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Effects of Aging and Prospective Memory on Recognition of Item and Associative Information

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Abstract

Older adults typically perform worse than young adults on tasks of associative, relative to item, memory. One account of this deficit is that older adults have fewer attentional resources to encode associative information. Previous studies investigating this issue have divided attention at encoding and then examined whether associative and item recognition were differentially affected. The current study utilized a different cognitive task shown to tax attentional resources: event-based prospective memory. Although older adults demonstrated worse associative, relative to item, memory, the presence of the prospective memory task at encoding decreased item and associative memory accuracy to the same extent in both age groups. These results do not support the resource account of age-related associative deficits.

Keywords

aging; associative recognition; prospective memory; dividing attention

Decades of cognitive research have documented changes in memory with advancing age. While semantic memory (e.g., vocabulary) increases steadily with age, episodic memory (i.e., day-to-day events) decreases markedly with age (for a review, see Salthouse, 2004). Moreover, studies have shown significant age-related declines in memory for associations formed between individual stimuli, compared to relatively small differences in memory for the individual stimuli themselves. This deficit in processing associative information has been observed with several types of stimuli, including word pairs (Castel & Craik, 2003; Healy, Light, & Chung, 2005; Kilb & Naveh-Benjamin, 2007; Light, Patterson, Chung, & Healy, 2004; Naveh-Benjamin, 2000; Naveh-Benjamin, Guez, & Marom, 2003a; Naveh-Benjamin, Guez, & Shulman, 2004b; Naveh-Benjamin, Hussain, Guez, & Bar-On, 2003b), picture pairs (Naveh-Benjamin et al., 2003b), words and nonwords (Naveh-Benjamin, 2000), words and fonts

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(Naveh-Benjamin, 2000, Naveh-Benjamin et al., 2003a), and words and faces (Naveh-Benjamin, Guez, Kilb, & Reedy, 2004a).

One account of age-related declines in processing associative information is that older adults fail to bind different components of an event. Naveh-Benjamin (2000) proposed the *associative deficit hypothesis*, which asserts that a critical component of older adults' memory decline is their deficiency in creating and retrieving links between units of information (e.g., word pairs) and items within their context (e.g., the color of a printed word). Numerous studies have demonstrated a disproportionate impairment in memory for associations relative to items in aging (Castel & Craik, 2003; Healy, et al., 2005; Kilb & Naveh-Benjamin, 2007; Light et al., 2004; Naveh-Benjamin, 2000; Naveh-Benjamin et al., 2003b; Naveh-Benjamin et al., 2004b). Similarly, Johnson, Hashtroudi, and Lindsay (1993) proposed a *source monitoring framework* which suggests that remembering a complex event entails both binding its components during encoding and evaluating and reconstructing the components during retrieval. Thus, age-related deficits in processing associative information may reflect weak binding processes at encoding or reconstruction processes at retrieval (e.g., Chalfonte & Johnson, 1996).

By the *attentional resource account*, however, the associative deficit in aging stems from the fact that older adults have fewer attentional resources to encode associative information (Craik, 1983; Rabinowitz, Craik, & Ackerman, 1982). To investigate this account, researchers have attempted to reduce attentional resources in young adults by dividing attention (DA) at encoding and then examining whether participants' test performance is lower for recognition of associative information relative to item information, thus mimicking the deficit observed in aging (Castel and Craik, 2003; Kilb & Naveh-Benjamin, 2007; Naveh-Benjamin et al., 2003a; Naveh-Benjamin et al., 2003b; Naveh-Benjamin et al., 2004b; Naveh-Benjamin et al., 2004a). Using this approach, Castel and Craik (2003) demonstrated greater declines in associative memory compared to item memory under DA relative to full-attention (FA). Such findings provide direct support for the hypothesis that the age-related deficit in associative memory reflects a decrement in attentional resources. However, numerous studies have failed to find an interaction between attentional status and recognition task, with younger adults showing similar declines in both associative and item recognition under conditions of DA compared to FA (Kilb & Naveh-Benjamin, 2007; Naveh-Benjamin et al., 2003b; Naveh-Benjamin et al., 2003a; Naveh-Benjamin et al., 2004b; Naveh-Benjamin et al., 2004a). As such, findings from the DA studies in young adults are mixed, making interpretation of the age-related associative deficit unclear.

