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# Associative Recognition of Face Pairs by Younger and Older Adults: The Role of Familiarity-Based Processing

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Previous research suggested that older adults have a specific impairment in remembering verbal associative information, but it is unclear how elaboration and familiarity might influence this deficit in situations that involve perceptual processing. In the present experiments, younger and older participants studied male–female pairs of faces. Participants were then administered an associative recognition test consisting of previously studied pairs, pairs that contained previously studied items that were not studied together (i.e., conjunction pairs), and entirely new pairs of faces, and participants were instructed to identify pairs that had been presented together at study. Overall, participants were successful at recognizing previously presented pairs but were highly likely to mistakenly endorse conjunction pairs. This pattern was more pronounced for older adults, especially when items were repeated at encoding. Such data suggest that memory for face pairs relies largely on the familiarity of each face and not on a more precise recollection of associative information.

*Keywords:* memory, memory and aging, associative recognition, face recognition, recollection and familiarity

Memories for complex events involve the integration of multiple units of information. For example, memories often contain contextual details, such as the time and place where an event occurred, which are bound together to form an integrative memory. A number of researchers have suggested that age-related differences in episodic memory are primarily characterized by deficits in memory for such associative information rather than by the individual components that comprise a memory (e.g., Chalfonte & Johnson, 1996; Naveh-Benjamin, 2000; Naveh-Benjamin, Hussain, Guez, & Bar-On, 2003). In particular, these theories hold that older adults are less able than are younger adults to create and retrieve connections that link individual units of information, with this associative deficit leading to impairments in episodic memory. However, identifying the specific mechanism(s) involved in this binding process remains elusive, and mechanisms range from differences in self-initiated (Craik, 1982) or elaborative processing of verbal materials to changes in hippocampal volume and efficiency (Spencer & Raz, 1995; Vargha-Khadem et al., 1997).

The evidence for such an associative deficit or impairment in older adults comes from several sources. For example, Chalfonte and Johnson (1996) had younger and older adults study items in a visual array presented in different colors or different locations. Although age differences in memory for the items were not apparent, older adults performed more poorly than did younger adults when tested on their memory for item-location or item-color information. Naveh-Benjamin (2000) further explored these binding deficits by presenting younger and older adults with lists of unrelated word pairs. Participants were later administered tests of their memory for the individual items in the pairs (i.e., an item recognition test) and for the pairs themselves (i.e., an associative recognition test). The associative recognition test required participants to distinguish between items that had been presented together and conjunctions of items that had been studied previously but in different pairs. Results showed that although younger and older adults differed little on the item recognition test, robust age differences were apparent on the associative recognition test, as older adults were much more likely than were younger adults to falsely endorse conjunction pairs.

Subsequent research has supported the idea that older adults exhibit deficits in memory for associative information (e.g., Bastin & Van der Linden, 2006; Castel & Craik, 2003; Light, Patterson, Chung, & Healy, 2004; Naveh-Benjamin, Guez, Klib, & Reedy, 2004a; Naveh-Benjamin, Guez, & Shulman, 2004). However, the majority of the research has required participants to remember arbitrarily paired units of information, such as unrelated words (but see, e.g., Castel, 2005; Naveh-Benjamin, Guez, Klib & Reedy, 2004). Although in some research aging and binding visual information in terms of attentional control and associative memory have been investigated (e.g., Madden, 2007, see also Ryan, Leung,

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Turk-Browne & Hasher, 2007), in these studies, the potential role of familiarity-based processing and its relation to older adults' conjunction errors in associative memory tasks that involve higher level perceptual information (e.g., pairs of faces) have not been examined. Given that associative deficits are apparent in a variety of domains, it is important to further elucidate how different kinds of materials give rise to processes that contribute to associative deficits (cf., Bastin & Van der Linden, 2006).

The current study was conducted with the goal of examining whether associative recognition deficits in older adults would apply to memory for pairs of faces. Several studies of this nature have been conducted with younger adults (e.g., Bower & Karlin, 1974, Exp 3; Watkins, Ho, & Tulving, 1976; Winograd, & Rivers-Bulkeley, 1977). However, we know of only two experiments in which older adults' associative recognition memory using face stimuli have been examined. Naveh-Benjamin, Guez, Klib, and Reedy (2004a) had younger and older adults study faces paired with names and found that associative recognition of face–name combinations was worse for older than for younger adults, despite relatively equivalent levels of memory for faces or names alone. Bastin and Van der Linden (2006) presented participants with pairs of faces, followed by a forced-choice associative recognition test (i.e., participants chose which of two faces was paired with a target face). Older adults were significantly poorer than were younger adults at choosing which face was part of a studied pair. However, given that a forced-choice procedure was used, these data do not permit an assessment of how familiarity might contribute to false alarms to conjunction pairs, which is critical for understanding the mechanisms that underlie the associative deficit. For example, dual-process theories of age-related decrements in associative recognition performance propose that older adults primarily rely on familiarity to make memory judgments in the relative absence of recollection for the specific pair that was studied together (Healy, Light, & Chung, 2005; Light et al., 2004; see also Jacoby, 1999). Thus, performance is best assessed by comparing recognition for intact versus conjunction pairs. That is, given that both types of pairs are composed of items that were studied (and should be equally familiar), only recollection of the specific pair allows one to distinguish between intact and conjunction pairs.

In the current study, we examined associative recognition performance in older and younger adults with pairs of faces. Specifically, younger and older adults studied pairs of faces, presented as male–female married couples, followed by an associative recognition test consisting of intact, conjunction, and entirely new pairs. Thus, we examined whether the widely reported associative recognition deficit evident for older adults generalizes to such materials. In addition, we manipulated the age of the individuals presented in the photos that were studied. Several researchers have reported an own-age bias (e.g., Anastasi & Rhodes, 2005; Perfect & Harris, 2003) for item recognition, such that recognition is better for individuals of one's own age group compared with individuals from other age groups. Associative recognition may similarly vary as a function of the age of the couples presented at encoding, with both age groups showing a memory benefit for their own target age group.

