The Effects of Pure Pair Repetition on Younger and Older Adults’ Associative Memory

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Although aging causes relatively minor impairment in recognition memory for components, older adults’ ability to remember associations between components is typically significantly compromised, relative to that of younger adults. This pattern could be associated with older adults’ relatively intact familiarity, which helps preserve component memory, coupled with a marked decline in recollection, which leads to a decline in associative memory. The purpose of the current study is to explore possible methods that allow older adults to rely on pair familiarity in order to improve their associative memory performance. Participants in 2 experiments were repeatedly presented with either single items or pairings of items prior to a study list so that the items and the pairs were already familiar during the study phase. Pure pair repetition (the effects of pair repetition after the effects of item repetition are taken into account) increased associative memory for older and younger adults. Findings based on remember and know judgments suggest that familiarity but not recollection is involved in mediating the repetition effect.

Keywords: associative memory, age-related changes, repetition, familiarity, recollection

Evidence shows that memory abilities decrease with age; however, older adults’ memories are affected differentially depending on the type of information being processed. For instance, research has shown that older adults are able to retrieve prior knowledge as well as younger adults can (Rabinowicz, Craik, & Ackerman, 1982), yet it is more difficult for older adults to retain episodic information in which they must encode events along with their corresponding contexts (see Naveh-Benjamin & Old, 2008, for a review). An associative-binding deficit hypothesis has been suggested to explain older adults’ memory deficits, stating that they are a result of problems in associating separate units of information (Bayen, Phelps, & Spaniol, 2000; Chalfonte & Johnson, 1996; Naveh-Benjamin, 2000). Support for this hypothesis comes from comparisons of age differences in item and associative recognition tests. For instance, Naveh-Benjamin, Guez, Kilb, and Reedy (2004) showed that older adults recognized individual faces or names about as well as did younger adults; however, they showed large deficits in memory for name–face associations (see also Bastin & Van der Linden, 2005; Castel & Craik, 2003; Kilb & Naveh-Benjamin, 2007; Light, Patterson, Chung, & Healy, 2004; Naveh-Benjamin, Hussain, Guez, & Bar-On, 2003; and a meta-analysis by Old & Naveh-Benjamin, 2008a).

One potential mediator for the associative deficit could be older adults’ tendency to rely too much on automatic retrieval processes rather than on more consciously controlled processes. According to dual processing theory, recognition can depend on one of two processes: recollection or familiarity (see Yonelinas, 2002, for a review). Here, recollection means that an item is (consciously) retrieved along with its original context, and familiarity refers to (automatic) recognition in the absence of any contextual information. For example, one might rely on familiarity when instantly recognizing someone’s face, but recollection must be used in order to remember that person’s name or other relevant information about him or her. Evidence from studies using a variety of methodologies converges to suggest that people’s ability to use recollection decreases with age, yet their ability to use familiarity does not (Hay & Jacoby, 1999; Jennings & Jacoby, 1993, 1997; Light et al., 2004; Maylor, 1995; M. G. Rhodes, Castel, & Jacoby, 2008).

Item and associative recognition tests may each require different levels of familiarity and recollection. For example, Hockley and Consoli (1999) have shown that participants are more likely to give a familiarity-based response in an item test yet are more likely to give a recollection-based response in an associative test, demonstrating that associative tests require more recollective processing than item tests. Moreover, if a participant is able to rely on recollection, then it is expected that performance on both tests will be quite high. On the other hand, if a participant relies mainly on familiarity (i.e., in the absence of recollection), performance in the item recognition test may still be high, but performance in the associative recognition test would suffer. This is because the individual items of a recombined pair (i.e., a new pair created from two studied words) would look familiar, causing the participant to mistakenly recognize the new pairing. When examining the empirical data, younger adults’ performance is more consistent with patterns predicted by recollection, whereas performance of older adults is more consistent with patterns predicted by famil-
arity. Specifically, older adults are more likely to falsely recognize new pairs in an associative test than new items in an item test, but younger adults show relatively low false alarm rates in both tests (Naveh-Benjamin, Shing, Kilb, Li, & Lindenberger, 2009; Old & Naveh-Benjamin, 2008b; M. G. Rhodes et al., 2008).

The purpose of the current set of experiments was to increase older adults’ associative memory performance by making their reliance on familiarity more effective. One potential mechanism that may allow older adults to take an advantage of their spared familiarity to improve their associative memory is unitization. Recent research has indicated that associative test performance can be increased in younger adults if pairs are sufficiently unitized—that is, if two components are encoded as if they were only one unit. For example, in testing young adults, Parks, Murray, Yonelinas, and Smith (2006) found a benefit of unitization in an associative test despite no effect in an item test. Most important, the associative memory improvement was driven more by familiarity than recollection.

In the current studies we tried to increase associative memory by independently manipulating the repetition of components (face and scene) and pairs (face–scene), aiming to increase the familiarity of the pairs (see below) and to enable older adults to capitalize on this intact pair familiarity in order to remember new associations. Specifically, younger and older adults were presented with information where item versus pair repetition was manipulated to assess whether pair repetition (which potentially unitizes the word pair) helps older adults’ associative memory (Experiments 1A, 1B, and 2) and whether such a benefit is mediated by older adults’ intact pair familiarity (Experiment 2).

**Experiment 1A**

One possible way to improve older adults’ associative memory is to increase the number of presentations for each pair. This method was explored by Light and colleagues (Light, Chung, Pendergrass, & Van Ocker, 2006; Light et al., 2004), who found that repetition increased hit rates for intact pairs in both younger and older adults but that it also impeded memory in older adults by increasing their false alarm rate to recombined pairs (see also M. G. Rhodes et al., 2008), making repetition more beneficial for younger than for older adults. Because repetition of a pair also involves repetition of its constituent items, it can be difficult to tease apart the separate effects of item and pair repetition. This distinction is crucial because item repetition could increase item familiarity, leading to false alarms to recombined pairs, whereas pair repetition could strengthen the association between the two items. Because Light et al. (2004; as well as M. G. Rhodes et al., 2008) repeated only pairs, both item and pair repetition increased, and the degree to which participants were influenced by each is unclear. At least one study has already attempted to isolate the effects of item repetition in younger adults, though. Earles and Kersten (2008) measured associative memory for video clips after increasing item repetition independently of pair repetition and found that more false alarms were seen for repeated items than repeated pairs, suggesting that pair repetition can, to some extent, protect against conjunction errors.

In the current experiment, the independent effects of item and pair repetition were examined by presenting either one singleton (item repetition condition) or one pair (pair repetition condition) at a time during an initial single training phase in preparation for later trials. Participants’ task during each of the four subsequent trials was to learn a study list of face–scene pairs, each followed by corresponding item and associative recognition tests. These study lists included pictures from the item repetition condition, pairs from the pair repetition condition, and study only pairs (those that were never presented in the training phase). Importantly, participants’ instructions at test in the current task were to base their memorial judgments solely on the study list for the given trial as opposed to the earlier training phase.

