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Attention to item-specific processing eliminates age effects in false memories

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Abstract

One possible reason for age differences in false memory susceptibility is that older adults may not encode contextual information that allows them to distinguish between presented and non-presented but internally activated items. The present research examines whether older adults can reduce false memories when given external contextual support. In the first two experiments, semantically related lists were presented in the context of sentences that either elicited or did not elicit meanings of items that converged on a non-presented theme word. Semantically related lists were presented as the second word of cue-target pairs in Experiment 3. Results demonstrated that when gist-based processing of list items was made less accessible, older and younger adults showed similar reductions in false recall and recognition. Finally, although both groups showed reductions, measures of response latencies indicated that non-presented critical theme words were internally activated. These results have implications for encoding deficit and strategy selection as they relate to accounts of age-related deficits in memory.

Keywords: False memories; Relational processing; Cue-encoding deficit

Age-related deficits in recall and recollection are well documented (for reviews see Anderson & Craik, 2000; Balota, Dolan, & Duchek, 2000). Older adults are less likely to correctly recall or recognize previously presented material. More recent research has demonstrated another type of age-related memory deficit in which older adults exhibit an increased propensity to make errors of commission involving recall or recognition of events that had not previously been experienced. For example, researchers have demonstrated that older adults show higher levels of false recall and recognition when presented with lists of both semantic (Balota et al., 1999; Kensinger & Schacter, 1999; La Voie & Faulkner, 2000; Norman & Schacter, 1997; Tun, Wingfield, Rosen, & Blanchard, 1998) and phonological associates (Sommers & Huff, 2003).

In an effort to understand the nature of the age deficit in errors of commission, numerous studied have been conducted comparing older and younger adults within the Deese/Roediger–McDermott (DRM) paradigm. In these studies individuals are presented with lists of semantically related words (e.g., bed, rest, tired) and then complete recall and/or recognition tests (Deese, 1959; Roediger & McDermott, 1995). The typical finding is that individuals (both younger and older) falsely recall or recognize highly related but non-presented theme words or lures (Balota et al., 1999; Deese, 1959; Mather, Henkel, & Johnson, 1997; Robinson & Roediger, 1997; Roediger & McDermott, 1995). Older adults

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also sometimes demonstrate higher rates of false memories than younger adults when absolute levels of false recognition are compared (Norman & Schacter, 1997), and consistently demonstrate higher levels of false memories when false recall is computed as a proportion of veridical recall (i.e., Balota et al., 1999).

Resistance to false memories in older and younger adults

Although the DRM effect is a powerful phenomenon, researchers have discovered that both older and younger adults are capable of reducing false recall and recognition. For example, when older and younger participants encoded pictorial information along with DRM list items in the study phase, they were less likely to falsely recognize the non-presented critical target at test (Schacter, Israel, & Racine, 1999). Schacter et al. proposed that false memories could be reduced if individuals rely on a "distinctiveness heuristic", and modify their decision strategy toward more conservative responding. Both older and younger adults have been shown to reduce false memories in a categorized picture paradigm, when they were given instructions at the time of retrieval that discouraged designating items as old simply on the basis of general similarity to studied items (Koutstaal, Schacter, Galluccio, & Stofer, 1999).

Distinctive processing at encoding has also been implicated in reducing false recognition of semantically related lures in young adults (Arndt & Reder, 2003; McCabe, Presmanes, Robertson, & Smith, in press). Distinctive processing refers to an *encoding* orientation that focuses on processing specific and individual item information that occurs when the to-be-remembered stimulus is initially encountered. When semantically associated list items were made perceptually distinct, by presenting each item in a font unique from that used to present other items, participants were less likely to erroneously recognize the critical theme word, than when semantic associates were presented in the same non-distinct font. This increase in item-specific processing has been shown to reduce false memories both between and within participants, providing support that the use of item specific information in the form of individuating unique cues is a memory process that occurs at encoding.

According to the distinctive processing framework, false memories can be reduced if individuals are able to remember item-specific information associated with studied items. This account contrasts with the distinctiveness heuristic in that the focus is on information acquired at encoding rather than on adopting a particular recognition criterion at retrieval. In fact, the distinctiveness heuristic only reduces false memories in a between-participants design (i.e., Dodson & Schacter, 2001), providing additional support that use of this heuristic affects the criterion chosen at retrieval. It is noteworthy that the distinctiveness heuristic and distinctive processing share common features, in that both have been shown to reduce false memories in younger adults, and both rely on the encoding of specific distinct information for the reduction to occur. However, an important difference is that distinctive processing relies on the ability of participants to have access to encoded individuating cues, whereas the distinctiveness heuristic is a mode of responding based on participants' metamemorial awareness that true recognition of studied items should include recollection of distinctive detail. The specific distinctive feature need not be remembered in detail; rather just the presence of that feature need be remembered. Reductions in false recognition are explained by a global shift in response strategies across conditions (e.g. Schacter et al., 1999).

Contextual cue encoding deficit in older adults

Research has demonstrated that older adults are able to reduce false memories by relying on the "distinctiveness heuristic" (Schacter et al., 1999). However, other research (Kensinger & Schacter, 1999) suggests that older adults cannot reduce errors of commission by engaging in distinctive processing. Kensinger & Schacter (1999) found that whereas younger adults reduced false memories across five study-test trials in the DRM paradigm, older adults continued to make similar levels of false recall and false recognition responses across the five study-test trials. They concluded that older adults failed to use item-specific information that accrued from repetition.

One possible reason why older adults may not be able to reduce false memories after engaging in distinctive processing, is that they may not encode or may not effectively use item-specific contextual and perceptual cues that individuate items within a given list (i.e., Glisky, Polster, & Routhieaux, 1995; Park, Puglisi, & Sovacool, 1983; Trahan, Larrabee, & Levin, 1986). Older adults are less likely to benefit from contextual reinstatement at retrieval (Rabinowitz, Craik, & Ackerman, 1982). Additionally, older adults are less likely to remember the source of information (McIntyre & Craik, 1987). Although these findings suggest that a deficit in the encoding of contextual cues develops as we age, more recent research suggests that older adults may encode but may not have access to perceptual context unless attention is directed to that context (Naveh-Benjamin & Craik, 1995). Naveh-Benjamin and Craik found that when attention was explicitly directed to perceptual context, older adults showed levels of veridical memory comparable to that of younger adults for contextual information.

These findings suggest that older adults may be capable of encoding perceptual-contextual attributes that can be used to individuate items. Older adults encode these

cues but they do not always use these cues effectively. Research suggests that older adults are more likely to rely on shared cues that related items within a list together as opposed to unique cues that provide item-specific information. In support of this hypothesis Tun et al. (1998) demonstrated that when a shared-cue strategy was less effective than a strategy based on item-specific information, younger adults adopted the appropriate strategy while older adults did not. In addition, when DRM list items were randomized during presentation to reduce producing shared cues, older and younger adults showed a comparable reduction in false memories, but older adults also showed a reduction in veridical memory (Tun et al., 1998). These results suggest that older adults may rely on shared cues because those cues improve veridical memory, whereas younger adults may rely both on shared and unique cues.