Participants in Experiment 1 were simply instructed to remember pairs of faces for a forthcoming test of memory for the pairs. Results from Experiment 1 indicated that participants' associative recognition performance, especially that of older adults, was quite poor, characterized by high levels of false alarms to conjunction pairs. The remaining experiments were conducted in an effort to understand the source of these effects. Participants in Experiment 2 were permitted to self-pace their encoding and study each pair for as long as deemed necessary to remember the pair for a later test. Finally, we tested a familiarity-based account of these data in Experiment 3 by manipulating item repetition.

## Experiment 1

In Experiment 1 participants studied male–female pairs of faces that they were to regard as married couples. Following the study phase, participants were administered a test of associative recognition that included pairs that had been studied together, conjunctions of faces that had been studied in different couples, and entirely new couples. Thus, Experiment 1 provides a test of the generality of associative recognition deficits previously reported for older adults.

### Method

*Participants.* Participants consisted of 30 younger and 29 older adults recruited from the Washington University psychology department participant pool (1 older adult was excluded from the original sample of 30 for failure to follow directions). Characteristics of the participants in this and subsequent experiments are presented in Table 1. Younger adults participated for course credit or for pay ($10). Older adults were paid ($10 per hour) for their participation. All participants were tested individually.

*Materials and design.* Materials consisted of 70 high-resolution, neutral-pose color photographs of faces taken from Minear and Park (2004). Thirty-four of the photographs selected were of older adults ($M_{\text{age}}$ = 74.65 years) and 36 were of younger adults ($M_{\text{age}}$ = 22.41 years), with equal numbers of photographs of males and females selected from each age group. Photographs were edited with Adobe Photoshop (Version 9.0) software to remove all extraneous jewelry and to crop each photograph such that only the face (and not the shoulders or clothing) was visible. Each face was paired with a photograph of an individual of the opposite gender and same age group to create 35 face pairs in total, 17 pairs consisting of faces of older adults and 18 pairs consisting of faces of younger adults (the additional younger pair served as a new pair on the practice test). Pairs of faces consisted of two photographs presented next to each other. All photographs were approximately 265 × 200 pixels in size and filled the width of the screen when presented side-by-side in a pair.

The study list consisted of 20 pairs of faces, with half of the pairs consisting of older individuals and half of younger individuals. Two additional pairs of faces were presented at the beginning and end of the study list to serve as primacy and recency buffers (with an older and younger couple presented in each buffer). Study pairs were presented in a fixed random sequence with the condition that no more than three pairs of the same age were presented consecutively.

The test list consisted of 30 pairs of faces, divided evenly among intact, conjunction, and new pairs. Intact pairs consisted of previously studied pairs. Conjunction pairs were created by re-pairing faces that had been studied previously, in different pairs, with the constraint that the re-pairing must create a male–female couple from the same age group. New pairs consisted of pairs of faces that had not been previously studied. Assignment to conditions was

Table 1
*Characteristics of the Younger and Older Adults Tested in Experiments 1–3*

| | Age | | Education | | Vocabulary | | *n* | |
|---|---|---|---|---|---|---|---|---|
| Age group | *M* | *SD* | *M* | *SD* | *M* | *SD* | Women | Men |
| Experiment 1 | | | | | | | | |
| Older adults | 73.96 | 6.22 | 14.05 | 2.24 | 34.79 | 3.74 | 21 | 8 |
| Younger adults | 19.43 | 1.28 | 13.58 | 1.48 | 33.43 | 2.63 | 22 | 8 |
| Experiment 2 | | | | | | | | |
| Older adults | 73.25 | 5.56 | 14.79 | 3.88 | 33.33 | 5.59 | 18 | 6 |
| Younger adults | 20.08 | 1.25 | 13.69 | 1.30 | 34.46 | 2.47 | 14 | 10 |
| Experiment 3 | | | | | | | | |
| Older adults | 75.83 | 6.16 | 15.12 | 2.57 | 33.53 | 3.88 | 24 | 6 |
| Younger adults | 19.77 | 1.14 | 13.93 | 1.08 | 32.93 | 2.90 | 19 | 11 |

*Note.* Age and education are in years. Vocabulary score is the Shipley–Hartford Vocabulary score out of a maximum score of 40.

counterbalanced such that each face was equally often part of an intact, conjunction, or new pair. All items were presented in the test phase in the same pose in which they had been studied.

*Procedure.* All study and test stimuli were presented centered vertically on a white background on an IBM-compatible computer, side-by-side. After providing informed consent, participants began the study phase of the experiment. Participants were instructed that they would study pairs of faces that should be regarded as married couples. They were further instructed that they would later be tested and that they should attempt to remember each couple such that if shown the face of one member of the couple they would be able to identify the other. Each face pair was presented for 4 s with a 500 ms interstimulus interval.

Immediately following the study phase, participants were given instructions for the test phase of the experiment. Participants were instructed that they would view pairs of faces and decide whether a pair was presented together as a married couple in the first part of the experiment. For pairs that had been presented together in the study phase, participants were instructed to identify the couple as together. For pairs consisting of faces that had been presented in the study phase but in different couples, participants were instructed to identify the couple as separate. Finally, participants were instructed to identify couples that had not been presented in the study phase of the experiment as new. Participants responded aloud and their responses were recorded by an experimenter. A three-item practice test was administered prior to beginning the real test in order to familiarize participants with the test procedure. The practice test consisted of one intact pair, one conjunction pair, and one new pair (the additional younger adult pair), with faces for the intact and conjunction pairs taken from the primacy and recency buffers. In addition, two of the pairs of faces presented for the practice test were of younger adults. Following completion of the practice test, participants began the real test. Test pairs were presented in a fixed random order with the constraint that pairs of the same age were not presented consecutively more than three times. After completing the test phase, participants were administered the 40-item Shipley–Hartford Vocabulary Test (Shipley, 1940), debriefed, and thanked for their participation. The experiment took approximately 20 to 30 min to complete.

