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Adult age differences in subjective and objective measures of strategy use on a sequentially cued prediction task

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Abstract

Differences in strategy use are thought to underlie age-related performance deficits on many learning and decision-making tasks. Recently, age-related differences in learning to make predictions were reported on the Triplets Prediction Task (TPT; Seaman, Howard & Howard, 2013). Notably, deficits appeared early in training and continued with experience. To assess if age differences were due to early strategy use, neural networks were used to objectively assess the strategies implemented by participants during Session 1. Then the relationship between these strategies and performance was examined. Results revealed that older adults were more likely to implement a disadvantageous strategy early in learning, and this led to poorer task performance. Importantly the relationship between age and task performance was partially mediated by early strategy use, suggesting that early strategy selection played a role in the lower quality of predictions in older adults.

Keywords

Strategy; aging; learning; prediction; decision-making

Introduction

Adaptive behavior requires that people learn about their environment and take what they learn into account when making decisions. Recent studies have suggested that age-related deficits in decision-making ability may be due to decreased learning in older adults (Mata, Josef, Samanez-Larkin, & Hertwig, 2011). Impaired learning in older adults has been well documented on category (Filoteo & Maddox, 2004; Glass, Chotibut, Pacheco, Schnyer, & Maddox, 2012; Maddox, Pacheco, Reeves, Zhu, & Schnyer, 2010), reversal (Mell et al., 2005, 2009; Weiler, Bellebaum, & Daum, 2008), reward (Chowdhury, Guitart-Masip,

Lambert, Dolan, & Düzel, 2013; Eppinger & Kray, 2011; Eppinger, Schuck, Nystrom, & Cohen, 2013; Samanez-Larkin, Hollon, Carstensen, & Knutson, 2008; Samanez-Larkin, Levens, Perry, Dougherty, & Knutson, 2012; Schott et al., 2007) and sequence (Curran, 1997; Dennis, Howard, & Howard, 2006; J. H. Howard, Howard, Dennis, & Kelly, 2008; J. H. Howard & Howard, 1997; D. V. Howard et al., 2004; Rieckmann & Bäckman, 2009; Rieckmann, Fischer, & Bäckman, 2010; Simon, Vaidya, Howard, & Howard, 2012) learning tasks (although see Glass et al., 2012; Gorlick & Maddox, 2013; Worthy, Gorlick, Pacheco, Schnyer, & Maddox, 2011; Worthy & Maddox, 2012). Thus, this general learning deficit could contribute to age differences in adaptive decision-making (e.g. Denburg, Tranel, & Bechara, 2005).

Recently, we have documented an age-related difference in the ability to make predictions based on sequential relationships (Seaman, Howard, & Howard, 2013). Modifying an existing sequence-learning paradigm, participants observed two cues and predicted a third, target event on each of a series of trials. Unbeknownst to participants, the first cue predicted the target 85% of the time whereas the second cue was random. Using this Triplets Prediction Task (TPT), we found that while both young and older adults demonstrate learning, age-related performance deficits appeared early in training and persisted with experience. Furthermore, consistent with recently reported sequence learning results (Schuck et al., 2013), we found significant age differences in explicit knowledge, with older adults showing less explicit knowledge than young adults. However, during the post-experimental interview, participants in both age groups reported using similar strategies. Specifically, the majority of participants in both groups reported using both cues to make their predictions instead of either cue alone. Here, we revisit the data reported by Seaman et al (2013), using more objective strategy measures to further examine strategy use on the TPT, the resulting consequences for performance and the development of explicit knowledge, and whether age-related differences in performance and the development of explicit knowledge are related to strategy use

Strategies on Prediction Tasks

Strategy use has been explored using a similar paradigm, the Weather Prediction Task (WPT: Gluck, Shohamy, & Myers, 2002; Knowlton, Squire, & Gluck, 1994). In the WPT, participants are asked to make a binary decision about whether it will “rain” or “shine” based on the presence or absence of up to four cues displayed simultaneously on a computer screen. In a sample of young adults, Gluck and colleagues (2002) found that participants implement one of three strategies on the WPT: they either make predictions based on all cues present (the multi-cue strategy), on whether or not a single cue is present (the one-cue strategy), or they simply learn the four patterns where only one cue is present and ignore all other scenarios (the singleton strategy). Hence, in the WPT strategies can vary from *simple* strategies that involve using one source of information to make predictions to *complex* strategies that involve integrating multiple sources of information.