Kilb and Naveh-Benjamin (2007) sought to extend the existing literature by assessing the effect of DA on subsequent memory for word pairs in *both* young and older adults. Attention was divided by administering a concurrent auditory choice task in which participants had to discriminate between three tones of differing pitch. In the FA condition, this task was absent and participants were prompted to focus their attention on encoding the word pairs. Afterwards, they were given item and associative memory tests. It was hypothesized that if attentional resources mediated the older adults' deficit in associative memory, then younger adults would show an associative deficit under DA, and older adults would show a larger associative deficit under DA relative to FA. If, however, the associative deficit reflected binding problems, then no differential effect on the two memory tasks would be expected in either group. No worsening of the associative deficit under DA was found, supporting the notion that attentional resources may not be the underlying cause of the associative deficit in older adults (Kilb & Naveh-Benjamin, 2007). However, it is possible that the DA manipulation may not have sufficiently disrupted the attentional resources available to participants. As such, it is important to examine alternative conditions under which attentional resources may be disrupted.

Another approach is to tax attentional resources utilizing a different cognitive task, such as tasks of prospective memory (PM). PM is defined as remembering to perform an intended action in the future and can either be event-based (i.e., the intended action is typically triggered by a specific event or cue) or time-based (i.e., remembering to perform the intended action at a particular point in time) (Einstein, Holland, McDaniel, & Guynn, 1992; Einstein & McDaniel, 1990). Like DA, PM tasks usurp attentional resources at encoding by relying on executive functions and monitoring (Cohen & O'Reilly, 1996; Marsh & Hicks, 1998). However, unlike DA tasks that are externally cued, PM tasks rely on self-initiated retrieval processes. Furthermore, event-based PM tasks may also emphasize the encoding of item, rather than associative, information, further leading to declines in associative performance (Hockley & Cristi, 1996).

PM tasks require participants to internally monitor for cues to perform the proper intended action (i.e., self-initiated retrieval) and, as such, are difficult for older adults (Einstein, McDaniel, Richardson, Guynn, & Cunfer, 1995; Park, Hertzog, Kidder, Morrell, & Mayhorn, 1997). In contrast, DA tasks are externally cued. This distinction is of particular importance, as older adults are thought to be fundamentally impaired in self-initiated retrieval (Craik, 1994). Indeed, studies have shown that in experimental settings, young adults outperform older adults in PM tasks across a variety of manipulations (for a review, see Henry, MacLeod, Phillips, & Crawford, 2004). Moreover, event-based PM tasks tend to emphasize monitoring for and encoding of item, rather than associative, information. For example, participants may be asked to monitor for a particular type of stimulus (i.e., animal names) in a pair of words or large array. This emphasis on processing item information at study has been shown to decrease subsequent associative recognition. In contrast, when associative information is emphasized at study, associative recognition greatly improves, yet item recognition does not suffer, demonstrating a tradeoff between item and associative memory based on the type of information emphasized at encoding (Hockley & Cristi, 1996). This suggests that PM tasks would disrupt memory for associative information more so than item information.

Although it is postulated that the difficulty or complexity of the PM task mediates the amount of resources available to successfully complete the concurrently presented ongoing task (e.g., McDaniel & Einstein, 2000), the exact mechanisms of this effect remain unclear. The *Multiprocess Framework of Prospective Memory* argues that depending on the combined complexity of the event-based PM (e.g., target saliency and distinctiveness) and ongoing (e.g., difficulty of task, focus of attention) tasks, cue detection can range from resource demanding to automatic (McDaniel & Einstein, 2000; McDaniel, Guynn, Einstein, & Breneiser, 2004).