### Results

The proportion of intact (i.e., "together") responses to intact, conjunction, and new pairs in Experiment 1 are presented in Table 2. Inspection of these data indicate that both older and younger adults frequently endorsed conjunction pairs as having been presented intact, with younger adults exhibiting better discriminability. This was confirmed in a 2 (age group: younger, older) × 2 (item type: intact, conjunction) × 2 (face age: younger, older) mixed-factor analysis of variance (ANOVA) on the proportion of intact responses to intact and conjunction pairs. Specifically, participants were significantly more likely to endorse intact ($M = .69$) than conjunction ($M = .50$) pairs, $F(1, 57) = 56.10$, $\eta_p^2 = .50$ (the alpha level for all statistical tests reported was set to .05). The proportion of intact responses did not vary on the basis of face age ($F < 1$) and, overall, older adults ($M = .65$) made more intact responses than did younger adults ($M = .55$), $F(1, 57) = 5.92$, $\eta_p^2 = .09$. A significant Age Group × Item Type interaction was also present, $F(1, 57) = 10.12$, $\eta_p^2 = .15$. Follow-up tests confirmed that older adults ($M = .59$) were significantly more likely to endorse conjunction pairs than were younger adults ($M = .41$), $F(1, 57) = 13.32$, $\eta_p^2 = .19$. In contrast, older ($M = .70$) and younger ($M = .69$) adults endorsed intact pairs approximately equally often ($F < 1$). No other reliable interactions were evident.

Such data suggest that participants in both age groups had difficulty distinguishing between intact and conjunction pairs, with younger adults exhibiting higher levels of discriminability than did older adults. We examined this formally by calculating measures of discriminability ($d'$) for intact versus conjunction pairs (see the far right column of Table 2). These data were subjected to a 2 (age group: younger, older) × 2 (face age: younger, older) mixed-factor ANOVA. Results showed that younger adults ($M = 0.68$) demonstrated reliably higher levels of discriminability than did older adults ($M = 0.27$), $F(1, 57) = 9.85$, $\eta_p^2 = .15$. Discriminability did not vary as a function of face age, $F(1, 57) = 1.56$, $p = .22$, $\eta_p^2 = .03$, nor did face age interact with age group, $F(1, 57) = 2.26$, $p = .14$, $\eta_p^2 = .04$.

Table 2
*Proportion Called Intact in Experiments 1 and 2, by Participant Age and Age of Couple in Photos*

| | Intact | | Conjunction | | New | | *d′* | |
|---|---|---|---|---|---|---|---|---|
| Age group | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* |
| Experiment 1 | | | | | | | | |
| Older adults | | | | | | | | |
| Older couple | .72 | .17 | .61 | .25 | .19 | .21 | 0.29 | 0.55 |
| Younger couple | .68 | .23 | .57 | .24 | .17 | .18 | 0.26 | 0.60 |
| Younger adults | | | | | | | | |
| Older couple | .65 | .24 | .44 | .24 | .15 | .19 | 0.52 | 0.78 |
| Younger couple | .73 | .22 | .39 | .31 | .06 | .11 | 0.85 | 0.76 |
| Experiment 2 | | | | | | | | |
| Older adults | | | | | | | | |
| Older couple | .76 | .22 | .63 | .25 | .21 | .24 | 0.33 | 0.63 |
| Younger couple | .78 | .24 | .60 | .28 | .16 | .24 | 0.47 | 0.67 |
| Younger adults | | | | | | | | |
| Older couple | .66 | .22 | .45 | .22 | .08 | .13 | 0.53 | 0.78 |
| Younger couple | .84 | .24 | .41 | .29 | .01 | .04 | 1.13 | 1.12 |

*Note.* $d'$ = discriminability for intact versus rearranged pairs.

### *Discussion*

Results from Experiment 1 showed that both older and younger adults had difficulty distinguishing intact from conjunction pairs, evident in the relatively low levels of discriminability and high levels of incorrect, intact responses to conjunction pairs exhibited by both groups. However, younger adults demonstrated better associative memory than did older adults. In particular, younger adults were less likely to incorrectly endorse conjunctions than were older adults and also demonstrated significantly higher levels of discriminability than did older adults. Thus, older adults demonstrated deficits in associative recognition performance similar to those reported with more typical materials, such as unrelated word pairs (e.g., Castel & Craik, 2003; Naveh-Benjamin, 2000).

One possible reason for the poor levels of associative recognition performance is that the materials used do not easily lend themselves to the type of elaboration that supports associative recognition performance (cf. Rhodes & Kelley, 2003, Experiment 4). In experiments similar to the current ones, but not reported here, we attempted to examine this by explicitly requiring participants to process each face pair in an evaluative (i.e., deep) manner.[1] Participants in one experiment judged which member of a couple might be dominant in decision making, whereas participants in another experiment judged whether each couple appeared to be happy or unhappy. Prior work examining single-item recognition has shown that evaluating personality characteristics produces superior performance compared with evaluating physical characteristics of faces (e.g., Bloom & Mudd, 1991; see Coin & Tiberghien, 1997, for a review). However, we found little or no improvement in associative recognition performance when such judgments were required (but see Naveh-Benjamin, Brav, & Levy, 2007), suggesting that elaborative encoding of pairs of faces may be difficult. Part of this may be due to the fact that participants were afforded relatively little time (4 s) at encoding. We addressed this issue in Experiment 2 by permitting participants to self-pace their encoding time.