Overall, Gluck et al (2002) found that data from all participants were best fit by a simple strategy, either the one-cue strategy or the singleton strategy. However, when they partitioned the data into four training blocks, they found changes across blocks such that

participants shifted away from simpler strategies towards the more complex strategy. They also found that those using the complex strategy in the last training block made more optimal predictions than those using a simple strategy (Gluck et al., 2002). This finding has been replicated in multiple studies, with a shift from simple to complex strategies as participants gain experience on the task (Price, 2009; Shohamy, Myers, Onlaor, & Gluck, 2004), and better performance being associated with the more complex strategy (Fera et al., 2005; Price, 2009; Shohamy et al., 2004). Thus, participants initially tend to use simple strategies on the WPT, but as they learn more about the task, they rely increasingly on more complex strategies, and those who do display better performance.

Strategy Use and Aging

A review by Lemaire (2010) has highlighted how aging has been associated with differences in strategy use in a variety of cognitive domains, including problem solving, reasoning, and decision-making. In addition to choosing different strategies from young adults, older adults generally have a smaller repertoire of strategies, are less efficient at implementing those strategies, and tend to make poorer choices when selecting strategies (Lemaire, 2010). Only two studies have examined strategy use by both young and older adults on the WPT and these studies report conflicting results. One study showed significant age differences in strategy use and performance (Price, 2005), while the other study revealed no age-related differences (Fera et al., 2005). Therefore, while age-related differences in strategy use have been documented on a variety of tasks, it is less clear whether or not these strategy differences exist when making predictions.

Strategy Use on the TPT

The current study used the data from Seaman et al (2013) to determine whether age-related differences in performance were associated with age-related differences in strategy use. As described above, there were no age differences in the subjective strategies reported by young and older adults. It is possible that participants were unable to articulate the prediction strategy they used in the post-experimental interview, or that they were not consciously aware of the strategy they were employing. In order to more objectively assess strategy use, we developed neural networks to model each of the strategies described by participants, and then fit these models to the actual predictions made by individual subjects. One advantage of using neural networks is that they can be trained to approximate an individual's predictions without making assumptions about the learning process. To objectively determine which strategy a participant used, we assessed which model fit the participant's predictions the best. With this technique, we were also able to examine strategy use at different points during the task.

First, in order to objectively determine the strategy implemented by each individual, we fit the models to all of each participant's data to determine if age differences in overall strategy could explain the age-related performance differences. Then, because age differences in performance appeared within Session 1, we used these models to see if age differences existed in the strategy implemented at the beginning of the task, as well as to determine how these strategies changed with experience. We then examined whether or not the strategies identified in Session 1 related to overall performance or explicit awareness.

Methods

Participants

Sixteen Catholic University undergraduates (19.46 ± 1.82 years old) and 16 community-dwelling older adults (67.93 ± 6.06 years old) participated in this study. Four participants (2 young and 2 older adults) were removed from analyses due to chance responding or performance three standard deviations away from the group mean. As described in Seaman et al (2013), the age groups were well matched in terms of gender, self-rated health and short-term memory, and revealed the expected age differences in vocabulary and processing speed, and strong working memory in the older adults. A complete characterization of the two groups can be found in Seaman et al (2013, Table 1).

Triplets Prediction Task (TLT)

As described in Seaman et al (2013), on each trial of the TPT participants were presented with two successive cue events and then they made a prediction about the spatial location of a third target event. Thus, each trial contained a three-event sequence, or triplet. After responding, participants were given feedback for 2000ms about the accuracy of their prediction and shown the correct location. Unbeknownst to them, the first cue predicted the target location 85 percent of the time. Thus, some triplets occurred frequently while others occurred infrequently. There were six potential sets of cue-target relationships counterbalanced across participants, and each participant had a unique sequence of trials. Participants completed 1680 trials in six, four-block sessions (i.e., 280 trials per session) over two days; trials in which they did not respond were excluded, leaving 1489 to 1680 trials per participant. Performance was measured by examining the proportion of all trials on which participants made the Optimal Prediction by selecting the most likely target.

Post-Experimental Recognition Test and Subjective Strategy Assessment

After the final day of training, participants completed a recognition test in which they observed all 64 possible combinations of cues and targets presented as in training and rated each as occurring frequently or infrequently by key press. This test allowed us to assess the level of explicit knowledge participants gained about the task structure by comparing participant rating of frequent and infrequent events during the learning task, creating a Recognition Score.