The advantage of the method used here is twofold: (a) Because participants should be trying to consciously retrieve information from the study list only during test, any effects of previously presented pictures during the training phase are assumed to be mediated by item or pair familiarity (presumed to be an automatic process) and not by recollection. Most important, (b) a pure measure of the effects of pair repetition can be obtained after controlling for item repetition. Specifically, item repetition can be assessed as any difference in performance between item repetition and study only conditions, and pure pair repetition can be assessed as any difference in performance in pair repetition and item repetition conditions.

If responding is based solely on recollection, there should be no effect of item or pair repetition at test because participants’ ability to consciously retrieve information directly from the study list would override any influence of item or pair familiarity from the prior training phase. However, if responding is based at all on familiarity, an interaction would be expected. Specifically, item repetition but not pure pair repetition should increase performance in item tests, and pure pair repetition but not item repetition should increase performance in the associative tests. That is, in the case of the item tests, one would not expect an effect of pure pair repetition because there is no a priori reason that presenting two words together would increase item memory more than presenting them singly. In fact, the contextual discordance between presenting the items in pairs during learning and as singletons at test could potentially impair memory performance (e.g., see Graf & Ryan, 1990). For the associative tests, item repetition is predicted to weaken performance because it would create an inclination to recognize highly familiar words from training that have been recombined to form new pairings.

Regarding age differences, Light et al. (2004) found that older adults did not benefit from pair repetition as much as did younger adults. One reason is that older adults (but not younger adults) are impaired by item repetition, which is inherent to pair repetition and which leads to a higher false alarms rate in the associative test. It is predicted that when using the purer measure of pair repetition (i.e., pair repetition minus item repetition), the memory performance of the older adults should increase at least as much as that of the younger adults, potentially due to the reliance on the effects of pair familiarity.

As an additional extension of previous work, Experiments 1A, 1B, and 2 included pictorial stimuli instead of word pairs. Findings have shown that older adults display an associative deficit for unrelated picture pairs compared with younger adults (Naveh-Benjamin et al., 2003), and it was expected that an associative deficit would be observed here in the study only condition. The stimuli consisted of faces paired with different scenes, which is similar to the common real-life situation of trying to remember
where a particular person was met, making the current findings more ecologically valid than the word pairs used by Light et al. (2004).

Method

Participants. Twenty-four younger adults were recruited from introductory psychology courses at the University of Missouri, and 24 older adults were recruited from central Missouri and Plymouth, Wisconsin. All participants reported being in good physical and mental health. The age groups were matched in gender (seven men and 17 women) and did not differ in years of education, $t(46) = 1.63, p > .05$ (see Table 1 for demographic information).

Design. This experiment was a 2 (age: younger vs. older) × 2 (test: face, scene, associative) × 3 (repetition type: study only, item repetition, pair repetition) design. Additionally, number of repetitions (1 or 3) was manipulated within item and pair repetition conditions. Test, repetition type, and number of repetitions were manipulated within lists.

Materials. Four study lists were used. Each study list included 42 unrelated pairs (14 for each repetition type—study only, item repetition, pair repetition) composed of faces and outdoor scenes. Half of the faces were female, and half were male; within each gender, half of the faces were younger adults, and half were older adults. Scenes were taken from Luo, Sakuta, and Craik (2008). Face tests each contained 12 target and 12 distractor faces, scene tests each contained 12 old and 12 new scenes, and associative tests each contained 15 intact and 15 recombined pairs. One third of each of the targets was taken from each repetition type (i.e., study only, item repetition, pair repetition). The number of repetitions was manipulated within repetition type such that half were shown once at training (1x condition) and half were shown three times at training (3x condition) in a spaced manner, such that at least one intervening event was shown between repetitions. The same allocation was used in the associative test for recombined pairs, which were created by rearranging pairs from the same condition (e.g., only a study only pair could be recombined with another study only pair). Because the item test distractors were not shown in either the training or study phases, they were arbitrarily assigned to the various repetition conditions such that they appeared temporally close to their corresponding targets. For example, the distractors allocated to the 1x condition were intermixed with the targets that were actually presented in the 1x condition.

During training, 168 unique events were shown, all of which were later presented in the study lists. Of the 112 singletons, 16 later appeared as targets in the face tests, 16 later appeared as targets in the scene test, 40 later appeared as intact pairs (i.e., 20 faces and 20 scenes), and 40 later appeared as recombined pairs. For the remaining 56 pairs presented during training, 16 later appeared as targets in the item tests (i.e., 16 faces and 16 scenes), 20 later appeared as intact pairs, and 20 later appeared as recombined pairs. Half of the total unique stimuli were in the 1x condition, and the remaining half were in the 3x condition, for a grand total of 336 events. All stimulus types were intermixed and divided into three sets of 112 for presentation during training.

The order of the four study lists was counterbalanced for each participant along with the order of the three recognition tests (between subjects). Also, the stimuli were randomly assigned to the repetition conditions and counterbalanced across participants such that a given picture appeared equally often in the study only, item repetition, and pair repetition conditions. Within the repetition conditions, a given stimulus was used equally in the 1x and 3x conditions. Each picture appeared equally often as an item target, an intact pair, and a recombined pair at test. Finally, any given face or scene appeared in only one of the tests of a given list.

Procedure. Participants began with the training phase. This phase was divided into three sets in order not to overload the participants, and their only instructions were to learn as much information as they could. Each event (consisting of a single item or a pair) was presented for 3 s at a time. Between sets, they were given a 2-min filler task. After the training phase, they were given further instructions about the four trials to come. Specifically, they were told that they would learn study lists, each followed by a face, scene, and associative test (the nature of which was described). Then they were given a practice trial containing a short study list and the three test types. During the study phase of each of the four lists, picture pairs were presented once every 3 s, and they were instructed to learn both the items and their pairings. After a 3-min filler task, participants received the three corresponding tests on

Table 1

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</table>

1 One methodological point is worth noting. Given that each singleton in the item repetition condition and each pair in the pair repetition condition appeared for the same duration at training, one might argue that items shown alone were viewed for a functionally longer period of time than those shown in pairs. Although this could be the case, we do not think that this changes the interpretation of our results for the following reasons. First, we would expect that item memory performance would be worse in pair repetition conditions than in item repetition conditions. However, this is clearly not the case in either Experiment 1A or Experiment 2, in which both repetition conditions elicited about the same performance levels in the item test. Second, if we wanted to equate the functional time for learning individual items, we might present singletons for 3 s and pairs for 6 s in the training phase. In such a case, having more time to learn the pairs should strengthen the familiarity of the pairs and increase the pair repetition effect even more. However, as the results indicate, we already showed this effect in all experiments even with equal presentation time of 3 s at training. That is, older adults showed an effect of pure pair repetition even under such less favorable training conditions of pairs. Hence, our results seem to be a more conservative test of our pair repetition manipulation. Finally, increasing the time for pairs relative to the singletons in the training phase might work against the same effect we are trying to assess—that of pair familiarity—because additional time per pair may promote pair recollection, with older adults potentially having a disadvantage in this type of processing.
faces, scenes, and the face–scene associations (with instructions to compare the test stimuli against the most recent study list presented). Participants were given unlimited time to respond “yes” or “no” to each test stimulus by pressing one of two designated keys on the computer keyboard.