## Experiment 2

Findings from Experiment 1 showed that younger and, to a greater extent, older participants have considerable difficulty distinguishing between face pairs presented together and conjunctions of faces that were previously studied. In Experiment 2, we examined whether this was due to the amount of time participants were given during encoding. Thus, whereas participants in the first experiment were given only 4 s to encode each pair of faces, participants in Experiment 2 were permitted to self-pace their encoding, with instructions to study the faces for as long as they deemed necessary to later remember each pair. If encoding of face pairs is sensitive to the amount of time permitted, associative recognition performance should improve compared with previous experiments.

In addition to their recognition judgment, we also asked participants in Experiment 2 to make judgments of their confidence that a pair was studied together. Prior work with younger adults indicates that associative recognition judgments are more often accompanied by recollective details than are item recognition judgments, presumably because item recognition judgments rely to a larger degree on familiarity (Hockley & Consoli, 1999). The high level of false alarms to conjunction pairs in Experiment 1 suggests that participants may be relying on familiarity accrued from a prior presentation to make recognition judgments and not relying on recollection of the specific pair that was studied. If that is the case, one might expect endorsements of conjunctions to be held with similar levels of confidence as correct intact responses. In addition, the relation between confidence and accuracy might vary as a function of age. For example, Kelley and Sahakyan (2003; see also Rhodes & Kelley, 2005) have suggested that older adults exhibit less correspondence between confidence and accuracy because

[1] The reader may contact Matthew G. Rhodes for a full description and analyses of these experiments.

they rely on more impoverished memorial information than do younger adults to make confidence judgments. Thus, older adults in Experiment 2 may be more prone to reporting high levels of confidence in errors (e.g., intact responses to conjunctions) than are younger adults.

### Method

*Participants.* Participants consisted of 24 younger and 24 older adults recruited from the same source and compensated in the same manner as those tested in the previous experiments.

*Materials and design.* The materials and design used in Experiment 2 were identical to those used in Experiment 1.

*Procedure.* The procedure used in Experiment 2 was identical to that used in Experiment 1, with two exceptions. First, rather than studying items at a fixed rate, participants were instructed to study each pair for as long as they felt was necessary to later remember the pair. Participants were instructed to press the space bar when they were done studying a pair, and encoding time was recorded as the time to press the space bar for each pair. Second, following each recognition judgment, participants were asked to rate their confidence that a pair was studied intact on a scale from 0–100. Specifically, participants were instructed to use high levels of confidence for items that they were confident were presented intact and low levels of confidence for items that were not presented intact. For example, participants were told that if they were absolutely sure that two items were not presented together, they should respond with a confidence rating of zero. In contrast, if they were absolutely sure that two items were presented together, they should make a confidence rating of 100. Participants practiced making confidence judgments during the practice test trials and did not proceed to the test phase until the experimenter was certain that the participant understood the confidence scale.

### Results

*Encoding time.* We first review data on mean self-paced encoding time prior to examining associative recognition data from Experiment 2.[2] Older adults spent more time studying older ($M$ = 11,931 ms; $SD$ = 8,284 ms) than younger ($M$ = 11,262 ms; $SD$ = 7,337 ms) face pairs, but this difference was not reliable, $F(1, 23) = 1.77$, $p = .20$, $\eta_p^2 = .07$. Younger adults spent roughly equivalent amounts of time studying older ($M$ = 8,423 ms; $SD$ = 4,639 ms) and younger ($M$ = 8,406 ms; $SD$ = 4,409 ms) face pairs ($F < 1$). A 2 (age group: younger, older) × 2 (face age: younger, older) mixed-factor ANOVA on mean encoding time showed that older adults ($M$ = 11,597) had longer encoding times than did younger adults ($M$ = 8,414), a difference that was marginally reliable, $F(1, 46) = 3.05$, $p = .09$, $\eta_p^2 = .06$. Encoding time did not differ on the basis of face age, $F(1, 46) = 1.46$, $p = .23$, $\eta_p^2 = .03$, nor did face age interact with age group, $F(1, 46) = 1.32$, $p = .26$, $\eta_p^2 = .03$. However, most importantly, results showed that the average encoding time was considerably longer than the 4 s provided in the previous experiments, confirmed for each group by a one-sample $t$ test with a comparison value of 4,000 ms ($t$s ≥ 4.82).

*Associative recognition.* The proportion of intact responses to intact pairs, conjunction pairs, and new pairs in Experiment 2 are presented in Table 2. As in Experiment 1, participants frequently endorsed conjunction pairs, with this pattern more pronounced for older adults. Analyses of intact responses to intact and conjunction pairs showed that participants were more likely to endorse intact ($M$ = .76) than conjunction ($M$ = .52) pairs, $F(1, 46) = 66.28$, $\eta_p^2 = .59$, and that the proportion of intact responses did not differ on the basis of face age ($F < 1$). In addition, older adults ($M$ = .69) called significantly more pairs intact than did younger adults, ($M$ = .59), $F(1, 46) = 5.95$, $\eta_p^2 = .12$. A significant Item Type × Age Group interaction was also present, $F(1, 46) = 8.16$, $\eta_p^2 = .15$. In particular, whereas older ($M$ = .77) and younger ($M$ = .75) adults endorsed intact pairs with relatively equal frequency ($F < 1$), older adults ($M$ = .62) were far more likely to endorse conjunction pairs than were younger adults ($M$ = .43), $F(1, 46) = 12.42$, $\eta_p^2 = .21$. A marginal Item Type × Face Age interaction was also present, $F(1, 46) = 4.02$, $p = .05$, $\eta_p^2 = .08$. Specifically, for intact pairs, participants endorsed significantly more younger ($M$ = .81) than older ($M$ = .70) face pairs, $F(1, 46) = 5.63$, $\eta_p^2 = .11$. In contract, no difference existed for conjunction pairs ($F < 1$). All other interactions were not reliable, $F$s$(1, 46) \leq 1.39$, $p$s ≥ .24.