Following the recognition test, participants were interviewed about the strategies they used using a semi-structured interview based on questionnaires adapted from prior studies (Gluck et al., 2002; Hosseini et al., 2010; Simon et al., 2011) and tailored to the TPT. In the interview, participants were first asked open-ended questions about the strategies they used and their explicit knowledge of the task structure. Then they answered forced-choice questions about the strategy used. The first of these forced-choice questions asked whether they 1) guessed on each trial, *Guessing*; 2) used the target on the previous trial to make their prediction, *Previous Target*; or 3) used the cues to make their predictions. If they indicated that they used the cues then a follow-up question asked which cues were used, either *Cue 1* *Cue 2*, or both cues together, the *Cue Pair*.

Neural Networks

Five different neural network (NN) models were created to mimic these strategies (NN_{C1}: *Cue 1*, NN_{C2}: *Cue 2*, NN_{CP}: *Cue Pair*, NN_{PT}: *Previous Target*, and NN_G: *Guessing* strategies). Using the statistical software JMP, these NNs were fit to all of the data for each participant independently to provide an objective estimate of the way each individual used the information presented in the task to make their predictions. Model fits were assessed by calculating the Akaike Information Criterion (AIC) model-fit statistic (Akaike, 1974; Busemeyer & Diederich, 2010) and these values were compared using Akaike weights (Wagenmakers & Farrell, 2004; Worthly & Maddox, 2012). A more thorough description of these NN models, how they were fit to the data, and how model-fit was assessed can be found in the supplementary materials.

Statistical Analyses

Age-related differences in strategy use were examined with a general likelihood, G^2 test, because some of the cell sizes did not meet the criteria for the chi-square tests. Changes in the frequency of objective strategy use over training in Session 1 were examined using Cochran's Q test. Then relationships between age (in years), Session 1 objective strategy use, TPT performance, and explicit knowledge were analyzed with correlations and mediation analyses. Indirect effects in the mediation models were tested using the *PROCESS* macro for SPSS (Hayes, 2013). Specifically, the significance was tested by estimating bootstrapped confidence intervals (BCa CI; Diccio & Efron, 1996) and effect size was estimated using the proportion of the maximum possible indirect effect (κ^2 ; Preacher & Kelley, 2011). While this study has a relatively small sample size, use of the bootstrapping makes increases the reliability of the results (Preacher & Hayes, 2004).

Results

Overall Objective Strategies: All Sessions

As described above, there are many reasons to believe the subjective strategies do not fully characterize the strategies actually implemented by participants. To provide a more objective estimate of the overall strategy implemented by each individual, NNs were fit to the data for each participant from all six sessions. As described above, Akaike weights were used to determine which of the five models best fit the predictions made by each participant. Table S4 presents the number of participants best-fit by each NN on the complete data set. Across individuals, the average Akaike weight (1.0, SD = 0.02) for these best-fitting models indicates that of the five models examined here, the best-fitting models provide a strong fit to the data.

Although nine people reported using a *Previous Target* or *Guessing* subjective strategy, the data were not well fit by either model. For most participants the cue-pair network (NN_{CP}) provided the best fit to the data from all sessions; this was the case for all but one of the older adults (92.9%), and for all but three of the young participants (78.6%). The group differences in the best-fitting models did not reach statistical significance, G^2 (2, $N = 28$) = 5.71, $p = .057$.

Objective Strategies in Session 1

As described above, there were no age differences in subjective or objective measures of overall strategy use. However, as described in Seaman et al. (2013), age-related differences in the proportion of Optimal Predictions made in the TPT appeared within Session 1 (Figure 1a) and persisted across the remaining sessions. Thus, it makes sense to determine if there were age-related differences in the strategies used within the first session, and whether or not strategy use changed within Session 1. To explore this, the five NN models were fit to the data for each of the four blocks within Session 1 and the best-fitting models for each block were selected by comparing Akaike weights. For ease of interpretation, we have grouped the five strategies described above into two broader categories; advantageous strategies can lead to optimal predictions (*Cue 1 or Cue Pair*), while disadvantageous strategies lead to chance performance (*Cue 2, Previous Target, Guessing*). Table 1 displays the number of participants best-fit by each NN at the block level within Session 1. Across individuals, the average Akaike weights for the best-fitting models at the block level of analysis, .93 ($SD = .13$), suggest that of the five models we considered, these models are by far the most likely to explain the data.