Results

Study only condition. To assess an associative deficit in this experiment, a 2 (age) × 2 (test: item or associative)² analysis of variance (ANOVA) for the study only conditions was performed on proportion hits minus proportion false alarms. The results indicated an interaction of age and test, revealing older adults’ associative memory deficit, $F(1, 46) = 11.19$, $\eta_p^2 = .20$, $p = .002$, such that younger adults outperformed the older adults in the associative test, $t(46) = 4.35$, $p < .001$, but there were no age differences in the item tests, $t(46) = 0.44$, $p = .67$ (see Figure 1A).

Next, we analyzed separately proportion hits and proportion false alarms (see also Table 2 for descriptive statistics in all conditions). When proportion hits was used as the dependent variable in a two-way ANOVA, the interaction between age and test was significant, $F(1, 46) = 4.11$, $\eta_p^2 = .08$, $p = .048$, but there was no age difference in the item test, $t(46) = 0.15$, $p = .88$, and no age difference in the associative test, $t(46) = 1.35$, $p = .18$. When proportion false alarms was used as the dependent variable, the Age × Test interaction was highly significant, $F(1, 46) = 19.31$, $\eta_p^2 = .30$, $p < .001$, revealing no age differences in the item test, $t(46) = 0.91$, $p = .37$, but reflecting the fact that older adults showed significantly more false alarms than did the younger adults in the associative test, $t(46) = 4.77$, $p < .001$.

Repetition. Specific analyses were completed in order to more directly contrast the current results with those obtained from Light et al. (2004) and to investigate the effect of number of repetitions. To this end, the focus was on separate hits and false alarms in the associative test only for data in the pair repetition condition (the results for the overall measure of hits minus false alarms can be seen in Figure 1A). A 2 (age) × 3 (repetition: study only, 1x pair repetition, and 3x pair repetition) ANOVA on the hit rate showed no effect of age, $F(1, 46) = 2.42$, $\eta_p^2 = .05$, $p = .13$, nor a significant interaction, $F(2, 92) = 0.43$, $\eta_p^2 = .009$, $p = .65$, but the effect of repetition, $F(2, 92) = 46.64$, $\eta_p^2 = .50$, $p < .001$, indicated a steady increase in performance with more repetitions (study only vs. 1x, $t(47) = 5.06$, $p < .001$; 1x vs. 3x, $t(47) = 5.105$, $p < .001$). Next, the same ANOVA was performed on the false alarm rate. This time, younger adults outperformed the older adults, $F(1, 46) = 227.06$, $\eta_p^2 = .83$, $p < .001$, but the repetition effect, $F(2, 92) = 7.93$, $\eta_p^2 = .15$, $p = .001$, indicated more false alarms in the 1x condition than in the study only, $t(47) = 2.42$, $p = .02$, and the 3x conditions, $t(47) = 3.72$, $p = .001$ (study only vs. 3x, $t(47) = 1.58$, $p = .12$). The interaction of age and repetition was only marginally significant, $F(2, 92) = 2.41$, $\eta_p^2 = .05$, $p = .095$ (see Table 2 for descriptive statistics across all conditions).

For brevity, the remaining results for the current experiment are limited to the study only versus 3x conditions, as this provided the strongest manipulation of repetition, and the results are limited to those that include repetition. A 2 (age) × 2 (test) × 3 (repetition type: study only, item repetition, pair repetition) ANOVA was performed on proportion hits, and a significant main effect of repetition, $F(2, 92) = 56.25$, $\eta_p^2 = .55$, $p < .001$, showed that the performance in the study only condition was lower than in both the item repetition, $t(47) = 7.93$, $p < .001$, and the pair repetition conditions, $t(47) = 10.92$, $p < .001$, though performance in the repetition conditions did not differ, $t(47) = 0.80$, $p = .43$. There was also an interaction of test and repetition, $F(2, 92) = 6.59$, $\eta_p^2 = .13$, $p = .002$. In the item tests, item repetition resulted in higher performance than did pair repetition, $t(47) = 2.14$, $p = .04$, which was higher than performance in the study only conditions, $t(47) = 6.69$, $p < .001$. However, in the associative test, pair repetition resulted in higher performance than did item repetition, $t(47) = 2.38$, $p = .02$, which resulted in higher performance than the study only conditions, $t(47) = 4.67$, $p < .001$. The interaction of age and repetition, $F(2, 92) = 0.08$, $\eta_p^2 = .002$, $p = .92$, and the triple interaction were not significant, $F(2, 92) = 0.37$, $\eta_p^2 = .008$, $p = .69$.

Next, the same analyses were repeated with proportion false alarms. There was a main effect of repetition, $F(2, 92) = 3.61$, $\eta_p^2 = .07$, $p = .031$, showing that pair repetition was associated with better memory performance (lower false alarms) than item repetition, $t(47) = 2.56$, $p = .014$, but no other differences were significant (study only vs. item, $t(47) = 1.41$, $p = .17$; study only vs. pair repetition, $t(47) = 1.24$, $p = .22$). The Age × Repetition interaction, $F(2, 92) = 3.89$, $\eta_p^2 = .08$, $p = .024$, showed that older adults had more false alarms in item repetition conditions compared with study only, $t(23) = 3.00$, $p = .006$, and marginally more than in pair repetition, $t(23) = 1.98$, $p = .05$, whereas the only significant result for younger adults was fewer false alarms in item repetition than study only conditions, $t(23) = 3.14$, $p = .005$. The interaction of test and repetition was significant as well, $F(2, 92) = 7.52$, $\eta_p^2 = .14$, $p = .001$. The item tests showed marginally fewer false alarms in item repetition than both study only, $t(47) = 1.76$, $p = .09$, and pair repetition, $t(47) = 1.71$, $p = .09$. However, the associative test showed significantly more false alarms in item repetition than study only, $t(47) = 2.09$, $p = .04$, and pair repetition $t(47) = 3.37$, $p = .002$. The triple interaction was nonsignificant, $F(2, 92) = 1.07$, $\eta_p^2 = .02$, $p = .35$.