The results of the Naveh-Benjamin & Craik (1995) and Tun et al. (1998) studies suggest that older adults may be able to reduce false memories by encoding unique attributes based on perceptual-contextual information if attention is directed to those attributes. However older adults will not use that information to improve memory unless shared cues are made less accessible. In addition, research suggests that older adults may engage in distinctive processing if individuating information is externally provided. For example, when given distinctive verbal elaborators to associate with categorized pictures, older adults showed a marked reduction in false recognition as compared to when asked to perform liking ratings of categorized pictures (Koutstaal & Schacter, 2001). These results suggest that older adults may encode contextual information but may not effectively use that information unless other strategies are made less accessible.

The present study

The primary goal of the present study was to further examine whether older adults could use distinctive processing to reduce false memories in the DRM paradigm. Although retrieval support has consistently led to a reduction in false memories in older adults (i.e., Koutstaal et al., 1999) strategies that force older adults to directly access encoded attributes that individuate items within a list have been less reliable. Therefore, the first set of experiments provided older and younger adults with item specific information externally to determine if such cues would serve to reduce false memories.

In the first two experiments DRM list items were presented in the context of sentences that made unique attributes associated with a given studied item accessible. Unique attributes were the sentence context. Experiment 1 compared rates of false memory for sentences that elicited the meaning of the semantic associates that converged on the meaning of the non-presented critical theme word (e.g., "The weary worker laid down on the *bed*." The critical theme word is SLEEP) were compared to studying semantic associates in isolation. We hypothesized that sentence context would provide sufficient distinctive information to individuate one item from another in a given list and therefore both older and younger adults should show reductions in false memories relative to the isolated word condition because they would encode and use item-specific information. In Experiments 2, sentences in which the contexts did not converge on the critical theme word (e.g., "The boy skipped rocks while standing by the river *bed*.") were introduced. Note that both sets of sentences contain the identical sentence-final word. The difference is that context for the final words in the convergent sentence condition all converge on the non-presented critical theme word but this is not the case in the divergent sentences. Divergent sentences were designed to reduce the possibility that participants would generate shared cues that related DRM list items together. We hypothesized that with limits placed on gist processing, older adults would then be forced to rely on unique attributes acquired through item-specific processing to make memory decisions.

Errors of commission in the sentence presentation condition were compared to those that resulted from standard DRM list presentation in a within-groups design. A within-groups design was employed to directly test distinctive processing without the influence of the distinctiveness heuristic. Finally, Experiment 3 was designed to specifically test whether the critical theme word was activated in internal associative networks (Balota et al., 1999). Response latencies serve as an objective index of the strength of false-recognition judgments by providing an estimate of the relative activation of different types of stimuli. To the extent that thematically related items are activated along with studied items, we would expect that recognition test latencies should be similar for veridical and false recognition. If critical theme words are activated then participants should be as fast at accepting the theme word as when studied items are accepted (Tun et al., 1998).

Experiment 1

Experiment 1 examined whether older and younger adults would reduce false recall and recognition of critical non-presented theme words, when semantically associated list items were presented in the context of convergent sentences. Sentences were designed to elicit the meanings of the list items that were semantically congruent with the critical non-presented theme word. Memory for DRM list items presented as the last words of sentences was compared to memory for those same items presented in single-word lists. A within-subjects

design was employed in order to eliminate the use of the "distinctiveness heuristic." We hypothesized that presenting DRM list items in the context of sentences would lead to a reduction in false recall and recognition of related lures because participants would rely on encoded contextual attributes when making decisions about veridical and false memories. These results would suggest that both older and younger adults encode contextual attributes, and can rely on a memory-based process to reduce false memories.

Method

Participants

Participants were 120 younger adults (62 women and 58 men; age range 18–29; $M = 19.9$, $SD = 1.8$) and 120 older adults (59 women and 61 men; age range 61–88; $M = 75.71$, $SD = 6.0$). Younger adults were recruited from the participant pool maintained by the Department of Psychology at Washington University. Older participants were community dwelling and were recruited through the participant pool maintained by the Aging and Development program at Washington University. Mean years of education were 13.9 ($SD = 1.8$) and 14.9 ($SD = 2.5$) for the younger and older adults, respectively. All participants completed the Vocabulary subtest of the Wechsler Adult Intelligence Scale-Revised (WAIS-R; Wechsler, 1981). Older adults received a mean score of 61.7 ($SD = 6.4$) and younger adults received a mean score of 59.3 ($SD = 5.4$). Pair-wise comparisons indicated that education and vocabulary scores did not differ between the two groups. Participants either received course credit (younger adults) or \$10/h (older adults) for participating.

Materials

The experimental materials consisted of 16 lists of either eight words or eight sentences each. Lists items were taken from the Stadler, Roediger III, & McDermott (1999) norms. Each list tested by Stadler et al. consists of 16 semantic associates of a non-presented theme word. In the present study, we selected eight associates from each list and created a sentence for each associate (128 total sentences) in which the selected word was in sentence-final position. The context of the sentence was constrained to elicit the meaning of the list item that converged on the meaning of the critical theme word. (e.g., "The weary worker laid down on the *bed*." In this case, the final word "bed" is congruent with the meaning of the critical theme word "sleep").

Sentence constraint was defined as the probability of the most likely completion when participants are provided with the beginnings of sentences and asked to supply potential endings (Fischler & Bloom, 1980). To ensure that the selected associate was the most frequent completion for the sentence, 20 younger adults and 20 older adults were presented with all 128 sentences each with the final word removed. Participants were asked to complete the sentence with the first word that came to mind. The main reason for conducting this separate pilot study was to ensure that the target item was the most frequent completion of the sentence for both convergent and divergent sentences. Neither age group nor sentence condition affected average completion.

Design and procedure

The experiment was based on a $2 \times 2 \times 2$ mixed factorial design. The between-subjects variable was age (younger or older). The within-subjects variables were type of presentation (convergent sentences or words only) and item type (studied or critical target). Further, half of the participants performed a recall task between each block and half of the participants completed a final recognition test. Experiment 1 was divided into three phases: encoding, distractor/retention, and retrieval. At encoding participants were presented with either sentences or words via computer. Participants were instructed to read the sentences or words out loud. Presentation of sentences and words were blocked by non-presented critical theme word. For example, all sentences that contained list items that were semantically related to *sleep* were presented in the same experimental block. Similarly, all words semantically related to *window* were presented in the same experimental block. Blocks of sentences and words were randomly presented to participants. Within each block, sentences, or words, were presented in a fixed order, from highest semantic association with the non-presented theme word to lowest semantic associates. Associative strength was based on the Stadler et al. (1999) norms.

If participants were in the recall condition, after each block of sentences or words were presented, participants either recalled the last words of the sentences that had been previously presented (convergent sentence condition), or recalled all of the words presented in the previous block (words-only condition). A 500 ms tone was presented to alert participants to recall. After the tone, a visual prompt on the computer screen instructed participants to recall. Participants had 60 s to recall as many words as they could and were instructed to recall an item only if they were "reasonably sure it had been presented on the preceding study list." Participants recalled words via paper and pencil in a packet provided by the experimenter. After 60 s had elapsed, a second tone indicated that the next block of sentences or words was to be presented. Four blocks of "convergent sentences" and four blocks of "words only" were presented to participants.