The proportion of participants best-fit by advantageous and disadvantageous strategies can be seen in Figure 1b. There was an overall trend of increasing advantageous strategy use throughout Session 1, $Q(3) = 9.39, p = .025$. However, as can be seen in Figure 1b, this trend is driven primarily by the young adults, who showed a significant increase in advantageous strategy use, $Q(3) = 11.88, p = .008$, while the older adults did not, $Q(3) = 1.57, p = .666$. Follow-up chi square analyses showed that while there was no significant age difference in strategy use during Block 1, $\chi^2(1) = .14, p = .705$, there was a significant age difference in Block 2, $\chi^2(1) = 4.09, p = .034$, Block 3, $\chi^2(1) = 8.02, p = .005$, and Block 4, $\chi^2(1) = 4.76, p = .029$.

Objective Strategy in Session 1, Explicit Knowledge and Task Performance

We next sought to determine how early strategy use, as measured by objective strategy in Session 1, was related to the development of explicit knowledge and overall task performance. As detailed above, performance on the TPT was measured by examining the proportion of Optimal Predictions across all sessions. To quantify objective strategy use in Session 1, we counted the number of blocks within Session 1 where each participant used an advantageous strategy, yielding an Advantageous Score that ranged from 0 to 4. Then, to measure the degree to which people could distinguish likely from unlikely triplets, responses from the post-experimental recognition test were used to construct a Recognition Score.

As revealed in Table 2, significant correlations were found between early strategy use, explicit knowledge, and performance. Importantly, the relationship between early strategy use and task performance was partially mediated by explicit knowledge. As displayed in Figure 2a, there was a significant indirect effect of Advantageous Score on Optimal Predictions through Recognition Score, $\beta = .251$, BCa CI [.100, .444], representing a moderate effect $\kappa^2 = .287$, 95% BCa CI [.118, .477]. This suggests that those who use advantageous strategies early in the task develop more explicit knowledge of the task structure and ultimately have higher overall performance.

We next sought to determine how age-related differences in performance and explicit knowledge were influenced by early strategy use. Significant correlations between age, strategy use, explicit knowledge, and performance were found (Table 2). As Figure 2b illustrates, the relationship between performance and age was partially mediated by strategy use. Specifically, there was a significant indirect effect of Age on Optimal Predictions through Advantageous Score, $\beta = -.187$, BCa CI $[-.375, -.053]$, representing a moderate effect, $\kappa^2 = .201$, 95% BCa CI $[.057, .381]$. However, Figure 2c shows that strategy use does not mediate the relationship between age and explicit knowledge, $\beta = -.078$, BCa CI $[-.313, .028]$. Collectively, these analyses suggest that the effect of age on TPT performance is mediated by strategy use early in training; those who use an advantageous strategy early in training end up performing better on the task overall, and this relationship explains part of the relationship between age and performance. However, early strategy use does not appear to explain the relationship between age and explicit knowledge.

Objective Strategy in Session 1 and Neuropsychological Measures

Finally, we investigated the relationship between cognitive abilities, as measured by neuropsychological measures shown in Table 3, and early strategy use, as measured by the Advantageous Score. For young adults there were no significant relationships between any of the neuropsychological measures and Advantageous Score ($p < .10$). However, for older adults there was a significant relationship between working memory capacity, as measured by Digit Span Backwards, and strategy use, as measured by Advantageous Score, $r(12) = .571$, $p = .033$, such that those with higher working memory were more likely to use an advantageous strategy early in training.

Discussion

This study examined age differences in strategy use on a sequential prediction task, the Triplets Prediction Task, extending previously reported results (Seaman et al., 2013). Using an objective assessment of strategy use, we found that there was a significant shift from disadvantageous to advantageous strategies within Session 1 for young adults, whereas older adults tended to persist in using disadvantageous strategies throughout. Furthermore, this advantageous strategy use in Session 1 mediated the relationship between age and overall performance on the task. However, there were no age-related differences in subjective strategies or overall objective strategies.

These results are important because age-related differences in the proportion of optimal predictions appeared during the first session and persisted throughout training (Seaman et al., 2013). By implementing a more advantageous strategy earlier in the task, young adults were able to outperform older adults relatively quickly. The age difference in prediction accuracy persisted despite the fact that older adults appeared to shift to an advantageous strategy at a later point in training; by the fifth session all but one older adult were best fit by an advantageous strategy. However, even with this strategy shift, older adults were never able to reach the same level of performance as the young. In fact, for older adults, there was a significant relationship between early strategy use and overall performance, $r(12) = .677$, $p = .008$, while there was no such relationship for young adults (Table S5).