Discussion

The findings of Experiment 1A show a clear associative deficit for the older adults. In the control condition (study only) in which there was no repetition, older adults were impaired relative to younger adults in the associative test yet there were no age differences in either item test. Furthermore, older adults’ impairment was seen as both fewer hits and even more so as increased false alarms in the associative test than younger adults, suggesting that older adults’ binding deficit is due mostly to the erroneous recognition of recombined lures but also reflects some deficit in recognizing previously shown pairings. These data are consistent with

² Item memory performance was calculated as an average between the face and scene tests in all experiments. For a more complete look at memory performance as a function of the three types of memory tests, please see Tables 2, 3, and 4 for descriptive statistics in Experiments 1A, 1B, and 2, respectively.

³ The source of the interaction of age and test on the hit rate was that there was no test difference for the younger adults, $t(23) = 0.66$, $p = .52$, but older adults demonstrated poorer performance for associative tests than item tests, $t(23) = 3.30$, $p = .003$. 
Comparisons made between the current findings and those of Light et al. (2004) are reserved for the General Discussion. The focus of Experiment 1A was in determining whether pure pair repetition can increase the pair familiarity of associations such that older adults are less likely to false alarm to recombined pairs. Analyses showed that repeated information was recognized more often than information shown once, though the type of repetition interacted with the different recognition tests, as expected. It was found that hits in the item test were higher in the item than pair repetition condition, whereas hits in the associative test were higher in the pair than item repetition condition. Because distractors in the item tests never appeared at training and were therefore arbitrarily assigned to the various repetition conditions, the patterns of false alarms for the item tests (the face and scene tests) are of little interest and are not discussed. However, the associative test revealed fewer false alarms in the pair repetition condition compared with item repetition. The fact that there were observable

Figure 1. Mean of proportion hits minus proportion false alarms as a function of age, test, and repetition in the study only and 3x conditions in Experiment 1A (Panel A) and in Experiment 2 (Panel B). Error bars represent standard errors around the mean.

Table 2
Memory Performance as a Function of Age, Test, and Repetition Condition in Experiment 1A

<table>
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<tr>
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</table>

Note. 1x = shown once at training; 3x = shown three times at training; H = proportion hits; FA = proportion false alarms.
effects of repetition from the training phase supports the notion that participants were not relying wholly on recollection, as otherwise they would have ignored information from the training phase. Instead, increased item and pair familiarity for previously seen stimuli in the practice phase caused participants to recognize more events at test even though they were instructed to ignore the earlier training phase altogether.

To observe the age differences in the purer measure of pair repetition, we calculated difference scores (see Figure 2A). The dependent variable on which the difference scores are based was overall memory accuracy (i.e., proportion hits minus proportion false alarms). Pure pair repetition can then be measured as performance in pair repetition minus item repetition conditions, and the effect of item repetition is simply the difference between item repetition and study only conditions. Upon inspection of the figure, it is evident that younger and older adults displayed nearly identical patterns of performance. Specifically, both age groups showed positive effects of item repetition in the item tests (one-sample t-tests indicated significant increases from zero in younger, $t(23) = 5.59, p < .001$, and older adults, $t(23) = 5.27, p < .001$) and positive effects of pure pair repetition in the associative test (in younger adults, $t(23) = 2.41, p = .02$; in older adults, $t(23) = 2.57, p = .02$). Furthermore, these effects were about the same size for the two groups (as evidenced by the lack of an interaction between the two difference scores above and age), $F(1, 46) = 0.42, \eta^2_p = .01, p = .52$. In other words, younger adults no longer showed larger effects of pair repetition than did older adults when the purer measure was used, which is consistent with evidence that younger and older adults do not differ in their ability to rely on familiarity (Jennings & Jacoby, 1993, 1997).

The only visible age difference in Figure 2A is in the effect of item repetition on the associative test such that younger adults showed increases due to item repetition, $t(23) = 3.73, p = .001$, whereas the older adults did not, $t(23) = 0.63, p = .54$. It should be noted here that both age groups displayed more hits in item repetition conditions than study only in the associative test; however, the older adults also showed more false alarms, whereas the younger adults did not. This suggests that any increases in memory performance that the older adults experienced due to earlier presentation were counteracted by their inability to reject the new pairings composed of formerly presented (i.e., familiar) items. We further investigated this differential age pattern in Experiment 1B.

### Experiment 1B

In Experiment 1A, it was observed that older adults showed an associative deficit relative to the younger adults in the study only condition, which did not involve any repetition; however, one might argue that such a pattern is potentially an artifact of the presentation rate. That is, given Salthouse’s (1996) view that older adults demonstrate a decline in processing speed, it is possible that the presentation time allotted during the study phase was enough for older adults to learn the individual pictures for the item test but was not enough for them to also learn the pairings for the associative test. In order to rule out this possibility, a new group of older adults completed the same tasks as in Experiment 1A with the exception that the current study phase had a presentation rate of 5 s rather than the 3-s rate used in Experiment 1A. If older adults no longer exhibit lower associative than item memory performance, then their associative deficit might be explained by reduced processing time.

A second purpose of Experiment 1B was to further investigate the finding in which younger adults’ associative memory benefited from preexposure of the singletons in the item repetition condition. We originally predicted that, due to increased item familiarity, item repetition should lead to more false alarms to recombined pairs, thereby failing to improve associative memory performance. Whereas older adults demonstrated the predicted increase in false alarms to recombined pairs, younger adults showed no difference in false alarms between the study only and item repetition conditions in Experiment 1A.

One possible explanation for this unexpected result in the younger adults (offered by one of the reviewers of the original manuscript) is that exposure to the singletons at training increased

![Figure 2](image-url)

**Figure 2.** Mean difference scores for the measure proportion hits minus proportion false alarms, reflecting the effect of item repetition (performance in item repetition minus study only conditions) and the effect of pure pair repetition (performance in pair repetition minus item repetition conditions) as a function of age and test for the 3x condition in Experiment 1A (Panel A) and in Experiment 2 (Panel B). Error bars represent standard errors around the mean.
their ability to use associative learning strategies when those singletons later appeared in pairs during the study phase. The reason that older adults did not benefit may again be due to their having a reduced speed of processing. This would mean they did not have enough time to use the same strategies as younger adults did in the 3 s during which each pair was shown at study. If the reason that older adults did not benefit from item repetition in Experiment 1A is simply that they did not have enough time to implement appropriate strategies during the study phase to learn the new pairings for the previously presented singletons, then a longer presentation rate should allow them to take advantage of the type of strategies that the younger adults did, thus enabling the older adults to show a benefit of item repetition in the associative test.

