condition across trials and lists.

Table 1
Descriptive characteristics of participants, arbitrarily divided into three groups

	Age Group			Total	Age <i>r</i>
	20-39	40-59	60-87		
N	85	208	188	481	
Age	28.52 (5.57)	51.87 (5.37)	71.43 (7.73)	55.39 (16.59)	
Prop. Female	.60 (.49)	.68 (.47)	.68 (.47)	.67 (.47)	.03
Years Education	15.34 (2.48)	15.80 (2.70)	16.45 (3.11)	15.97 (2.86)	.11 [*]
Vocab	11.71 (3.07)	11.57 (3.21)	12.58 (2.40)	11.99 (2.93)	.12 [*]
Digit Symbol	11.24 (3.16)	11.75 (4.12)	12.29 (2.72)	11.87 (3.48)	.16 [*]
Logical Mem	11.64 (2.75)	12.09 (3.24)	12.88 (2.61)	12.32 (2.95)	.15 [*]
Word Recall	12.16 (3.00)	12.04 (3.75)	12.53 (3.18)	12.25 (3.41)	.03

Note: Parentheses contain the standard deviation.

^{*} $p < .05$

^{**} $p < .01$. Age *r* refers to the correlation between the demographic variables and age.

Table 2
Correlations among age, recall performance, study time utilization, and monitoring accuracy by condition collapsed across lists and trials

	1.	2.	3.	4.
1. Age				
No Probe		-.42 **	.25 *	----
Probe 1	-----	-.42 **	.24 *	-.01
Probe 2		-.46 **	.36 **	-.01
2. Recall				
No Probe	-.39 **	-----	-.54 **	----
Probe 1	-.39 **		-.65 **	-.13
Probe 2	-.31 **		-.65 **	.02
3. Study Time Utilization				
No Probe	.26 **	-.37 **		----
Probe 1	.35 **	-.58 **	-----	-.01
Probe 2	.17 *	-.50 *		-.15
4. Monitoring Accuracy				
No Probe	----	----	----	
Probe 1	-.04	.18 *	.06	-----
Probe 2	-.21 **	.33 **	-.15	

Note:

* $p < .05$

** $p < .01$. The upper portion represents the verbal bivariate correlations, and the lower portion represents the spatial correlations.