Eight sentences or words were presented in a given block so that eight list items associated with the critical target were presented as the last word of those sentences (or as single words). All stimuli were presented in 16 point Arial type font and none of the participants indicated any difficulty in being able to see the words or sentences. Sentences were presented individually, and after participants read a given sentence, the experimenter pressed the space bar so that the next sentence would be presented. All words of a given sentence were presented at the same time. The average presentation time for sentences was 2.3 ($SD = .4$) s. Words were presented at a fixed rate of 2 s each.

If participants were in the recognition test condition, participants completed arithmetic problems between each block for 60 s. After all blocks had been presented, participants performed a five minute distractor task in which they solved logic problems. Participants were then given the recognition test, consisting of 64 items, in which the first, third, and eighth list items from studied lists served as targets on the test. The first, third, and eighth list items from the eight non-studied lists served as distractors, along with the critical targets associated with studied lists, and the critical targets associated with the non-studied lists. Participants saw individual words presented on the computer screen and were asked to indicate whether each was old or new. Participants pressed the 'a' key if the item was old and the 'k' key if new.

The experiment was counterbalanced such that a given item served in the convergent-sentence and word-only conditions equally often, and a given item served as a target or distractor equally often.

Results

Recall

Table 1 displays the proportion of studied items and critical theme words recalled in the words-only and convergent sentences conditions. It is important to note that no other unrelated or extra-list intrusions were recalled.

Table 1
Mean veridical and false recall as a function of age and type of presentation for Experiment 1

	Studied *M* (*SE*)	Critical *M* (*SE*)
Convergent sentences		
Older	.50 (.02)	.25 (.05)
Younger	.66 (.02)	.06 (.02)
Words only		
Older	.65 (.02)	.19 (.03)
Younger	.80 (.02)	.21 (.01)

When list items were studied in the context of convergent sentences, younger adults showed a significant reduction in false recall compared to when list items were presented in the words-only condition. Older adults, on the other hand, were equally likely to recall the critical theme word in the convergent sentence and words-only condition. A 2 (type of presentation: convergent sentences, words-only) × 2 (age: older, younger) × 2 (item type: studied, critical target) mixed analysis of variance (ANOVA) was performed on average recall. All p-values reported are less than. 05 unless otherwise stated. A main effect of item type was found, $F(1,58) = 629.58$, $MSe = .02$. Participants were more likely to recall studied items ($M = .65$) than non-presented but related lures ($M = .18$). A main effect of age was also found, $F(1,58) = 5.32$, $MSe = .02$. Younger adults ($M = .43$) recalled more items than older adults ($M = .40$). With regard to type of presentation, convergent sentences ($M = .37$) elicited significantly less recall as compared to words in isolation ($M = .46$).

When the interaction between age and type of item was examined, a significant cross over interaction was found, $F(1,58) = 38.25$, $MSe = .02$. Older adults were less likely to correctly recall studied items ($M = .57$) than younger adults ($M = .76$) and more likely to recall related lures ($M = .22$) than younger adults ($M = .13$). This interaction is present in both the convergent sentences condition and the words-only condition, and indicates that older adults are *relatively* more susceptible to false memories, when false recall of the critical target is taken as a proportion of total recall (i.e., Balota et al., 1999). Finally, the three-way interaction between age, type of item, and type of presentation was significant, $F(1,58) = 7.56$, $MSe = .03$. To explore this interaction a separate analysis was performed on false recall.

A 2 (type of presentation: convergent sentences, words only) × 2 (age: older, younger) ANOVA on average false recall found a main effect of age, $F(1, 58) = 8.06$, $MSe = .19$. Older adults ($M = .22$) were more likely to falsely recall the critical target than younger adults ($M = .14$). The interaction between type of presentation and age was significant, $F(1,58) = 9.51$, $MSe = .04$. Younger adults reduced critical target intrusion in the convergent sentence condition as compared to the words-only condition, whereas older adults did not show a similar reduction. These results suggest that older adults may not have encoded contextual attributes, and therefore could not engage in memory-based processes to reduce false recall.

Recognition

Table 2 displays hits, false alarms to critical theme words and false alarms to unrelated lures for both older and younger adults. As with results from the recall test, younger adults were less likely to falsely recognize

Table 2
Mean raw and adjusted recognition hits and false alarms in Experiment 1

	Studied *M* (*SE*)	Critical *M* (*SE*)	Critical corrected *M* (*SE*)	Unrelated lures *M* (*SE*)
Convergent sentences				
Older	.67 (.04)	.62 (.04)	.35 (.03)	.27 (.03)
Younger	.63 (.02)	.39 (.04)	.19 (.04)	.20 (.03)
Words only				
Older	.73 (.04)	.65 (.04)	.40 (.05)	.25 (.03)
Younger	.69 (.02)	.61 (.03)	.45 (.04)	.16 (.03)

related lures when list items were studied in the context of convergent sentences as compared to when those items were presented in isolation. A 2 (type of presentation: convergent sentences, words-only) × 2 (age: older, younger) × 2 (item type: studied, critical target) mixed analysis of variance (ANOVA) was performed on average recognition. A main effect of item type was found, $F(1,58) = 25.71$, $MSe = .03$. Participants were more likely to recognize studied items ($M = .68$) than non-presented but related lures ($M = .58$). A main effect of age was also found, $F(1,58) = 9.05$, $MSe = .05$. Younger adults ($M = .58$) recognized less items than older adults ($M = .67$). With regard to type of presentation, convergent sentences ($M = .58$) elicited significantly less recall as compared to words in isolation ($M = .67$), $F(1,58) = 8.66$, $MSe = .06$.

When the interaction between age and type of item was examined, a significant interaction was found, $F(1,58) = 4.34$, $MSe = .03$. Older adults were as likely as younger adults to correctly recognize studied items and more likely to recognize related lures ($M = .64$) than younger adults ($M = .54$). Finally, the three-way interaction between age, type of item, and type of presentation was significant, $F(1,58) = 4.54$, $MSe = .04$. To explore this interaction a separate analysis was performed on false recognition. We employed a correction when analyzing the false recognition responses. A correction was employed because of the age difference in false alarm responding to unrelated lures ($F(1,58) = 6.50$, $MSe = .03$). Recognition scores were corrected by subtracting "old" responses to unrelated lures from "old" responses to critical lures (A similar procedure has been previously used by Kensinger & Schacter (1999)). The correction was not made when recall results were analyzed because older and younger adults were as likely to falsely recall unrelated lures. Unrelated lures encompassed critical items associated with non-studied lists and distractors taken directly from non-studied lists. Because no difference was found in false alarm responding between these two item types, false alarms to these lures were combined.

This analysis found no main effect of age, $F < 1$. However, we did find a main effect of type of presentation, $F(1,58) = 10.67$, $MSe = .07$. When list items were encoded in the context of sentences participants were less likely to falsely recognizing critical lures. Further, the interaction between type of presentation and age was significant, $F(1,58) = 4.42$, $MSe = .05$. Younger adults showed a much greater reduction in false recognition of critical lures when list items were presented in the context of sentences as compared to older adults.