Method

Participants. Twenty-four older adults were recruited from central Missouri. All participants reported being in good physical and mental health. For demographic information, please see Table 1.

Design and materials. These were identical to Experiment 1A.

Procedure. Although the presentation rate for the training phase was the same as it was in Experiment 1A (i.e., 3 s), the presentation rate during each of the four study phases was increased to 5 s per pair. Other than that change, the procedure was identical to that of Experiment 1A.

Results

In order to determine whether having a longer presentation rate eliminated the associative deficit, the older adults in the current experiment were compared with the younger adults in Experiment 1A. A 2 (age) × 2 (test) ANOVA performed on the hit rate revealed no significant interaction, $F(1, 46) = 0.83, \eta^2_p = .02, p = .37$; however, the corresponding two-way ANOVA performed on false alarms did show an interaction of age and test, $F(1, 46) = 17.49, \eta^2_p = .28, p < .001$. Follow-up tests revealed no age differences in the item test, $t(46) = 0.98, p = .33$, but older adults provided more false alarms than did younger adults in the associative test, $t(46) = 3.83, p < .001$. For a more complete picture of the results, the current sample was also compared with the older adults in Experiment 1A. There was a Group × Test interaction in the hit rate, $F(1, 46) = 6.19, \eta^2_p = .12, p = .02$, reflecting that older adults in the current sample scored higher than did their counterparts in Experiment 1A in the associative test, $t(46) = 2.53, p = .02$, but there was no difference on the item test, $t(46) = 0.16, p = .88$. Because older adults in the current sample had a higher level of education than did the older adults in Experiment 1A, a 2 (group) × 2 (test) analysis of covariance (ANCOVA) was performed that included education as a covariate, but the interaction remained, $F(1, 46) = 6.03, \eta^2_p = .12, p = .02$. Turning to the effect on false alarms, a 2 (group) × 2 (test) ANOVA showed no interaction, $F(1, 46) = 0.04, \eta^2_p = .001, p = .84$.

A separate reason for conducting Experiment 1B was to investigate if older adults’ repetition effects would more closely match the patterns of younger adults with a longer presentation rate during the study phase. To this end, the repetition effects seen by older adults in Experiment 1A were contrasted with those of Experiment 1B. The data were analyzed using a 2 (test: item or associative) × 3 (repetition: study only, item repetition, or pair repetition) × 2 (experiment: 1A, 1B) ANOVA on the hit rate. (As in Experiment 1A, the remaining results for the current experiment are limited to the study only vs. 3x conditions.) For brevity, only the effects including the experiment variable are reported here. Results indicate no main effect of experiment, $F(1, 46) = 0.48, \eta^2_p = .01, p = .49$, but experiment did interact with test type, $F(1, 46) = 5.07, \eta^2_p = .10, p = .03$. Specifically, participants in Experiment 1B made marginally more hits in the associative test than did those in Experiment 1A, $t(46) = 1.85, p = .07$, but there were no group differences in the item test, $t(46) = 0.48, p = .64$. Importantly, there was no significant interaction between experiment and repetition, $F(2, 92) = 1.30, \eta^2_p = .03, p = .28$, and no triple interaction, $F(2, 92) = 0.39, \eta^2_p = .008, p = .68$. A three-way ANOVA on false alarms revealed no significant effects involving the variable of experiment (experiment, $F[1, 46] = 1.40, \eta^2_p = .03, p = .24$; Experiment × Test, $F[1, 46] = 0.12, \eta^2_p = .003, p = .73$; Experiment × Repetition, $F[2, 92] = 0.90, \eta^2_p = .02, p = .41$; Experiment × Test × Repetition, $F[2, 92] = 0.66, \eta^2_p = .01, p = .52$; for descriptive statistics, please see Table 3).

Table 3

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</table>

Note. 1x = shown once at training; 3x = shown three times at training; H = proportion hits; FA = proportion false alarms.
Discussion

The results of Experiment 1B do not support the claim that the pattern of older adults’ performance in Experiment 1A can be completely explained by their reduced processing time. When a sample of older adults was given an additional 2 s to learn each pair, they were more likely to correctly recognize intact pairs in the associative test; however, the additional time did not affect their ability to correctly reject the recombined pairs. Because the associative deficit is typically seen more in false alarms rather than hits (Naveh-Benjamin et al., 2009; Old & Naveh-Benjamin, 2008b; M. G. Rhodes et al., 2008) and this pattern was not eliminated, these data do not suggest that the reason for the associative deficit in Experiment 1A can be tied to the presentation rate alone.

As for the item repetition effect shown by the younger adults in the associative test of Experiment 1A, there is no evidence that the lack of effect in the older adults is due to a shortage of study time. The nonsignificant interaction of experiment, test, and repetition shows that increasing the study time for older adults did not change the effect of repetition type in either the item or associative test. Potential mechanisms behind younger adults’ item repetition advantage in the associative test of Experiment 1A are addressed in the General Discussion.

Experiment 2 was designed to explore the mechanism behind the associative memory benefit provided by pair repetition, in both older and younger adults.

Experiment 2

Although efforts were made to ensure that any effect of repetition was driven by item or pair familiarity in Experiment 1A, it remained possible that the pair repetition effects for both younger and older adults observed in Experiment 1A could also be associated with increased recollection. That is, pair repetition could increase the likelihood that participants recollected a specific pair from the training phase rather than from the study phase. For example, suppose that the Pairs A–B and C–D are each shown three times during training and one additional time in a study list. If A–C later appears in the associative test, one could reject it because of a recollection that A was originally presented with B (and/or that C was presented with D). In this situation, there are eight opportunities to use recollection (i.e., three times from the training phase and once from the study phase for A–B and the same for C–D).

The above explanation points to two different levels of recollection in this task. At the micro level, contextual information is needed to remember the corresponding item that appeared with A. At the macro level, contextual information is needed to remember whether the stimuli were presented at training (to be ignored at test) or at study (to be remembered at test). In other words, it is possible that participants can recollect an original pairing without knowing precisely when it appeared during the experiment. If so, the prediction is that increased associative memory performance for the pair repetition condition would be seen within measures of recollection. Therefore, it cannot be said with certainty that effects of repetition in Experiment 1A are completely driven by item and/or pair familiarity alone.