Analyses of discriminability ($d'$) estimates (far right column of Table 2) for intact pairs, compared with conjunction pairs, showed that both groups exhibited moderate levels of discriminability, with younger adults ($M$ = 0.83) demonstrating better discriminability than did older adults ($M$ = 0.40), $F(1, 46) = 7.65$, $\eta_p^2 = .14$. Discriminability was also significantly better for younger ($M$ = 0.80) than for older ($M$ = 0.43) face pairs, $F(1, 46) = 4.32$, $\eta_p^2 = .09$. Age group did not interact with face age, $F(1, 46) = 1.66$, $p = .20$, $\eta_p^2 = .04$.

*Confidence data.* We examined confidence in intact responses (see Table 3) in a 2 (age group: younger, older) × 2 (item type: intact, conjunction) × 2 (face age: younger, older) mixed-factor ANOVA.[3] Results showed that confidence in intact responses to intact pairs ($M$ = 80.44) was reliably higher than was confidence in conjunction pairs ($M$ = 72.03) that were also endorsed, $F(1, 40) = 24.26$, $\eta_p^2 = .38$. Confidence did not vary on the basis of age group ($F < 1$), but participants exhibited higher levels of confidence in intact responses to younger ($M$ = 79.34) than to older ($M$ = 73.13) face pairs, $F(1, 40) = 13.03$, $\eta_p^2 = .25$. Item type did not interact with age group ($F < 1$) or face age, $F(1, 40) = 1.93$, $p = .17$, $\eta_p^2 = .05$, nor was the triple interaction of item type, face age, and age group reliable ($F < 1$). A trend for a Face Age × Age Group interaction was present but not reliable, $F(1, 40) = 2.99$,

[2] The pattern of data reported was identical when median encoding times were examined.

[3] Data for intact responses to new pairs were excluded from this analysis, as such responses were less frequent than were intact responses to intact and conjunction pairs. Six participants were excluded from the analyses reported. One younger participant did not endorse a single conjunction pair consisting of older adults, 3 younger participants did not endorse a single conjunction pair consisting of younger adults, and 1 younger participant did not endorse a single conjunction pair. In addition, 1 older participant did not endorse a single conjunction pair consisting of younger adults. Analyses were conducted that included these participants (with the exception of the single younger participant who did not endorse any conjunction pairs) and collapsed across face age. Overall, participants made reliably higher confidence judgments for intact ($M$ = 80.62) pairs than for conjunction ($M$ = 70.69) pairs that were called intact, $F(1, 45) = 33.66$, $\eta_p^2 = .43$. Confidence did not vary on the basis of age group ($F < 1$), nor did age group interact with item type ($F < 1$).

Table 3
*Confidence in Intact Responses in Experiment 2, by Participant Age and Age of Couple in Photos*

| | Intact | | Conjunction | | New | |
|---|---|---|---|---|---|---|
| Age group | *M* | *SD* | *M* | *SD* | *M* | *SD* |
| Older adults | | | | | | |
| Older couple | 80.16 | 16.81 | 67.47 | 21.66 | 57.08 | 24.82 |
| Younger couple | 79.34 | 17.67 | 75.85 | 19.06 | 71.17 | 18.11 |
| Younger adults | | | | | | |
| Older couple | 76.73 | 10.83 | 66.19 | 14.73 | 55.94 | 11.01 |
| Younger couple | 84.35 | 9.34 | 76.75 | 13.57 | 50.00 | — |

*Note.* Dash indicates that only one participant made an intact response to a new face pair with younger couples, thus, a measure of variability is not applicable.

$p = .09$, $\eta_p^2 = .07$. Thus, both older and younger adults exhibited greater confidence in correct, intact responses than in false alarms to conjunction pairs.

### Discussion

Results from Experiment 2 showed that permitting participants to self-pace encoding had only a modest effect on associative recognition performance. In particular, both groups continued to exhibit high levels of false alarms to conjunction pairs, with younger adults showing better discriminability than shown by older adults. Such data beg the question of why associative recognition performance was relatively poor across each of the experiments reported thus far. We suggest that the high levels of false alarms to conjunction pairs implicate a reliance on familiarity as a basis for recognition decisions, particularly for older adults. Experiment 3 provides a more direct test of this account.

## Experiment 3

Results from the prior experiments have been consistent in showing high levels of false alarms to conjunctions of faces that were previously studied in other pairs. Such data suggest that recognition decisions were largely guided by the familiarity derived from a prior presentation of a face rather than from a specific memory of the particular pair in which a face was presented. This idea is consistent with dual-process theories of memory (e.g., Jacoby, 1991). Dual-process theories hold that memory judgments can be accomplished with a consciously controlled process of recollection that can be distinguished from more automatic bases for memory, in which memory judgments rely on familiarity of information coming to mind. From this perspective, false alarms to conjunction pairs reflect the influence of familiarity for individual faces of a pair in the absence of sufficient recollection to determine the context in which a face was presented. The higher level of false alarms to conjunction pairs apparent for older adults likewise suggests that their recognition decisions were based on familiarity to a greater extent than were those of younger adults (see also Jacoby, 1999; Light, Prull, La Voie, & Healy, 2000)

We tested this account in Experiment 3 by manipulating the familiarity of face pairs presented at study. In particular, half the face pairs studied were presented one time, and half were presented four times each. At test, participants judged intact and conjunction pairs composed of faces presented either one time or four times, along with entirely new pairs (cf., Jacoby, 1999; Light et al., 2004). If recognition decisions are largely driven by familiarity, particularly for older adults, then false alarms should be highest for conjunctions composed of faces presented four times rather than for conjunctions composed of faces presented one time. That is, if older adults' judgments are primarily based on the strength derived from a previous presentation and not memory for the context in which a face was presented, false alarms should be positively related to the number of times a face was presented. In contrast, younger adults might be better able to recollect the prior presentation of a pair, with their ability to recollect an item in context increasing with repetition. This suggests that younger adults would be able to offset the effects of increased familiarity by means of recollection and would exhibit fewer false alarms to conjunctions of repeated items.