Discussion of Experiment 1

The primary goal of Experiment 1 was to determine whether older adults could reduce false memories to the same extent as younger adults when sentence presentation was used to increase the opportunity to encode and use item-specific contextual information. Older adults did not reduce false recall even when semantic associates were presented in the context of sentences. On the other hand, younger adults did show a reduction in critical item intrusion. Based on these findings, it is plausible that presenting DRM list items in the context of convergent sentences increased item-specific processing, which in turn allowed young adults to improve discrimination between critical theme words and studied items.

Results from the younger adults sample conceptually replicate those of Arndt & Reder (2003), who found that when DRM list items were presented in unique fonts, younger adults were less likely to falsely recognize related lures than when items were presented in the same font. Further, it is unlikely that participants in the current experiments used the distinctiveness heuristic as a strategy for memory decisions because type of presentation (convergent sentences or single words) was manipulated as a within-subjects variable. Because younger adults demonstrated reductions in false recall and recognition when presented with sentences vs. words, it is likely that these reductions were due to memory based processes that required re-instantiation of encoding context. The findings from Experiment 1 lend further support to the hypothesis that older adults may not encode or efficiently use contextual information to individuate items within a list.

Although Experiment 1 externally provided participants with information that individuated items within a given list, producing shared cues through relational processing remained an accessible strategy. In fact, reading sentences may have promoted a greater production of shared cues because sentences are typically processed at a more meaningful level than words in isolation (Prior & Bentin, 2003). Because older adults have been shown to use gist-based strategies even when those strategies prove ineffective (i.e., Tun et al., 1998), we are unable

to conclude from Experiment 1 whether older adults suffer from a cue-encoding deficit or rather a deficit in using available cues. Older adults may be less able to use available contextual information when strategies that promote gist-based processing remain accessible. In order to further explore this issue, divergent sentences were introduced in Experiment 2.

Experiment 2

Experiment 2 was designed to reduce the likelihood of generating shared cues while increasing the accessibility of item-specific information. We predicted that when older adults are less likely to produce shared cues they will then rely on item-specific information and show decreases in false recall and recognition of the critical target similar to younger adults. To reduce the possibility of generating shared cues, we presented participants with sentences designed to elicit meanings of list items that did not converge on the meaning of the critical theme word. By eliciting these divergent meanings, we hypothesized that both older and younger adults would be less likely to organize list items relationally according to the meaning of the non-presented theme word. An additional motivation for Experiment 2 was to replicate the results from Experiment 1. Therefore, we also included a convergent sentences condition.

Method

Participants

Participants were 120 younger adults (78 women and 42 men; age range 18–22; $M = 19.7$, $SD = 1.1$) and 120 older adults (73 women and 47 men; age range 66–89; $M = 76.2$, $SD = 5.1$). The same recruitment and payment procedures used in the previous experiments were again employed in this experiment. Mean years of education were 13.2 ($SD = 2.8$) and 14.1 ($SD = 3.4$) for the younger and older adults. All participants completed the Vocabulary subtest of the Wechsler Adult Intelligence Scale-Revised (WAIS-R; Wechsler, 1981). Older adults received a mean score of 62.2 ($SD = 4.4$) and younger adults received a mean score of 60.0 ($SD = 4.5$). Pair-wise comparisons indicated that education and vocabulary did not differ between the two groups.

Materials

As in the previous experiments, the experimental materials consisted of 16 lists of eight items (sentences or words) each. Divergent sentences were constructed by the experimenter so that the list item was always the last word of the sentences. The context of the sentence was constrained to elicit the meaning of the list item that *did not* converge on the meaning of the critical target. An example of a divergent sentence is as follows: The boy skipped rocks by the river *bed*. *Bed* is the list item associated with the non-presented theme word, *sleep*. Convergent sentences used in Experiment 1 were again used in Experiment 2. It should be noted that convergent and divergent sentences were constructed to be highly constrained to elicit a particular meaning of a DRM list item. The primary difference between these two types of sentences is that divergent sentences elicit meanings of list items but none of those meanings are semantically related to the underlying critical theme word. As in Experiment 1, to ensure that the selected associate was the most frequent completion for the sentence, a separate group of 20 younger adults and 20 older adults was presented with all 128 sentences each with the final word removed. Participants were asked to complete the sentence with the first word that came to mind. Average rates of completion with the target item did not differ as a function of either sentence condition or age group.

Design and procedure

The experiment used a $2 \times 2 \times 3$ mixed design. The between subjects variable was age (older or younger), and the within subjects variables were type of presentation (convergent sentences, divergent sentences, or words only) and item type (studied item or critical target). The procedure of Experiment 2 was similar to that of Experiment 1. Half of the participants were asked to recall items between each block presentation, and the second half completed a final recognition test. Participants in the recall test condition studied sentences or lists of words, and had to recall the last word of those sentences, or recall the words. As in Experiment 1, participants were given 60 s to recall the last words of sentences, or words alone, after each block of stimuli. Nine blocks of stimuli were presented in Experiment 2. Three blocks were convergent sentences, three blocks were words only, and three blocks were divergent sentences. Blocks of stimuli were presented randomly. The experiment was counterbalanced so that stimuli that were presented in the words-only condition were also presented in the context of divergent sentences. Participants in the final recognition test condition worked on arithmetic problems between each block. A five minute distractor task followed the last block of sentences or words. Participants then completed a final recognition task consisting of 64 items. Twenty-seven of those items had been studied previously in the context of sentences or words-only. For distractors, 21 were words from non-studied lists, and 16 were critical lures (9 associated with studied items and 7 associated with non-studied items).

Results

Recall

Table 3 illustrates the proportion of studied words and critical lures recalled for the convergent and divergent sentences as well as for the words-only condition. A 3 (type of presentation: convergent sentences, divergent sentences, words-only) × 2 (age: older, younger) × 2 (type of item: studied, critical target) ANOVA was performed on items recalled. Not surprisingly, main effects of item type and age were found, [$F(1,58) = 1221.88$, $MSe = .02$; $F(1,58) = 7.86$, $MSe = .02$]. Further, as in Experiment 1, the interaction between age and type of item was significant, $F(1, 58) = 64.60$, $MSe = .02$. This cross-over interaction indicated that older adults were relatively more susceptible to false memories than younger adults because older adults produced lower levels of veridical recall ($M = .57$) and higher levels of false recall ($M = .18$) when compared to younger adults ($M = .75$; $M = .11$). A significant main effect for type of presentation was also found, $F(1,58) = 24.61$, $MSe = .02$. Recall output was greater for words studied in isolation ($M = .47$) than when words were presented in the context of convergent ($M = .37$) and divergent sentences ($M = .34$). Finally, the three-way interaction between age, type of item, and type of presentation was significant, $F(2,116) = 6.01$, $MSe = .03$.