To assess the role of item and pair familiarity and recollection in the effects of pair repetition, Experiment 2 extended the findings of Experiment 1A by including remember–know responses. In the remember–know procedure, measures of familiarity and recollection were computed from participants’ own reports of their phenomenal experience. That is, if they could bring back to mind a recollection of something that occurred at the time the item was encoded, they were instructed to indicate “remember”; if they were merely aware of the item’s prior occurrence, they were instructed to indicate “know” (see Gardiner, Ramponi, & Richardson-Klavehn, 1998; Tulving, 1985). The remember–know paradigm has been widely used, as evidenced in a meta-analysis citing nearly 400 experiments (Rotello, Macmillan, & Reeder, 2004). Furthermore, Yonelinas and Jacoby (1995) have shown convergence between estimates of recollection and familiarity using the remember–know paradigm and the well-established process dissociation procedure.

Because the main question of interest is whether increased associative memory accuracy from repetition can be attributed to pair familiarity or recollection, the accuracies of familiarity- and recollection-based responses were calculated separately and compared. If pure pair repetition increases memory via micro-level recollection, increases in associative test performance from pair repetition should be seen within the remember responses. Alternatively, if pure pair repetition is supported by pair familiarity, then effects of repetition should be observed within the know responses.

Method

Participants. An additional 26 younger adults (ages 18–25) and 25 older adults (ages 67–82) were drawn from the same pools as Experiments 1A and 1B. Younger and older adults did not differ either in gender (the proportion of men was .29 for both younger and older adults) or in years of education, t(49) = 1.29, p > .05 (see Table 1 for demographic information).

Design and materials. These were the same as in Experiment 1A.

Procedure. The procedure was identical to that of Experiment 1A with the exception that remember/know/guess responses were collected for each event presented at test. Instructions for these responses were adapted from Gardiner et al. (1998; see Appendix). Slight modifications were added in order to make the directions clearer for the older adults. Specifically, in place of saying “remember,” participants were asked to say “context” if recognizing a picture in the item test (or a pair in the associative test) triggered a unique thought that occurred when that picture was initially seen at study. Instead of saying “know,” participants said “familiar” to indicate that they were encountering strong feelings of familiarity without any accompanying contextual information. They also said “guess” when relying on chance alone. For each test item, participants were first given unlimited time to indicate “yes” or “no” to a given probe as in Experiment 1A. If they pressed “no,” they would immediately be given the next test stimulus. If they pressed “yes,” then a new screen would ask whether the response was given because of “context,” “familiarity,” or a “guess.” Participants were given unlimited time in providing this second response. As was done in Experiment 1A, prior to beginning each test, participants were reminded to base their responses only on the immediately preceding study list rather than the earlier training phase.
Results

The memory accuracy results closely replicated those obtained in Experiment 1A (see Figure 1B and Table 4). Because the focus of Experiment 2 was to determine the relationship between repetition effects and the participants’ own subjective responses, the results section is dedicated to memory performance as a function of remember and know judgments. Specifically, we wanted to assess whether younger and older participants’ associative memory increase in the pure pair repetition condition occurred when they indicated that their performance was based on familiarity (know response) or on recollection (remember response).4

Memory performance for remember responses only. Percentages of responses categorized as remember, know, or guess were 57, 38, and 5, for the younger adults, and 33, 57, and 10, for the older adults. The accuracy was calculated only for remember responses by taking the proportion correct of all remember responses made. This was the dependent variable used in a 2 (age) × 2 (test) × 3 (repetition) ANOVA (see Figure 3A). Older adults showed overall poorer performance than did the younger adults, F(1, 37) = 45.21, \( \eta_p^2 = .55, p < .001 \), and there was lower accuracy in the associative test than the item tests, F(1, 37) = 23.97, \( \eta_p^2 = .39, p < .001 \). Furthermore, the Age × Test interaction, F(1, 37) = 14.26, \( \eta_p^2 = .28, p = .001 \), showed a pattern reflecting the associative deficit such that general age differences were observed in the associative test, t(47) = 6.04, p < .001, than the item tests, t(44) = 2.41, p = .02. No other effects reached significance (repetition, F[2, 74] = 0.69, \( \eta_p^2 = .02, p = .51 \); Age × Repetition, F[2, 74] = 0.78, \( \eta_p^2 = .02, p = .46 \); Test × Repetition, F[2, 74] = 1.38, \( \eta_p^2 = .04, p = .26 \); Age × Test × Repetition, F[2, 74] = 1.18, \( \eta_p^2 = .03, p = .32 \).5

Memory performance for know responses only. Proportion correct was next calculated for know responses only and used in a 2 (age) × 2 (test) × 3 (repetition) ANOVA (see Figure 3B). This time, there was no main effect of age, F(1, 39) = 1.63, \( \eta_p^2 = .04, p = .21 \), but the associative test yielded higher performance than did the item tests, F(1, 39) = 84.71, \( \eta_p^2 = .69, p < .001 \). Also, the main effect of repetition, F(2, 78) = 3.44, \( \eta_p^2 = .08, p = .04 \), reflected higher performance in pair repetition compared with both study only, t(47) = 3.03, p = .004, and item repetition conditions, t(47) = 2.79, p = .008. The interaction of age and test was significant too, F(1, 39) = 19.70, \( \eta_p^2 = .34, p < .001 \), revealing significant age differences in the associative test, t(47) = 2.02, p = .049, but none in the item tests, t(48) = 0.85, p = .40. The Test × Repetition interaction was also significant, F(2, 78) = 3.13, \( \eta_p^2 = .07, p = .049 \), showing that the effect of repetition was limited to the associative test. More specifically, there was no effect of repetition for the item tests, F(2, 92) = 0.87, \( \eta_p^2 = .02, p = .42 \); however, the associative test indicated higher performance for pair repetition than study only, t(41) = 2.32, p = .025, and item repetition conditions, t(40) = 2.41, p = .021. The remaining effects were nonsignificant (Age × Repetition, F[2, 78] = 0.39, \( \eta_p^2 = .01, p = .68 \); Age × Test × Repetition, F[2, 78] = 1.72, \( \eta_p^2 = .04, p = .19 \)).

Previous experiments have shown that reliance on familiarity is not especially helpful during associative tests (e.g., see Hockley & Consoli, 1999), presumably because familiarity typically consists of knowledge only for the individual components. However, if participants can have familiarity for pairings, then they should show greater than chance-level performance when relying on pair familiarity alone. Although older adults performed no better than chance in study only, t(22) = 1.55, p > .05, and item repetition conditions, t(23) = 0.16, p > .05, pair repetition produced familiarity-based memory scores that were higher than chance, t(21) = 2.43, p < .05.