The strategies presented in this paper involved different levels of complexity, and are theoretically supported by different cognitive capacities. Because cues are presented sequentially instead of simultaneously during the TPT, the *Cue Pair* strategy requires participants to retain and integrate information over time. Thus, implementing this strategy places demands on both executive function and working memory. By comparison, the other strategies do not require integration of information across successive events within trials and place lower demands on working memory capacity. The *Previous Target*, *Cue 1*, and *Cue 2* strategies load working memory capacity in similar ways, in that they require tracking only four cue-target relationships, but these strategies differ in the amount of time information must be maintained in working memory.

The disadvantageous strategy used most frequently by older adults during the first session, *Cue 2*, is the simplest strategy because it requires participants to remember and respond based only on the most recently presented information. Several other studies of decision-making have found that older adults tend to choose simple strategies (Mata, Schooler, & Rieskamp, 2007; Worthy & Maddox, 2012) and this bias has important implications for decision making. When a more complex strategy is optimal, implementing simpler strategies can result in poorer performance (Gluck et al., 2002; Price, 2009). Thus, because optimal performance on the TPT requires the use of more complex strategies, age differences in performance occurred because older adults were using a simpler strategy during Session 1.

It is possible that if the older adults used an advantageous strategy from the beginning, their performance would have been equivalent to that of young adults. One study has found that when older adults use the most appropriate strategy for a given task, age-related deficits in performance disappear (Maddox et al., 2010), although see (Mata, Wilke, & Czienskowski, 2009). Furthermore, when the most appropriate strategy for the task is simple in that it places fewer demands on working memory, older adults can actually outperform young (Worthy et al., 2011; Worthy & Maddox, 2012). Additional research is necessary to determine whether or not older adults could reach equivalent levels of performance by implementing an advantageous strategy from the beginning of the task.

Previous studies have suggested that older adults do not execute strategies as well as young adults (Lemaire, 2010; Mata et al., 2009) and there is evidence in the present study consistent with this. Specifically, the older adults who revealed an objective advantageous strategy in Session 1 were not fit as well as their younger counterparts (AIC $M = 321$ and 290 , $SD = 33$ and 61 , respectively). This suggests that even though some older adults were using an advantageous strategy, the older adults did not implement it as well as the young.

This ability to execute more advantageous strategies could rely on general cognitive ability. In general, complex strategies are more cognitively demanding, and using a complex strategy can lead to age-related impairments in performance (Lemaire, 2010; Mata, von Helversen, & Rieskamp, 2010). Unlike many decision-making tasks, during the TPT cues are presented sequentially, thereby increasing working memory load. In fact, older adults who used advantageous strategies more often during Session 1 had higher working memory capacity, as measured by Digit Span Backwards, than those who used disadvantageous strategies. This suggests that the older adults with better working memory were more likely

to employ advantageous strategies in the first session than those with poorer working memory.

The analyses presented here reveal relationships between age, the strategy implemented in Session 1, explicit knowledge of the task structure assessed at the end of training, and overall task performance. We found that the development of explicit knowledge mediated the relationship between early strategy use and performance. This result is consistent with Price (2009), who showed relationships between strategy use, performance, and explicit awareness on the WPT. However, early strategy use does not mediate the relationship between age and explicit knowledge. This suggests there may be a dissociation between task performance and explicit awareness, but more studies are needed to fully characterize the relationships between age, strategy use, task performance, and explicit awareness.

Although not detailed here, we also investigated the relationship between the subjective reports of strategy and our overall objective estimate of strategy, to provide a measure of meta-cognitive awareness. While we found that almost half of the subjective reports of strategy matched our overall objective strategy assessment (Older: $N = 8$, Young: $N = 5$), there were no significant age-related differences in this measure of meta-cognition, nor was there evidence supporting a relationship between meta-cognitive awareness and either overall task performance or explicit knowledge ($ps < .10$). Thus, meta-cognitive awareness of strategy does not appear to convey a performance advantage, nor does it explain the age differences in task performance found in this sample.