Light et al. (2004) reported data consistent with this prediction. In particular, those researchers had older and younger adults study word pairs presented one time or four times. Participants were then administered an associative recognition test that included conjunctions of items that had been presented one time or four times in different pairs. Results showed that younger adults were less likely than were older adults to endorse conjunction pairs consisting of repeated items, with older adults exhibiting high levels of false recognition for conjunction pairs consisting of repeated items. This likely occurred because older adults could not counter the increase in familiarity accrued by repetition with a specific recollection of an item's occurrence within a pair.

To summarize, participants in Experiment 3 studied pairs of faces presented either one time or four times. They were then administered a test of associative recognition in which intact and conjunction pairs consisted of faces presented one time or four times. On the basis of prior data (Light et al., 2004), we expected that older adults would be more likely to mistakenly endorse conjunction pairs consisting of repeated items than those consisting of faces presented only one time, with this pattern less pervasive for younger adults. Such data would suggest that familiarity guided responses to a greater extent for older adults than for younger adults.

### Method

*Participants.* Participants consisted of 30 younger and 30 older adults recruited from the same source and compensated in the same manner as those tested in the previous experiments.

*Materials and design.* The materials used consisted of 106 photographs of faces taken from the same source (i.e., Minear & Park, 2004) used for the previous experiments and formatted in the same manner. Eight of these photographs served as pairs presented in the primacy or recency phase of the experiment, and two photographs served as a new pair on the practice test. The remaining 96 photographs (half consisting of older adults, half consisting of younger adults) served as items presented in the study or test phase. As in previous experiments, each face was paired with a photograph of an individual of the opposite gender and of the same age group, creating 48 face pairs in total. These were further divided into three sets of 16 face pairs that served equally often as intact, rearranged, or new pairs at test. In addition, within each set of 16 faces, half of the pairs were presented four times during the study phase, and half were presented one time during the study phase, with presentation four times or one time counterbalanced across participants.

The study list consisted of 80 pairs of faces, with 16 pairs presented four times each and 16 pairs presented one time. Half of the pairs consisted of older individuals, and half consisted of younger individuals. Study items were presented in a fixed random sequence, with the condition that no more than 3 pairs of the same type (i.e., younger or older face pair) were presented consecutively. For pairs presented four times each, an average of 18.96 pairs ($SD$ = 2.45) intervened between each presentation of a particular pair (range = 6–33). The test list consisted of 48 pairs of faces, divided evenly among intact, conjunction, and new pairs. Half of the intact pairs consisted of faces presented four times during the study phase, and half consisted of faces presented one time during the study phase. Likewise, half of the conjunction pairs consisted of photos that had each been studied four times in different pairs, and half consisted of photos that had each been studied one time in a different pair. Thus, each face in intact and conjunction pairs had always been presented an equal number of times.

*Procedure.* The procedure was identical to that used in Experiment 2, with the exception that a fixed presentation rate (4 s) was used.

## Results and Discussion

*Associative recognition.* The proportion of intact responses to intact pairs, conjunction pairs, and new pairs in Experiment 3 are presented in Table 4. Data for intact responses to intact pairs and conjunction pairs were examined in a 2 (age group: younger, older) × 2 (item type: intact, conjunction) × 2 (face age: younger, older) × 2 (repetition: one time, four times) mixed-factor ANOVA. Because all main effects and lower order interactions are subsumed by a reliable four-way interaction, $F(1, 58) = 4.64$, $\eta_p^2 = .07$, we focus exclusively on that higher order interaction.

Table 4
*Proportion Called Intact in Experiment 3, by Participant Age, Age of Couple in Photos, and Repetition*

| | Intact | | Conjunction | | New | | $d'$ | |
|---|---|---|---|---|---|---|---|---|
| Age group | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* |
| Older adults | | | | | | | | |
| Older couple | | | | | .24 | .21 | 0.06 | 0.47 |
| 1× | .48 | .29 | .50 | .31 | | | | |
| 4× | .86 | .18 | .78 | .23 | | | | |
| Younger couple | | | | | .17 | .16 | 0.12 | 0.66 |
| 1× | .25 | .23 | .27 | .25 | | | | |
| 4× | .75 | .23 | .63 | .28 | | | | |
| Younger adults | | | | | | | | |
| Older couple | | | | | .07 | .10 | 0.64 | 0.75 |
| 1× | .48 | .25 | .33 | .28 | | | | |
| 4× | .88 | .23 | .51 | .27 | | | | |
| Younger couple | | | | | .04 | .09 | 0.75 | 0.58 |
| 1× | .42 | .26 | .41 | .30 | | | | |
| 4× | .88 | .16 | .30 | .26 | | | | |

*Note.* False alarms to new pairs are constant across repetition. $d'$ = discriminability for intact pairs versus rearranged pairs.