Alternatively, the *Preparatory Attention and Memory Model* argues that regardless of the combined complexity of the PM and ongoing tasks, the process is not automatic and a certain degree of attentional resources will always be required to monitor for PM cues (Smith, 2003; Smith & Bayen, 2004; Smith, Hunt, McVay, & McConnell, 2007). Typically, when the PM cues consist of a category of items, such as animals (Zimmermann & Meier, 2006; Cherry et al., 2001), or multiple items (Cohen, West, & Craik, 2001; Park et al., 1997; Einstein et al., 1992; Smith & Bayen, 2006), it taxes attention to a degree that older adults, who suffer from decreased attentional resources, show significant declines relative to young adults. Therefore, PM tasks may tax attentional resources to the extent that participants are unable to encode associative information successfully, as hypothesized by the attentional resource account.

Task interference is the extent to which event-based PM tasks usurp resources from the ongoing task (Hicks, Marsh, & Cook, 2005; Marsh, Cook, & Hicks, 2006). It is indicated by increased reaction times, an effect attributed to resources being redirected to monitoring for PM cues. To date, most event-based PM tasks have used reaction times to measure task interference. Recently, however, Cook, Marsh, Clark-Foos, and Meeks (2007) found that similarly to DA, event-based PM tasks presented concurrently at encoding decrease subsequent memory performance. Specifically, participants had worse free recall performance when stimuli were encoded with a concurrent PM task (i.e., pressing a key if a word denoting furniture appeared) than when stimuli were not encoded with a concurrent PM task. Interestingly, participants never saw any PM cues. Rather, the presence of an intention was enough to draw significant attentional resources away from encoding and decrease subsequent memory performance. This finding provides an important alternative approach to discerning the two competing theoretical accounts of the associative deficit (i.e., impaired binding processes or deficient attentional resources).

The current study utilized an event-based PM task designed to yield task interference on subsequent memory accuracy (e.g., Cook et al., 2007). As participants encoded word pairs, they were also instructed to press a button whenever an animal name appeared. This novel DA task has not been used previously in associative memory paradigms, especially with regard to its reliance on monitoring processes, self-initiated requirements, and drawing of attention to item-specific information. Moreover, similarly to Kilb & Naveh-Benjamin (2007), the current study sought to reduce the attentional resources available to encode associative information in *both* young and older adults. It was expected that the PM task would be more difficult for older adults than young adults. Furthermore, the PM task was expected to yield significant task interference in both age groups, and that older adults' associative recognition performance would be lower than that of young adults. What remained unclear was whether this task interference would be significantly greater for associative, relative to item, recognition. It was hypothesized that if the associative deficit observed in older adults stems from declines in attentional resources, the current task should yield deficits in associative, relative to item, memory in both age groups. If, however, age-related associative deficits arise from deficient binding mechanisms and do *not* reflect declines in attentional resources, then the PM task should yield equal deficits in item and associative memory in both young and older adults.

Methods

Participants and Design

Sixty young adults (ages 18–33 years) were tested in total, with 15 participants in each between-subjects condition. There were 38 females (*M* age = 19.17 years, *SD* = 1.81; *M* education = 13.75 years, *SD* = .95). The young adult subjects were recruited from the psychology participant pool at the University of North Carolina at Chapel Hill, and received course credit for a single 30 minute session. Fifty-six community-dwelling healthy older adults (ages 60–90 years; 31 females) were also tested, with 14 participants in each between-subjects condition (*M* age = 72.64 years, *SD* = 6.01; *M* education = 16.34 years, *SD* = 2.13). All older adult participants received a series of neuropsychological tests in order to determine their cognitive capacity and to rule out any participants with discernible cognitive deficits. [1] Young adults did not receive this battery because they were not at risk for any neurodegenerative disorders. Young and older participants were randomly assigned to either the item or the associative memory test. They were also randomly assigned either to receive the PM task, or to have no concurrent task present at encoding. As such, a 2 × 2 × 2 between subjects factorial design was used to examine the effects of age (young vs. old), attention (PM task vs. no task), and memory test (item vs. associative).