To examine whether participants were able to reduce false recall depending on presentation context, we compared average false recall in each sentence condition to average false recall in the words-only condition. When average false recall of critical lures in the convergent sentences condition was compared to those in the words-only condition a main effect of age was present, $F(1,58) = 16.06$, $MSe = .03$, and the interaction between type of presentation and age was significant, $F(1,58) = 4.27$, $MSe = .05$. These findings replicate those of Experiment 1, and demonstrate that older adults did not reduce false recall when list items were presented in the context of convergent sentences.

Table 3
Mean veridical and false recall as a function of age and type of presentation in Experiment 2

	Studied *M* (*SE*)	Critical *M* (*SE*)
Convergent sentences		
Older	.50 (.02)	.28 (.04)
Younger	.66 (.02)	.07 (.02)
Divergent sentences		
Older	.58 (.02)	.04 (.02)
Younger	.68 (.02)	.06 (.01)
Words only		
Older	.62 (.02)	.23 (.03)
Younger	.82 (.01)	.20 (.04)

When average false recall of critical lures in the divergent sentences condition was compared to that in the words-only condition, a main effect of type of presentation was found, $F(1,58) = 36.71$, $MSe = .02$. Participants in the divergent sentences condition ($M = .05$) were less likely to intrude the critical target as compared to participants in the words-only condition ($M = .22$). The main effect of age was not significant, $F < 1$. Older and younger adults were as likely to produce the critical target in these conditions. Further, the interaction between type of presentation and age was not significant, $F < 1$. This last finding is particularly important because it suggests that older and younger adults were equally able to reduce false recall in the divergent sentence condition.

Recognition

As Table 4 illustrates, both older and younger adults were less likely to falsely recognize critical theme words when DRM lists were presented in the context of divergent sentences, than when those lists were presented in isolation. A 3 (type of presentation: convergent sentences, divergent sentences, words-only) × 2 (age: older, younger) × 2 (type of item: studied, critical target) ANOVA was performed on items recognized. Main effects of item type and age were found, [$F(1,58) = 79.12$, $MSe = .03$; $F(1,58) = 6.69$, $MSe = .06$]. The interaction between age and type of item was also significant, $F(1,58) = 4.36$, $MSe = .03$. These findings are consistent with those obtained in Experiment 1. A significant main effect for type of presentation was also found, $F(1,116) = 38.45$, $MSe = .05$. Recognition of studied items and related lures was greater for words studied in isolation ($M = .71$) than when words were presented in the context of convergent ($M = .57$) and divergent sentences ($M = .45$). Finally, the three-way interaction between age, type of item, and type of presentation was significant, $F(2,116) = 6.90$, $MSe = .05$.

Table 4
Mean raw and adjusted recognition hits and false alarms in Experiment 2

	Studied *M* (*SE*)	Critical *M* (*SE*)	Critical adjusted *M* (*SE*)	Unrelated lures *M* (*SE*)
Convergent sentences				
Older	.68 (.04)	.64 (.05)	.36 (.04)	.28 (.03)
Younger	.62 (.02)	.33 (.04)	.15(.05)	.19 (.03)
Divergent sentences				
Older	.57 (.03)	.37 (.04)	.10 (.03)	.27 (.03)
Younger	.56 (.02)	.32 (.04)	.13 (.03)	.19 (.03)
Words				
Older	.77 (.02)	.65 (.04)	.46 (.04)	.18 (.03)
Younger	.74 (.02)	.69 (.04)	.47 (.04)	.22 (.02)

To explore the nature of this interaction, a 3 (type of presentation: divergent sentences, convergent sentences, or words only) × 2 (age: older or younger) ANOVA was performed on the mean corrected proportion of false alarms to the critical target. False alarms to critical targets were corrected because a marginally significant main effect of age was found in false alarms to unrelated lures, $F(1,58) = 3.19$, $p = .08$, $MSe = .03$. The analysis on corrected false alarms to critical targets found a marginal main effect of age, $F(1,58) = 3.42$, $p = .07$, $MSe = .04$. Further a main effect of type of presentation was found, $F(2,116) = 37.30$, $MSe = .05$. Finally, the interaction between age and type of presentation was significant, $F(2,116) = 5.09$, $MSe = .04$.

Simple effects analyses comparing convergent sentences to words-only indicated that the main effect of age was significant, $F(1,58) = 5.83$, $MSe = .05$. Older adults were more likely to false alarm to the critical targets ($M = .41$) than younger adults ($M = .31$). Further a main effect of type of presentation was found $F(1,58) = 20.99$, $MSe = .07$, indicating that false alarms to critical theme words were higher after the words-only presentation ($M = .47$) than after the convergent sentence presentation ($M = .26$). The interaction between age and type of presentation was significant, $F(1,58) = 5.33$, $MSe = .07$. These results replicate those found in Experiment 1.

An ANOVA comparing corrected false alarms to critical lures in the divergent sentences condition to the words-only condition was also performed. Although a main effect of type of presentation was found, $F(1,58) = 84.82$, $MSe = .05$, no other significant effects were found, $F < 1$. These results demonstrate that both older and younger adults were less likely to falsely recognize critical targets when list items were presented in the context of divergent sentences as compared to in isolation.

Discussion of Experiments 2

The primary goal of Experiment 2 was to test whether older adults would reduce false memories when the possibility of generated shared cues was reduced. Experiment 2 demonstrated that younger adults showed a greater reduction in false memories than older adults when list items were presented in the context of convergent sentences. Both Experiments 1 and 2 showed that older adults were as likely to falsely recall and recognize critical theme words when presented with convergent sentences as when presented with words alone; however, younger adults showed a significant reduction in false recall and recognition. These findings suggest that older adults either do not encode or do not effectively use memory for contextual information.

To explore whether older adults suffer from an encoding or utilization deficit, Experiment 2 introduced the divergent sentences manipulation. Divergent sentences were designed to reduce the likelihood of generating shared cues while maintaining the accessibility of contextual information that individuated items within a given list. We found that older adults showed comparable reductions in both false recall and false recognition of the critical target compared with younger adults when semantically related items were presented in the context of divergent sentences. One interpretation of these results is that the presentation of divergent sentences forced older adults to rely on item-specific contextual information when making decisions about veridical and false memories, because they were unable to generated shared cues that related list items together.

This interpretation and these findings would suggest that older adult do encode contextual detail, nevertheless, they are less likely than young adults to use that information unless the possibility of generated shared cues that relate lists items together is minimized. However, an alternative and perhaps simpler explanation is that critical theme words were not internally activated in the divergent sentence condition. Much research suggests that false memories as a result of the presentation of semantically related words result from an internal activation that spreads to semantically related lures. At recall or recognition, participants must distinguish between activation resulting from actual list presentation and internal activation of related lures due to spreading activation across associative networks (Balota et al., 2000; Benjamin, 2001; Roediger III, Balota, & Watson, 2001). If the critical item is never internally activated, then there should be no reason to expect participants to falsely recall of recognize the item. By reducing the possibility of shared-cue generation, the divergent condition may have reduced the possibility for internal activation of the critical theme word (i.e., Tun et al., 1998). Although this possibility exists, recognition results from younger adults in both the convergent and divergent conditions suggest that critical theme words may have been internally activated. False alarms to related lures in these conditions were similar and significantly greater than zero. However, to further test whether critical theme words become activated in conditions that minimize the production of shared cues, Experiment 3 as designed.