Specifically, those data indicated that younger adults were able to offset increases in familiarity accrued by repetition for younger faces but not for older faces for conjunction pairs. Older adults, in contrast, exhibited influences of familiarity for both older and younger faces for conjunction pairs. Both groups exhibited similar effects for intact pairs. Follow-up tests confirmed this pattern. For example, for older face pairs, both older, $F(1, 29) = 38.26$, $\eta_p^2 = .57$, and younger, $F(1, 29) = 78.03$, $\eta^2_{\ p} = .73$, adults were more likely to endorse intact pairs presented four times than pairs presented one time. The same pattern was also apparent for younger face pairs, as both older, $F(1, 29) = 82.86$, $\eta^2_{\ p} = .74$, and younger, $F(1, 29) = 63.87$, $\eta_p^2 = .69$, adults were more likely to endorse intact pairs presented four times than pairs presented one time. A different pattern was apparent for conjunction pairs. Specifically, for older face pairs, younger adults were more likely to endorse conjunctions composed of faces presented four times than to endorse conjunctions of faces presented one time, $F(1, 29) = 6.43$, $\eta_p^2 = .18$. For younger face pairs, however, younger adults were numerically less likely to endorse conjunctions composed of faces presented four times than to endorse faces presented one time, although this difference was not reliable, $F(1, 29) = 2.43$, $p = .13$, $\eta_p^2 = .08$. In contrast, older adults exhibited higher levels of false alarms to conjunctions composed of faces presented four times than to conjunctions of faces presented one time, for both older face pairs, $F(1, 29) = 17.61$, $\eta_p^2$=.38, and younger face pairs, $F(1, 29) = 32.57$, $\eta_p^2 = .53$. Thus, for conjunctions of younger faces, repetition increased false alarms for older adults, but did not do so for younger adults.

These data are consistent with predictions from a dual-process model and provide a conceptual replication of prior results (e.g., Jacoby, 1999). That is, younger adults were better able to use recollection to offset the effects of increased familiarity that came from repetition, but only for younger face pairs. For example, if one compares older adults' performance for younger pairs composed of items presented four times with younger adults' performance for younger pairs composed of items presented a single time, older adults exhibited reliably higher levels of false alarms to conjunctions than younger adults, $F(1, 58) = 8.76$, Cohen's $d$ = .78. Thus, older adults' deficits are consistent with diminished recollection and reliance on familiarity.

Discriminability ($d'$) estimates are displayed in the far right column of Table 4. Because cell sizes were too small to calculate discriminability by each level of repetition and face age, we focus primarily on repetition, collapsing across face age. A 2 (age group: younger, older) × 2 (repetition: one time, four times) mixed-factor ANOVA showed that younger adults ($M$ = 0.79) exhibited reliably better discriminability than did older adults ($M$ = 0.09), $F(1, 58) = 22.24$, $\eta_p^2 = .27$. Discriminability was also significantly better for pairs composed of faces presented four times ($M$ = 0.79) than for pairs composed of faces presented one time ($M$ = 0.08), $F(1, 58) = 29.80$, $\eta_p^2 = .34$. In addition, a reliable Age Group × Repetition interaction was present. This reflects the fact that for younger adults, discriminability was reliably better for pairs composed of faces presented four times ($M$ = 1.33) than for pairs composed of faces presented one time ($M$ = 0.24), $F(1, 29) = 27.18$, $\eta_p^2 = .48$. Older adults likewise exhibited better discriminability for pairs composed of faces presented four times ($M$ = 0.25) than those presented one time ($M$ = −0.07), $F(1, 29) = 4.52$,

$\eta^2_p = .14$, but the effect of repetition was of a smaller magnitude than that apparent for younger adults.[4]

*Confidence data.* Mean confidence in intact responses is displayed in Table 5. Because 39 participants (21 younger adults, 18 older adults) had at least one cell missing when omnibus analyses were conducted, we collapsed across levels of face age and focused primarily on repetition. These data were examined in a 2 (age group: younger, older) × 2 (item type: intact, conjunction) × 2 (repetition: one time, four times) mixed-factor ANOVA.[5] Results showed that confidence was reliably higher for intact pairs ($M = 74.96$) than for conjunction ($M = 69.38$) pairs, $F(1, 49) = 14.49$, $\eta^2_p = .23$, but did not vary between age groups, $F(1, 49) = 1.69$, $p = .20$, $\eta^2_p = .03$. In addition, the number of presentations of a face was positively related to assessed confidence, as confidence ratings were significantly higher for pairs composed of faces presented four times ($M = 77.52$) than for pairs composed of faces presented one time, ($M = 66.82$), $F(1, 49) = 37.53$, $\eta^2_p = .43$. A reliable Age Group × Item Type interaction was also present, $F(1, 49) = 8.59$, $\eta^2_p = .15$. Specifically, younger adults exhibited significantly higher confidence ratings for intact pairs ($M = 74.97$) than for conjunction ($M = 65.09$) pairs, $F(1, 24) = 17.25$, $\eta^2_p = .42$. However, older adults' confidence ratings did not distinguish between intact ($M = 74.95$) and conjunction ($M = 73.67$) pairs ($F < 1$).[6] Thus, these data suggest that older adults held correct and incorrect intact responses with equal confidence, whereas younger adults' confidence ratings were higher for correct, intact responses.

*Discussion.* Participants in Experiment 3 studied pairs of faces in which the level of familiarity was manipulated by varying the number of times each pair was presented. Overall, results were consistent with the idea that familiarity exerted a strong influence on performance, particularly for older adults. For example, data for false alarms to conjunction pairs showed that in contrast to younger adults, older adults consistently exhibited elevations in false alarms with increasing repetition (cf., Jacoby, 1999; Light et al., 2004). Such data suggest that the strength or familiarity of an item accrued from multiple prior presentations largely guided older adults' recognition decisions, leading to confidently held associative recognition errors for conjunction pairs.