[1]The older adult participants tested in this experiment had a mean Mini-Mental State Exam score (Folstein, Folstein, & McHugh, 1975) of 29.33 (*SD* = 1.14).

Materials

The memory and PM tasks were presented on an iBook G4 Macintosh laptop. Stimuli were presented and responses were recorded with MacStim (Darby, 2006). During the encoding phase, participants were shown 60 pairs of unrelated words, one pair at a time. During the retrieval phase, participants were shown 90 pairs of unrelated words. Thirty word pairs were "intact" (i.e., direct replications from the encoding phase), 30 were "recombined" from two separately encoded pairs, and 30 were "new," unstudied pairs. The mean frequency of the words was 183.23 (*SD* = 124.54) (Kucera & Francis, 1967). All words were nouns and there were a total of three lists that were counterbalanced equally across conditions. In the PM condition, six animal words (dog, horse, fish, bear, snake, and chicken) were intermixed into the study and retrieval word pairs, replacing six words of approximately equal length, as PM cues. The mean frequency of the animal words was 60.83 (SD = 31.27) (Kucera & Francis, 1967). The distracter task, 20 order of operations math problems, was conducted via paper and pencil.

Procedure

Participants first signed an informed consent form and were told that the experiment was a sentence generation study, and that they would also complete some related problem solving tasks. Participants were instructed on how to generate sentences out loud; those assigned to the item condition were told to generate two independent sentences, one for each word in the word pair, while those in the associative condition were told to generate one sentence that utilized both words in the word pair (Giovanello, Schnyer, & Verfaellie 2004). By doing so, the word pairs were encoded as two individual items in the item condition and as a pair of associates in the associative condition. The encoding phase was self paced, as participants were instructed to press the mouse key after generating the sentences for each word pair. Following the instructions, they were given a practice trial consisting of six word pairs. After ensuring that there were no questions, participants in the PM condition were given the PM instructions. Participants were told that there was a secondary interest in PM, and they should press the letter 'A' whenever they saw a word that corresponded to an animal, in addition to completing the sentence generation task. Participants were not informed as to how many animal words they should expect. Regardless of whether or not participants were in the PM condition, the distracter task was administered immediately thereafter (Einstein & McDaniel, 1990). The distracter task consisted of a worksheet of 20 math problems that took approximately seven minutes to complete and was designed to release the PM instructions from working memory. Once completed, participants were again refreshed on the sentence generation task, with no mention of the PM task.

Next, participants began the encoding phase of the experiment, where they generated sentences for a total of 60 word pairs, shown one pair at a time on the computer screen. Depending on their assigned condition, participants either generated two sentences (item condition) or one sentence (associative condition) per word pair. Additionally, the participants in the PM condition had six animal words intermixed randomly into the 60 word pairs. Upon completion of the encoding phase, participants were informed that they would be receiving a self-paced memory test for the words they had just studied. They were shown 90 pairs of words, one pair at a time, and asked to determine whether or not the words were previously viewed. Participants in the item condition were told to press the '1' key if they previously saw the words in the pair, even if the two words were not shown together, and to press the '2' key if the words were not seen. In contrast, those in the associative condition were told to press the '1' key if they previously saw the word pair together and to press the '2' key if that was not the case. Upon completion experiment, participants were debriefed as to the goals and objectives of the study.

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Results

The data were analyzed with a between-subjects factorial analysis of variance (ANOVA). The independent variables were age (young vs. old), the type of memory task (item vs. associative), and the presence of the PM task (present vs. absent). The dependent variable was accuracy on the memory task (item vs. associative). Additionally, performance on the PM task served as a dependent variable of secondary interest. Recognition memory performance was measured by Intact Hits – New False Alarms for the item condition, and Intact Hits – Recombined False Alarms for the associative condition (see Table 1).