Experiment 3 was also designed to provide convergent evidence that older adults can indeed reduce false recall and recognition through accessible distinctive contextual information. In the previous two experiments semantic associates were presented in the context of sentences. Although sentences were designed to increase the accessibility of distinctive contextual information, sentences encourage meaningful processing (Prior & Bentin, 2003). Therefore, it is possible that sentence presentation not only made item-specific information more accessible, but also information derived through relational process-

ing. To remove this possible confound Experiment 3 presented semantic associates in the context of paired-associates.

Experiment 3

In Experiment 3 individuating context was manipulated by presenting DRM list items as the second word of paired associates. As with the sentences, two conditions of paired associative context were designed. In the first, cue words were chosen to elicit the meaning of the list item that converged on the meaning of the critical theme word. For example, 'mattress – bed' was presented in the convergent pair condition, and 'river – bed' was presented in the divergent pair condition. In addition, Experiment 3 investigated whether the critical theme words were internally activated by measuring response latencies associated with recognition memory. Response latencies have been used previously to provide estimates of the relative activation of the different types of stimuli in the DRM paradigm (Tun et al., 1998).

Method

Participants

Participants were 48 younger adults (28 women and 20 men; age range 18–22; $M = 20.2$, $SD = 2.0$) and 48 older adults (25 women and 23 men; age range 62–85; $M = 73.1$, $SD = 4.8$). The same recruitment and payment procedures used in the previous experiments were again employed in this experiment. Mean years of education were 12.8 ($SD = 3.2$) and 13.1 ($SD = 2.6$) for the younger and older adults, respectively. All participants completed the Vocabulary subtest of the Wechsler Adult Intelligence Scale-Revised (WAIS-R; Wechsler, 1981). Older adults received a mean score of 59.8 ($SD = 7.5$) and younger adults received a mean score of 61.2 ($SD = 3.1$). Pair-wise comparisons indicated that education and vocabulary did not differ between the two groups.

Materials

As in the previous experiments, the experimental material consisted of semantically associated word lists taken from norms produced by Stadler et al. (1999). We used 20 semantically related lists, 16 of which had been used in the previous experiments. In addition, 12 list items were presented within a given block. List items served as the second word of paired associates. The first word of the pair was generated to either elicit the meaning of the list item that converged or did not converge on the meaning of the critical theme word. For example, 'mattress—bed' was a pair presented in a convergent list and 'river—bed' was a pair presented in a divergent list. Both forward and backward associative strength was computed between the first and second words of pairs and we found no difference in the average forward or backward associative strengths between the convergent and divergent paired associates.

Design and procedure

The experiment used a $2 \times 2 \times 2$ mixed design. The between subjects variable was age (older or younger), and the within subjects variables were type of presentation (convergent pairs, divergent pairs) and item type (studied item, critical target). After signing informed consent forms, participants were told that they would be presented with pairs of words visually for 2 s each. They were told to study each pair and informed that memory would be assessed on a later recognition test. Participants were also told that the test would assess memory for individual items in a pair and that both the first and the second word of a given pair may appear on the recognition test.

Paired associates were presented in blocks so that all pairs that contained semantic associates related to a given critical theme word were presented together. Ten blocks of stimuli were presented. Half of the blocks contained convergent pairs and the other half contained divergent pairs. Blocks of stimuli were presented randomly. Between each block participants were given 60 s to work on arithmetic problems. A 500 ms tone indicated the end and beginning of each block. The experiment was counterbalanced so that all semantically associated lists were tested in the context of both convergent and divergent pairs.

After all 10 blocks had been presented participants completed a five minute distractor task. The recognition memory test followed. Both the first and second word of a given pair were presented on the recognition test. However, words were presented randomly and individually. This procedure ensured that participants studied both the first and second word of the pairs. The first, third, and eighth pair of a given list formed the studied items on the recognition test. Of those, 30 words were members of semantically associated lists and 30 words were the first words of the cue-target pairs. For example, is the semantic associate "bed" was presented, the word paired with "bed," was also presented on the recognition test; however the presentation of each member of a pair was random. Sixty words from non-presented lists served as distractors. Of those, 30 words were members of semantically associated lists and 30 were the first words of the cue-target pairs that included semantic associates. Finally, 20 non-presented critical theme words were presented as distractors. Of those, 10 were associated with the 10 presented blocks and 10 were

associated with non-presented lists. Participants saw individual words presented on the computer screen and were asked to indicate whether each was old or new. Participants pressed the 'a' key if the item was old and the 'k' key if new. Participants were informed that their response latencies were being recorded and to respond as quickly and as accurately as possible.

The experiment was counterbalanced such that a given item served in the convergent-pair and divergent pair equally often, and a given item served as a target or distractor equally often. In both the study and test phase of this experiment all stimuli were presented in 16 point Arial type font and none of the participants indicated any difficulty in being able to see the words.

Results

Recognition

As Table 5 illustrates, both older and younger adults were less likely to falsely recognize the critical theme word if DRM list items were presented in the context of divergent pairs than convergent pairs. To analyze these results statistically, a 2 (older, younger) × 2 (type of item: studied, critical) × 2 (type of pair: convergent, divergent) ANOVA was performed of the average proportion recognized using DRM list associates as studied items.[1] In the previous two experiments, recognition false alarms were corrected to equate for differential 'yes' responding between older and younger adults. No such correction was needed in Experiment 3 because older and younger adults were equally likely to false alarm to distractors. Further, there was no difference between false alarms to critical theme words associated with non-presented DRM lists and false alarms associated with unrelated items.

To begin with, we found a main effect for type of pair, $F(1,94) = 80.91$, $MSe = .04$. Studying convergent pairs ($M = .62$) yielded more 'yes' responses on the recognition test than studying divergent pairs ($M = .43$). Not surprisingly, we found a significant difference between type of item, $F(1,94) = 80.17$, $MSe = .02$. Participants were more likely to claim that a studied item ($M = .61$) had been presented than a critical theme word ($M = .47$). The interaction between type of item and type of pair was also significant, $F(1,94) = 54.41$, $MSe = .04$. Whereas recognition 'yes' responses to critical theme words decreased from. 63 to. 31 moving from the convergent to the divergent pair condition, recognition 'yes' responses to studied items remained relatively stable (from. 62 in convergent to. 59 in divergent). These results are consistent with those obtained in Experiment 2. Finally, a main effect of age was not found, $F < 1$. However, the interaction between type of item and age was significant, $F(1,94) = 9.17$, $MSe = .02$. Older adults ($M = .58$) were less likely to correctly recognize studied items when compared to younger adults ($M = .64$), but were more likely to recall critical theme words ($M = .49$) than younger adults ($M = .45$). These results suggest that older adults were relatively more susceptible to this false memory effect than younger adults.