Memory performance for remember versus know responses. In order to further assess whether recollection or pair familiarity was more sensitive to pair repetition, a 2 (age) × 3 (repetition) × 2 (response type: remember or know) ANOVA was performed for the associative test only. Overall, there was a higher proportion correct for remember than know responses, F(1, 31) = 22.07, \( \eta_p^2 = .32, p < .001 \), a marginal effect of repetition, F(2, 62) = 2.77, \( \eta_p^2 = .08, p = .07 \), and a marginal interaction between repetition and response type, F(2, 62) = 2.66, \( \eta_p^2 = .09, p = .06 \). Because we had a specific directional hypotheses for this interaction, we carried out follow-up tests, which revealed that there was no effect of repetition within remember responses, F(2, 84) = 0.48, \( \eta_p^2 = .01, p = .62 \), but know responses yielded higher memory accuracy in pair repetition conditions compared with both study only, t(41) = 2.32, p = .025, and item repetition, t(40) = 2.41, p = .021. The remaining interactions were nonsignificant (Age × Remember–Know, F[1, 31] = 1.54, \( \eta_p^2 = .05, p = .22 \); Age × Repetition, F[2, 62] = 1.71, \( \eta_p^2 = .05, p = .19 \); Age × Repetition × Remember–Know, F[2, 62] = 0.39, \( \eta_p^2 = .01, p = .68 \)).

Discussion

Many of the results obtained in this experiment are in agreement with the results of Experiment 1A.5 First of all, older adults showed an associative deficit relative to the younger adults in study only conditions. Second, there was a differential effect of repetition such that item repetition especially increased performance in the item tests (in younger adults, t(25) = 3.64, p = .001; in older adults, t(24) = 6.78, p < .001), and pure pair repetition especially increased performance in the associative test (in younger adults, t(25) = 3.42, p = .002; in older adults, t(24) = 3.19, p = .004; see Figure 2B). As in Experiment 1A, there was no interaction between age and these two difference scores, F(1, 49) = 0.19, \( \eta_p^2 = .004, p = .66 \). Third, younger adults displayed

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4 Another option for estimating memory performance would be to calculate proportion hits minus proportion false alarms separately for remember and know responses. That is, proportion hits for remembered events could be calculated as the total number of correct “yes” responses (judged as remember) divided by the total number of targets, and proportion hits for known events could be calculated as the total number of “yes” responses (judged as know) divided by the total number of targets. However, it should be noted that each of these proportions would include information regarding both the accuracy and the frequency of responses. In other words, a score of .3 for remember hits and .5 for know hits would seem to indicate higher accuracy for events judged as known; however, it also indicates that more events were judged as known than remembered. Furthermore, these scores are not independent. Because we were interested in memory accuracy once participants provide a certain response (remember or know), proportion correct was used.

5 A closer inspection of the data reveals some slight inconsistencies between the effects in Experiments 1A and 2, but these differences are considered minor and do not impact the overall interpretation of the results.
positive effects of item repetition in the associative test, \( t(25) = 3.77, \ p = .001 \), but older adults did not, \( t(24) = 0.24, \ p = .82 \).

The primary goal of Experiment 2 was to determine the degree to which the effects of pair repetition (using the current methodology) were mediated by either recollection or pair familiarity. Because there were repetition effects despite instructions to ignore the earlier training phase, one might conclude that participants were relying on pair familiarity to some degree. Alternatively, it is possible that repetition increased the ability to retrieve a micro-level recollection (e.g., A was presented with B) without increasing the ability to retrieve a macro-level recollection (e.g., is A–B remembered from the study or training phase?). If this second alternative is true, then there should be an effect of repetition within measures of recollection. Otherwise, repetition effects should be limited to measures of familiarity.

When looking at accuracy separately as a function of response type, repetition effects were observed only within know responses. Although the lack of effects within remember responses could be at least partially driven by younger adults’ ceiling effects, the statistical analyses indicate that the accuracy of familiarity-based responses is more sensitive to repetition effects than that of the recollection-based responses. For cases in which participants gave know responses, both younger and older adults displayed higher associative memory performance for pair repetition than both item repetition and study only conditions (see Figure 3). Because older adults were at floor in the item repetition condition (.50), it is possible that these data give an underestimation of their pure pair repetition effect.

In summary, these results show that familiarity-based (but not recollection-based) responses led to higher associative memory accuracy for pair repetition than item repetition and study only conditions, indicating positive effects of pure pair repetition. Taken together, these data provide evidence that the effects of pure pair repetition in younger and older adults’ associative memory are driven primarily by pair familiarity.

### General Discussion

Overall, these experiments have demonstrated that older adults’ poor learning and remembering of associations can be improved through the use of pair repetition, and their benefit of pure pair repetition (i.e., the net effects of pair repetition beyond item repetition) was at least as large as that observed in younger adults. Furthermore, pair familiarity alone seems to account for these improvements.

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Table 4

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**Associative test**

Note. 1x = shown once at training; 3x = shown three times at training; H = proportion hits; FA = proportion false alarms.

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It should be noted that even though the training phase occurred prior to all four study-test trials, the repetition effect did not interact with trial order. The data from Experiment 1A were included in a 2 (age) × 3 (repetition: study only, item repetition, or pair repetition) × 2 (order: Trial 1 or Trial 4) ANOVA for associative test performance only. Findings showed no effect for order, \( F(1, 46) = 0.04, \eta_p^2 = .001, \ p = .85 \); Age × Order, \( F(1, 46) = 1.10, \eta_p^2 = .02, \ p = .30 \); Repetition × Order, \( F(2, 92) = 0.71, \eta_p^2 = .02, \ p = .49 \); or a triple interaction, \( F(2, 92) = 1.19, \eta_p^2 = .03, \ p = .31 \). When the same analysis was completed for Experiment 2, order again did not interact with any of the other variables: Age × Order, \( F(1, 49) = 0.68, \eta_p^2 = .003, \ p = .68 \); Repetition × Order, \( F(2, 98) = 2.05, \eta_p^2 = .04, \ p = .13 \); Order × Age × Repetition, \( F(2, 98) = 0.65, \eta_p^2 = .01, \ p = .53 \). However, there was a marginal effect of order, \( F(1, 49) = 3.85, \eta_p^2 = .07, \ p = .06 \), reflecting better overall performance in Trial 4 compared with Trial 1.
Consistent with Light et al. (2004), only younger adults showed a reduction in false alarms in pair repetition compared with study only conditions. However, comparisons between pair repetition and the new item repetition condition showed that older adults displayed at least as large of a reduction in false alarms for pair repetition as did younger adults (and a pattern of a larger reduction for older adults in Experiment 2). These data suggest that the effects of item repetition are especially problematic for older adults’ associative memory (potentially via the increase in item familiarity) and that controlling for these negative effects eliminates the superior advantage7 of repetition in younger adults over the older adults, as shown by Light et al. and by M. G. Rhodes et al. (2008).

When older adults were given additional time for encoding in Experiment 1B, their hit rate increased in the associative test; however, their ability to reject recombined pairs remained impaired, demonstrating that the most typical characteristic of the associative deficit remained. Furthermore, the overall patterns involving repetition were identical between the older adults in Experiments 1A and 1B.