Collapsed across item and associative conditions, younger adults successfully responded to 5.13 of 6 PM cues (SD = 1.07), while older adults responded to only 3.79 of 6 PM cues (SD = 2.28), a significant difference, $t(37.81) = 2.84$, $p < .01$. A 2 × 2 × 2 between-subjects factorial ANOVA was also conducted on memory accuracy. Word pairs including the animal cues were excluded from the analysis because the PM task may have disproportionally benefited encoding of the animal words and increased subsequent item recognition.[2] There were significant main effects of: age, $F(1,108) = 57.19$, $p < .001$, $\eta_p^2 = .35$, with young adults (M = .83, SD = .08) outperforming older adults (M = .71, SD = .14), presence of PM task, $F(1,108) = 24.48$, $p < .001$, $\eta_p^2 = .19$, where participants in the PM condition (M = .73, SD = .13) did worse than those who were not (M = .81, SD = .11), and type of memory task $F(1,108) = 33.32$, $p < .001$, $\eta_p^2 = .24$, with participants in the item condition (M = .82, SD = .10) outperforming those in the associative condition (M = .72, SD = .13).[3] There was no two-way interaction between age and presence of PM task, $F(1,108) < 1$, $\eta_p^2 = .10$, nor between presence of PM task and type of memory task, $F(1,108) < 1$, $\eta_p^2 < .01$. Additionally, there was no three-way interaction, $F(1,108) < 1$, $\eta_p^2 < .01$. However, there was a significant two-way interaction between age and type of memory task, $F(1,108) = 16.15$, $p < .001$, $\eta_p^2 = .13$. Younger adults performed comparably between the item (M = .84, SD = .08) and associative (M = .81, SD = .07) conditions, while older adults performed better in the item (M = .79, SD = .11) than the associative (M = .63, SD = .11) condition.

Discussion

The current study utilized a novel approach to examine the associative deficit in aging. Specifically, attention was divided at encoding with an event-based PM task. The PM task was selected for its reliance on monitoring processes, self-initiated requirements, and drawing of attention to item-specific information. These characteristics provided a unique opportunity to test the attentional resource account of the associative deficit. Consistent with the literature, older adults had worse associative, relative to item, memory. However, the presence of the PM task decreased item and associative recognition to the same extent in both young and older adults. This is consistent with previous studies examining the effects of DA on item and associative recognition (Kilb & Naveh-Benjamin, 2007; Naveh-Benjamin et al., 2004a; Naveh-Benjamin et al., 2003a; Naveh-Benjamin et al., 2004b; Naveh-Benjamin et al., 2003b, but see Craik & Castel, 2003), and extends these studies with an alternate cognitive task that taxes attentional resources. The results indirectly support the theory that older adults have a deficit in binding information that is both absent in young adults and unaffected by attentional manipulations. The results do not support the theory that age-related deficits in associative memory stem from reduced attentional resources, as reducing attentional resources did not produce an associative deficit in young adults and did not lead to an exaggerated associative deficit in older adults.

[2]Per a reviewer's request, main effects and interactions were examined when the word pairs with animal words were omitted. The results were identical to those reported in the main text when they were not omitted.

[3]The partial eta squared statistic describes the proportion of total variability attributable to a factor (SPSS Inc., 2005).