Response latencies

Recognition response latencies were measured as an index of activation of critical theme words. As can be seen in Table 6, participants were as fast at indicating that non-presented critical theme words were presented as saying studied items were presented. Further, both older and younger adults were slower to indicate that critical theme words were not presented when compared to saying unrelated distractors were not presented. To analyze these results a 4 (type of item: studied-yes, critical-yes, distractor-no, critical-no) × 2 (type of condition: convergent, divergent) × 2 (age: older, younger) ANOVA was performed on average response latencies. Response latencies that were shorter than 200 ms and longer than 2000 ms were eliminated from the analysis. Further, because no significant difference was present between response latencies made to studied DRM list items and studied items that served as the first words of cue-target pairs, response latencies made to those two types of items were averaged together; thus one average for studied items was computed.

To begin with we found a main effect of type of item, $F(3,282) = 168.55$, $MSe = 49193.06$. Both older and younger adults were significantly slower to indicate that critical theme words were not presented ($M = 1532.67$) than to indicate that unrelated lures were not presented ($M = 1105.46$). A main effect of age was also found, $F(1,94) = 1596.29$, $MSe = 717367.58$, demonstrating that older adults ($M = 1322.53$) were significantly slower at making recognition decisions than younger adults ($M = 1119.84$). Finally, when type of condition was examined, no significant difference in response latencies was found. That is, participants demonstrated similar response latencies in the convergent and divergent pairs conditions.

[1] It should be noted that studied items were divided into two categories, one that contained DRM semantic associates, and one that contained the individuating context words. Because recognition performance was significantly different between these two, separate analyses were performed using the average hits for studied DRM associates and the average hits for the contextual words. The analysis reported compares average 'yes' responses to studied DRM associates and average 'yes' responses to critical theme words. The analysis comparing average 'yes' responses to contextual words and critical theme words is not described, but is consistent with the reported results.

Table 5
Mean recognition hits and false alarms in Experiment 3

	Studied-cue *M* (*SE*)	Studied-target *M* (*SE*)	Critical *M* (*SE*)	Unrelated lures *M* (*SE*)
Convergent pairs				
Older	.52 (.03)	.59 (.03)	.65 (.03)	.33 (.02)
Younger	.57 (.02)	.65 (.03)	.60 (.04)	.31 (.02)
Divergent pairs				
Older	.54 (.03)	.56 (.02)	.33 (.03)	.33 (.02)
Younger	.56 (.03)	.65 (.02)	.29 (.03)	.31 (.02)

Table 6
Response latencies as measured in milliseconds associated with recognition judgments in Experiment 3

	Studied-yes *M* (*SE*)	Critical-yes *M* (*SE*)	Distractor-no *M* (*SE*)	Critical-no *M* (*SE*)
Convergent pairs				
Older	1169 (59)	1183 (73)	1246 (64)	1681 (95)
Younger	1071 (56)	1058 (66)	965 (65)	1362 (94)
Divergent pairs				
Older	1164 (56)	1197 (52)	1239 (74)	1701 (68)
Younger	1081 (49)	1064 (46)	972 (57)	1387 (55)

Because critical-no responses took almost 400 ms longer than any other responses, we performed a separate 3 (type of item: study-yes, critical-yes, distractor-no) × 2 (type of condition: convergent, divergent) × 2 (age: older, younger) ANOVA on average response latencies. When critical-no response latencies were removed from the analysis, no main effect of type of item was found, $F < 1$. That is, participants were as fast to indicate a critical theme word was presented as to indicate a studied item was presented. Further, we found no significant interactions, $F < 1$. These latency data provide empirical support that critical theme words are internally activated, and even if participants reject these lures, the time spent to make that decision is significantly longer than time spent to reject unrelated distractors.

Discussion of Experiment 3

Experiment 3 provided additional evidence that older adults encode item-specific information and can use that information to reduce susceptibility to false memories. Specifically, in the divergent pairs condition, both older and younger adults were less likely to falsely recognize critical theme words than in the convergent pairs condition. An alternative explanation for these findings is that false alarms to critical theme words may have been more likely in the convergent pairs condition, because convergent pairs presented participants with more semantic associates than divergent pairs. Although a possibility, we believe this explanation is unlikely because internal activation of the critical theme words, as measured by response latencies did not differ between convergent and divergent pairs. For both the convergent and divergent conditions, latencies for false recognition were similar to those associated with veridical recognition responses. By contrast, both age groups took significantly longer to reject the critical theme words than to reject other distractors. If internal activation is taken as an indicator of the development and strength of false memories (i.e., Tun et al., 1998), then our findings would suggest that in both conditions false memories developed. However, participants in the divergent condition may have been able to buffer against explicit susceptibility by accessing item-specific information that individuated list items from one another.

Finally, one interesting difference between the results of the first two experiments and Experiment 3 has to do with younger adult performance. In the first two experiments younger adults were far less likely to falsely recall or recognize critical theme words if their associates were presented in the context of convergent sentences as compared to in isolation. However, in Experiment 3, when DRM list items were presented as the second words of convergent paired associates, younger adults were as likely to falsely recognize critical theme words as older adults. One possible reason why younger adults did not show a reduction in false recognition when presented with convergent pairs is that convergent pairs may not have provided enough contextual information to counteract the cost of generating shared cues that related the items within a given list. Sentence context may have been more distinctive than word pairs that related DRM list items to the underlying critical theme words. The distinctive nature of sentence context may have led to differential activation of critical theme words in

the convergent and divergent conditions. The implication for these results is discussed in more detail in the General Discussion.

General discussion

The ability of older and younger adults to reduce false memories was examined in three experiments. Previous research suggests that older adults may not encode unique perceptual and contextual attributes that individuate items within a list, resulting in higher rates of false recall and recognition. However, the present study demonstrated that older adults can encode and use unique attributes of items to reduce false recall and recognition. Unique attributes were externally provided by presenting to-be-remembered DRM list items in the context of convergent or divergent sentences.

When presented with convergent sentences, older adults did not show a reduction in false recall or recognition as compared to when semantic associates were presented in isolation. Younger adults, in contrast, were able to reduce both false recall and false recognition when semantic associates were presented within convergent sentences as compared to when semantic associates were presented in isolation. When presented with divergent sentences, both older and younger adults showed comparable reductions in false recall and false recognition. Similarly, when DRM list items were presented in the context of divergent paired associates both older and younger adults were less likely to falsely recognize critical theme words than when those items were presented in the context of convergent pairs. However, it should be noted that while analogous, the presentation of paired associates and sentences are not parallel. It remains unclear whether critical theme words were similarly activated in the context of sentences as compared to in the context of paired associates.

The findings of Experiments 2 and 3 do suggest that older adults do encode and have access to item-specific information. The results of these experiments also highlight the conditions under which older and younger adults rely on item-specific information when making recall and recognition decisions and are consistent with the findings of Koutstaal (2003) and Kouststaal et al. (2003). Koutstaal et al. presented older and younger adults with ambiguous objects that were either accompanied or not accompanied by a disambiguating conceptual label at study. Older adults showed elevated levels of false recognition in conditions that contained labels but not in conditions without labels. Older adults used perceptual item-specific information to reduce false memories, but only when semantic information relating items was absent. Similarly, the results from the present study demonstrate that although older adults encode perceptual and contextual information, they may have difficulty efficiently using this information. Perceptual and contextual information may be available to older adults, but may only become accessible when other information, such as relational information, is made less accessible.