Conclusion

Here we found that age-related differences in objectively assessed strategy use occurred relatively early in a prediction task, and that these differences in strategy use were related to task performance. Older adults were more likely than young to select a simpler, disadvantageous strategy during the first session and this led to poorer performance. Furthermore, those older adults who did select an advantageous strategy did not implement this strategy as well as young adults, also leading to poorer performance. There was also some evidence to suggest that older adults with better working memory used the complex, advantageous strategy more often than those with poor working memory. This is likely because the TPT presented cues sequentially instead of simultaneously, challenging working memory more than previously used tasks such as the WPT. While some studies have shown that interventions can improve the performance of older adults on relatively simple decision making tasks (Hosseini et al., 2010; Samanez-Larkin, Wagner, & Knutson, 2011), the results presented here raise questions about the efficacy of a strategy intervention on a more challenging task like the TPT. Further research is needed to explore the effects of intervention on prediction ability and more complex decision-making tasks.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.

Learning and Strategy Use. (a) Proportion of trials where the optimal prediction (OP) was made over block within Session 1 by age group. (b) Number of participants using Advantageous strategies by Age group (determined by best fitting NN model) during each block of Session 1. Adapted from “Adult age differences in learning on a sequentially cued prediction task,” by K. L. Seaman, D. V. Howard and J. H. Howard, Jr., 2013, *Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, p. 4. Copyright 2013 by Oxford Journals.

Figure 2.

Mediation models. (a) Standardized regression coefficients for the relationship between Session 1 strategy use and task performance as mediated by explicit knowledge. The standardized regression coefficient between strategy use and task performance controlling for explicit knowledge is in parentheses. (b) Standardized regression coefficients for the relationship between age and task performance as mediated by Session 1 strategy use. The standardized regression coefficient between age and task performance controlling for Session 1 strategy use is in parentheses. (c) Standardized regression coefficients for the relationship between age and explicit knowledge as mediated by Session 1 strategy use. The standardized regression coefficient between age and explicit knowledge controlling for Session 1 strategy use is in parentheses. * $p < .05$.

Table 1

Number of participants best-fit by NNs in Session 1 by Block and Age Group

Block	Older				Young			
	1	2	3	4	1	2	3	4
Advantageous Models								
NN _{C1}	3	4	1	7	4	4	5	7
NN _{CP}	3	3	5	1	3	8	8	6
Disadvantageous Models								
NN _{C2}	7	6	3	3	4	1	1	1
NN _{PT}	1	1	5	3	3	1	0	0
NN _G	0	0	0	0	0	0	0	0

Note. NN = Neural Network; C1 = Cue 1; CP = Cue Pair; C2 = Cue Pair; PT = Previous Target; G = Guessing.

Table 2

Correlations between Age and Measures of Performance and Strategy

Variable	1	2	3
1. Age (in years)	—		
2. Proportion of Optimal Predictions	-.535 **	—	
3. Recognition Score	-.642 **	.737 **	—
4. Advantageous Score	-.427 *	.587 **	.422 *

Note.

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

Table 3

Correlation between Advantageous Score and Neuropsychological Measures by Age Group

	1	2	3	4	5	7
Young						
1. Advantageous Score	—					
2. WMS-III Digit Span Forward	.342	—				
3. WMS-III Digit Span Backward	.349	.333	—			
4. WAIS-III Digit Symbol Coding	.449	.356	.621 *	—		
5. WAIS-III Digit Symbol Paring	.015	.346	.346	-.041	--	
6. WAIS-III Digit Symbol Recall	-.130	.246	-.113	-.280	.856 **	--
7. NAART35 Vocabulary	-.080	-.220	.305	-.035	.265	.056
Older						
1. Advantageous Score	—					
2. WMS-III Digit Span Forward	.279	—				
3. WMS-III Digit Span Backward	.571 *	.305	—			
4. WAIS-III Digit Symbol Coding	.255	.140	.346	—		
5. WAIS-III Digit Symbol Paring	.070	-.031	.079	.585 *	--	
6. WAIS-III Digit Symbol Recall	-.027	-.041	.182	.567 *	.843 **	--
7. NAART35 Vocabulary ^a	-.413	-.215	-.585	-.481	-.234	.016

Note. NAART35 = Short Version of the North American Adult Reading Test (Uttl, 2002); WAIS-III = Wechsler Adult Intelligence Scale-Third Edition (Wechsler, 1997a); WMS-III = Wechsler Memory Scale-Third Edition (Wechsler, 1997b).

^a NAART35 Vocabulary is scored such that higher scores are related to poorer performance. For all other neuropsychological tests, higher scores indicate better performance.

**
 $p < .01$.

*
 $p < .05$.