Repetition effects (the effect of pure pair repetition in particular) were shown in the memory accuracy of know (but not remember) responses in Experiment 2 (the results of which replicated most of the major effects of Experiment 1A), suggesting that pair familiarity mediates the effects of repetition. Although we isolated the effects of pair familiarity using the remember–know procedure, there has been some criticism of using this procedure (e.g., Cohen, Rotello, & Macmillan, 2008). However, we argue that the remember–know procedure has shown dissociations between familiarity and recollection in both behavioral conditions (see Gardiner & Richardson-Klavehn, 2000, for a review) as well as in different brain regions (e.g., see a meta-analysis by Kim, 2010) and is a useful tool for discriminating between the two processes. At the same time, we acknowledge that our findings should converge with those of other methods of measurement, like the process-dissociation procedure (Jacoby, 1991).

The finding that pair repetition is supported by pair familiarity indicates that one potential avenue for helping older adults’ associative memory is to increase the familiarity of the pairs in question. By capitalizing on their relatively intact familiarity, it is possible to boost older adults’ associative memory with relatively small effort on their part, as familiarity seems to be based on more automatic mechanisms (see Yonelinas, 2002, for a review). Although studies have shown that older adults benefit from the use of strategies (e.g., see Naveh-Benjamin, Craik, Guez, & Kreuger, 2005), suggesting that in real life, older adults may choose to use a less taxing option for improving their memory performance if available.

Although our findings highlight the fact that repetition increased associative memory, our broader point is that manipulations allowing associative memory to be supported by pair familiarity should lead to equal advantages for younger and older adults, especially because evidence shows that older adults can maintain high levels of familiarity into their mid-80s (Petrian et al., 2010). The current results demonstrate that pair repetition falls into this category; however, there is evidence that other manipulations of unitization (like the use of compound words; see Kounios et al., 2003; Quamme, Yonelinas, & Norman, 2007; S. M. Rhodes & Donaldson, 2007) are also driven by familiarity and should therefore elicit positive effects in older adults’ associative memory. Our results suggest that one way to increase older adults’ associative memory is to alter the way information is presented (potentially creating holistic Gestalt-type episodic conjunctions; see Kahana, 2002), and future research should assess such changes in the representations.

Note that although pair repetition did not eliminate age-related associative memory differences in absolute terms, it did so in relative terms. Relative to their performance levels in the item

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7 The word advantage should be used cautiously, because the instructions in the current experiments were to ignore the training phase. In a sense, showing an increase in performance for repeated information could signify an inability to properly inhibit repetitions from the training phase. Considering that this is at least partially due to a failure of the recollection of source memory, this strengthens the claim that a sizable portion of the effects of repetition observed here are due to effects of item and pair familiarity, in this case, of materials presented in the training phase.
repetition condition (hits minus false alarms averaged over both Experiments 1A and 2), older adults increased their associative memory score in the pair recognition test by 75% (.24 to .42), whereas younger adults increased it by 23% (.65 to .79).

At a theoretical level, our results are in line with local models of memory that suggest that item information and associative information are represented separately, for example, the source of activation confusion (SAC) model (Reder et al., 2000; Reder, Paynter, Diana, Ngiam, & Dickison, 2007). In contrast, global models of memory (e.g., matrix; Humphreys, Bain, & Pike, 1989; MINERVA 2; Hintzman, 1984, 1988) assume that item and associative information are not stored separately. One prediction of local models, like SAC, is that strengthening item information should not necessarily affect associative information. The results of Experiments 1A, 1B, and 2 are in line with this assumption, as they show that strengthening item information (by a repetition manipulation) does not necessarily strengthen associative information (at least not in older adults). Furthermore, these experiments show that strengthening associative information (by a pure pair repetition manipulation) selectively affects associative but not item information (in both younger and older adults).

Very recently, Overman and Becker (2009) reported that repetition of pairs did not improve older adults’ associative memory when compared with repetition of items, which differs from the present experiments. The likeliest explanation for this discrepancy is that Overman and Becker repeated information only once, whereas information was repeated three times in Experiments 1A, 1B, and 2 of the current article. Support for this explanation can be obtained from the 1x condition in the current results. Although the 1x condition was excluded from most of the analyses, its means shown in Tables 2–4 indicate that there was no positive effect of pure pair repetition on the associative test in older adults. Furthermore, the results of Overman and Becker show that younger adults benefited from pair repetition (as reflected in their hit rate but not in their false alarm rate), and this result is similar to the patterns for younger adults in the 1x condition of the current set of experiments. Apparently, to achieve beneficial effects on associative memory via pure pair repetition, materials have to be repeated more than once. One potential reason for the need of several repetitions is related to the above discussion on unitization; in order to unitize a pair, there should be enough repetitions to create and strengthen intraitem organization (Mandler, 1979).

In conclusion, Experiments 1A, 1B, and 2 indicate that the manipulation of pair repetition (and the assessment of its pure effects, after item repetition effects were taken into account) was successful in increasing the associative memory performance of older and younger adults and was supported by pair familiarity.

References

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(Appendix follows)
Appendix

Remember–Know Instructions Used in Experiment 2

Recognition memory is associated with two different kinds of awareness: recollection and familiarity. Quite often, recognition can trigger the recollection of thoughts or events that accompany what is actually being recognized; other times, recognition is driven by a feeling of familiarity.

- Example 1: When you recognize someone’s face, you might recollect the context in which you spoke to this person at a party the previous night.
- Example 2: When you recognize someone’s face, you might not be able to remember the context. However, you are very confident in your recognition and have a very strong feeling of familiarity.

The same kinds of awareness can be associated with recognizing pictures in the current study. Sometimes recognizing a picture (or pair of pictures) might cause you to remember something you were thinking about when it was originally studied. In this case, you are recollecting the context that you experienced at the time of study. Other times, you might recognize an event without remembering the context surrounding it. Instead, the event will seem familiar, and you may feel confident that you studied it, but you will not recollect anything specific that you experienced during its earlier presentation.

For each picture or pair that you recognize during test, you will need to reveal whether you are recollecting the context, if it is simply familiar, or if you are guessing.

When the computer screen says “How do you recognize it?”, you can respond by saying one of the following:

- Context—seeing the picture or pair triggers a unique memory that occurred during study.
- Familiar—you are confident that you saw the picture or pair, but you are not sure why.
- Guess—you believe there is a 50/50 chance that you are correct.

If you are leaning towards an answer at all, please do not respond by saying guess.

Also, please note that these are not confidence ratings. That is, using “context” as a response does not necessarily mean that you are more confident than when using a “familiar” response—“context” simply means that another thought has been triggered by the event.

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