The encoding of non-overlapping distinctive attributes provides a unique specification of the target element and thus facilitates memory by rendering the target element highly distinguishable (Lockhart, Craik, & Jacoby, 1976). In conjunction with the encoding of non-overlapping distinctive attributes, individuals most often engage in organizational processing and therefore encode information that relates to-be-remembered stimuli together. Organizational or relational processing generates information that is based on the commonalities among studied items while item-specific information arises from the processing of differences between studied items (Hunt & McDaniel, 1993).

Encoding of relational information would tend not only to improve recall and recognition of studied items but also increase false recall and recognition of semantically related lures. In contrast the encoding of item-specific distinctive attributes should increase accurate recognition of study items and decrease false recognition of related lures. In conditions under which both item-specific information and relational information is encoded, younger adults have been found to rely on item-specific information and show dramatic reductions in false recognition (Arndt & Reder, 2003; McCabe et al., in press). However, under similar conditions, older adults weigh relational information more heavily, and do not show comparable reductions in false memories, as evidenced by their failure to reduce false recall or recognition in the convergent sentence condition.

Under conditions in which participants must self-generate item-specific information, older adults may not attend to that information during encoding because they may lack the attentional resources necessary to focus on both item-specific and relational information (e.g. Craik, 1982). Consistent with this hypothesis, Reder, Wible, & Martin (1986) found that older adults were more likely to rely on ''plausibility'' in making their judgments regarding previously presented sentences, whereas younger adults were more likely to recall item-specific information. Reder et al. suggested that this ''plausibility reliance'' may be due to differences in attentional resources across group. Reder et al. concluded that it was less demanding for older adults to retrieve plausibility information than item-specific information.

Alternatively, older adults may by default rely on relational processing not because they lack the attentional resources to engage in multiple processes at encoding, but because relational processing is less effortful and provides more useful information. When older adults engage in relational processing they are more

likely to correctly remember list items than when they engage in item-specific processing (Tun et al., 1998). Therefore, relational processing is not only less effortful than item-specific processing, it also provides individuals with a way to organize information that facilitates higher rates of veridical recall and recognition. Thus, an important direction for future research is to design studies to differentiate between these two possible explanations.

The present study does suggest that older adults are able to reduce false recall or recognition only when organization based on the similarities of to-be-remembered items is disrupted. Similar findings have been demonstrated in younger adults, where false recall was reduced in the DRM paradigm by varying the proximity of semantic associates within a list (Goodwin, Meissner, & Ericsson, 2001). False recall was greatest in conditions where semantic associates were more closely grouped together. Goodwin et al. hypothesized that when semantic associates were interspersed with unrelated filler items, participants were less likely to make semantic connections to the critical lures. The contextual organization of list items directly influenced the likelihood of false recall. In the divergent sentences condition and the divergent pairs condition of Experiments 2 and 3, participants may have been less likely to make semantic connections to critical theme words, thereby reducing false memories.

Although a plausible explanation for the reduction in false memories, the recognition latency results of Experiment 3 suggest that critical theme words were internally activated even in the divergent pairs condition, where relational processing was made less accessible. Both older and younger adults accepted studied items as quickly as they accepted related lures as having been presented. Further, both groups of participants were slower to reject critical theme words as compared to unrelated lures. These findings suggest that at retrieval both older and younger adults examine information associated with the memory for critical theme words to determine whether those words were indeed presented. In the divergent condition both older and younger adults were able to accurately discriminate between internal activation and actual presentation.

We believe that the response latency results suggest that the critical theme words were similarly activated in both the convergent and divergent pairs conditions, and that both older and younger adults accessed item-specific information in the divergent condition to reduce explicit susceptibility to false memories. However, we are unable to rule out the possibility that a reduction in relational or gist processing was the sole contributor to the reduction found in false memories in the divergent condition.

The purpose of the divergent sentences and divergent pairs conditions was to reduce the possibility of producing shared cues that related DRM list items together. The inequality in shared cue production between divergent and convergent conditions may have resulted in the differential false recognition across the two conditions. Although a possibility, and one of the major tenants of the Fuzzy-Trace Theory (cf. Brainerd & Reyna, 1998), the production of shared cues may not be the only factor in the creation of false memories. Our results suggest that the production of shared cues affects the decision process of participants at retrieval. The response latency data suggests that in both divergent and convergent conditions critical theme words were internally activated; however, only in convergent conditions did participants accept on a yes-no recognition test those internally activated lures. We argue that related lures are accepted on a recognition test because those lures are internally activated and are consistent with shared cues produced at encoding. When the production of shared cues is disrupted, participants are able to reject internally activated related lures because they can access only memory of encoded item-specific information to perform memory tasks.

Sentences may tax working memory

Turning our attention to veridical recall, it should be noted that veridical recall typically increases when item-specific information is made more accessible (Arndt & Reder, 2003; Hunt & Smith, 1996; McCabe et al., in press). In the present experiment, veridical recall and recognition were lower when list items were presented in the context of convergent sentences than when they were presented alone. However, these results are not surprising. Presenting list items in the context of sentences, and having participants try to remember the last words of those sentences is analogous to the Daneman & Carpenter (1980) reading span task. Daneman and Carpenter found that their reading span test, in which participants had to read sentences and remember the last words of those sentences, was correlated with traditional assessments of comprehension. Further, participants' retrospective reports, collected in the Daneman and Carpenter study, suggested that processing and storage of working memory was taxed by the reading span task. This task is inherently more difficult than trying to remember lists of words; therefore it is not surprising that under these conditions, veridical recall and recognition were lower.

It is possible that the demands on working memory led to the reduction in false memories found when participants were presented with sentences. That is, one consequence of increasing demands on working memory might be to reduce the likelihood that participants will be able to use relational processing to encode list items, thereby reducing internal activation of the critical lure.

However, if this was indeed the case, then similar effects would have been obtained in older and younger adults in both the convergent and divergent sentences conditions. Older adults were as likely to falsely recall the critical target when presented with list items in the context of convergent sentences, as when presented with these semantic associates in isolation. If working memory demands reduced older adults' ability to engage in relational processing in the convergent sentence condition, then they would have been expected to demonstrate even greater reductions in false memories.

Conclusions

The present study demonstrated that older adults can encode and use item-specific information to avoid false memories in the DRM paradigm. The study also found that in addition to relying on the "distinctiveness heuristic" older adults can engage in distinctive processing at encoding to reduce false recall and false recognition. However, older adults may rely on relational or gist-based processing more than item-specific processing either because of limited attentional resources at encoding, or because relational processing has proven to be a more efficient and useful strategy. Future research needs to investigate whether older adults can use both item-specific and relational information at retrieval and should also be aimed at examining the strategy selection differences between older and younger adults. Finally, our research supports the hypothesis that older adults may not suffer a deficit in the ability to encode perceptual and contextual information. Future research needs to further explore this avenue so that a better understanding of age-related changes in memory can be attained. If the same level of information is available to both older and younger adults, researchers must then begin to focus on why some of that information remains accessible to younger adults, but becomes inaccessible as a function of normal aging.

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