Castel and Craik (2003) reported a greater decline in memory for associations than memory for items in young adults under DA when encoding word pairs. One difference between their study and the current one is the procedure used to calculate item memory. The present study used a straightforward, well-established measure of calculating item memory as the difference between hits to intact pairs and false alarms to new pairs (e.g., Giovanello et al., 2004). In contrast, Castel and Craik (2003) calculated item accuracy by comparing hit rates to a composite of the different lure conditions (i.e., two recombined words, an old word with a new word, and two new words). Another difference concerns the concurrent task used to reduce attentional resources. Whereas the current study used an event-based PM task, Castel and Craik (2003) used a digit-monitoring task typically employed in DA studies. It should be noted, however, that another study using the same concurrent task did not elicit an associative deficit in younger adults (Naveh-Benjamin, et al., 2003b). Nonetheless, the inconsistencies between the current findings and those of Castel and Craik (2003) may reflect differences in the calculation of item recognition performance, the concurrent task used, or a combination of the two factors.

The effect of the PM task on associative memory performance may be attributed to differing strategies of completing PM tasks as posited by the theory of *Dual Mechanisms of Cognitive Control* (Braver, Gray, & Burgess, 2007). The variability in both PM and episodic memory exhibited in the current study could be due to differing proactive and reactive strategies. Participants utilizing proactive strategies may have had greater PM performance, as attentional resources were shifted towards actively monitoring for the animal words, and additionally, less associative memory performance, as less attentional resources were available to encode the associative information. Conversely, participants utilizing reactive strategies may have had worse PM performance, as they are passively looking out for the animal words and thus occasionally do not notice them, and better associative memory performance, as more attentional resources are available to encode the associative information. Indeed, among older adults, where there is variability of PM performance, there is a trend toward a negative correlation between PM and associative memory ($r = -.51$, $p < .07$). Whether this correlation reflects the use of differing strategies or individual differences is unclear, as the current experiment did not directly control for the specific cognitive strategy that participants utilize. Rather, the current design was expected to, and yielded, significant task interference in both groups, as well as a PM performance decline in older adults relative to young adults. Potentially, future experiments may seek to emphasize proactive strategies by further increasing the complexity and difficulty of the PM task (e.g., unrelated targets, less salient cues, etc.) in order to encourage the necessity of proactive strategies to sequester additional attentional resources from the ongoing task.

The current study is consistent with the existing literature on age-related deficits in episodic associative memory (e.g., Naveh-Benjamin, 2000) and PM (e.g., Rendell, McDaniel, Forbes, & Einstein, 2007). As practitioners seek to combat cognitive decline in the elderly, these two deficits remain key issues. Recent studies have shown that associative recognition can be improved by the unitized (i.e., holistic) encoding of word pairs (Quamme, Yonelinas, & Norman, 2007). Such mnemonic strategies can be applied to overcome the associative deficits observed in older adults. PM, on the other hand, is difficult for older adults because relies on self-initiated retrieval processes. In a review, Henry et al. (2004) report that older adults actually perform as well, or better, than younger adults in naturalistic settings. While this issue is not fully addressed by the literature, there is evidence that this may reflect strategies adopted to overcome PM deficits, such as increased efficiency in the usage of external cues (Phillips, Henry, & Martin, 2007). Therefore, to address the necessity of PM in leading an independent life, clinicians could emphasize conjunction (e.g., pairing daily medication with a meal) or external (e.g., a planner or calendar) strategies to optimize the usefulness of these cues.

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Table 1

Mean proportion hits and false alarms and standard deviations for item and associative memory performance in all conditions.

	Hits		**False Alarms**		**Hits – FA**	
	M	***SD***	***M***	***SD***	***M***	***SD***
Item Memory						
Young						
No Prospective	0.94	0.03	0.07	0.06	0.87	0.08
Prospective	0.90	0.06	0.09	0.09	0.81	0.08
Old						
No Prospective	0.89	0.09	0.06	0.06	0.83	0.10
Prospective	0.87	0.08	0.13	0.11	0.74	0.11
Associative Memory						
Young						
No Prospective	0.92	0.06	0.07	0.05	0.85	0.06
Prospective	0.88	0.06	0.10	0.05	0.78	0.06
Old						
No Prospective	0.85	0.06	0.17	0.09	0.68	0.09
Prospective	0.77	0.13	0.20	0.10	0.57	0.11