Table 5
*Confidence in Intact Responses in Experiment 3, by Participant Age, Age of Couple in Photos, and Repetition*

| | Intact | | Conjunction | | New | |
|---|---|---|---|---|---|---|
| Age group | *M* | *SD* | *M* | *SD* | *M* | *SD* |
| **Older adults** | | | | | | |
| Older couple | | | | | 63.34 | 22.26 |
| 1× | 69.60 | 17.35 | 74.55 | 17.88 | | |
| 4× | 80.98 | 16.14 | 79.21 | 15.32 | | |
| Younger couple | | | | | 62.26 | 14.46 |
| 1× | 66.50 | 19.46 | 63.25 | 20.74 | | |
| 4× | 79.00 | 16.66 | 74.25 | 16.87 | | |
| **Younger adults** | | | | | | |
| Older couple | | | | | 49.22 | 17.85 |
| 1× | 70.20 | 16.59 | 62.80 | 12.84 | | |
| 4× | 78.53 | 12.99 | 70.12 | 17.31 | | |
| Younger couple | | | | | 62.26 | 14.46 |
| 1× | 69.56 | 19.81 | 61.11 | 14.46 | | |
| 4× | 84.06 | 10.87 | 66.78 | 30.63 | | |

*Note.* Confidence in false alarms for new pairs are constant across repetition.

## General Discussion

In the present study, we examined older and younger adults' associative recognition performance for pairs of faces. Results from three experiments indicated that both groups frequently and confidently endorsed conjunctions of faces that had been studied but had not been presented together. This occurred not only when participants were permitted to engage in self-directed encoding operations (Experiment 1) but also when participants were allowed to study pairs for as long as they deemed necessary to prepare for an upcoming test (Experiment 2). Similar to other work in which aging and familiarity-based processing has been examined (e.g., Jacoby, 1999; Light et al., 2004), we also found that repetition of face pairs at encoding (Experiment 3) greatly influenced participants' false alarm rates, particularly those of older adults, suggesting a reliance on familiarity at test.

The present results provide support for the associative deficit hypothesis in older adults (e.g., Castel, 2007; Castel & Craik, 2003; Light et al., 2004; Naveh-Benjamin, 2000; Naveh-Benjamin, Guez, Klib, & Reedy, 2004; Naveh-Benjamin, Guez, & Shulman, 2004) and extends this concept to nonverbal, face materials. We

[4] We also analyzed discriminability with face age entered as a factor. Results showed that discriminability did not vary on the basis of face age ($F < 1$), nor did face age interact with age group ($F < 1$).

[5] Data for intact responses to new pairs were excluded from this analysis. Ten participants were excluded from the analyses reported. Three younger participants did not endorse a single conjunction pair consisting of faces presented one time, and 2 younger participants did not endorse a single conjunction pair consisting of faces presented four times. In addition, 3 older participants did not endorse a single intact pair studied one time, and 1 older participant did not endorse a single conjunction pair consisting of faces presented one time. Analyses were conducted in which these participants were included and in which only age group and item type were examined as factors. Overall, participants had reliably higher confidence in intact responses to intact ($M = 77.46$) pairs than in those for conjunction ($M = 70.82$) pairs, $F(1, 58) = 22.08$, $\eta^2_p = .28$. Confidence did not vary on the basis of age group, $F(1, 58) = 1.64$, $p = .21$, $\eta^2_p = .03$, but a reliable Age Group × Item Type interaction was present, $F(1, 58) = 8.50$, $\eta^2_p = .13$. Follow-up analyses indicated that younger adults exhibited reliably higher confidence in intact responses to intact ($M = 77.60$) pairs than those to conjunction ($M = 66.83$) pairs, $F(1, 29) = 19.20$, $\eta^2_p = .40$. In contrast, older adults' confidence in intact ($M = 77.33$) pairs was only marginally different from their confidence in conjunction ($M = 74.81$) pairs, $F(1, 29) = 3.25$, $p = .08$, $\eta^2_p = .10$.

[6] We also analyzed confidence with face age entered as a factor. Three younger participants were excluded from this analysis: 1 who did not endorse any older, intact face pairs and 2 who did not endorse any younger, conjunction pairs. Results showed that confidence ratings did not reliably differ between older ($M = 75.29$) and younger ($M = 73.10$) face pairs, $F(1, 55) = 2.80$, $p = .10$, $\eta^2_p = .05$, but that a reliable Face Age × Item Type interaction was present, $F(1, 55) = 9.02$, $\eta^2_p = .14$. In particular, for intact pairs, confidence ratings did not differ for older ($M = 76.70$) faces and younger ($M = 78.43$) faces, $F(1, 57) = 1.49$, $p = .23$, $\eta^2_p = .03$. However, confidence in intact responses to conjunction pairs was significantly higher for older ($M = 72.96$) faces than for younger ($M = 67.41$) faces, $F(1, 56) = 7.26$, $\eta^2_p = .12$.

suggest that such associative recognition deficits can be accounted for by dual-process theories of memory. As noted previously, dual-process theories contend that memory judgments can be supported either by the consciously controlled retrieval of specific details from a prior experience (i.e., recollection) or by the general strength (i.e., familiarity) of information elicited by a recognition probe. In the current study, discrimination between intact and conjunction pairs likely relies on recollecting the specific context in which a particular face was presented. That is, because both intact and conjunction pairs consist of items that have been studied previously (and should be equally familiar), discrimination depends on recollecting the specific face pair presented. From this perspective, the high level of false alarms to conjunction pairs reflects the influence of familiarity for individual faces in the absence of sufficient recollection to determine the context in which a face was studied. Thus, when making recognition judgments about pairs of faces when each is familiar, both younger and older adults were highly susceptible to memory errors.

Older adults in the current study consistently exhibited higher levels of false alarms to conjunction lures than did younger adults. For example, combining results across the experiments reported, the mean weighted effect size difference in false alarms to conjunction pairs for older versus younger adults was reliable (Cohen's $d = .73$; 95% CI: .51, .95).[7] Such data provide support for the hypothesis that older adults have difficulty forming and retrieving links between individual units of information (Naveh-Benjamin, 2000) and suggest that older adults may be more reliant on familiarity as a basis for associative recognition judgments than are younger adults (Healy et al., 2005). We do not contend that familiarity was not a factor in younger adults' recognition decisions. For example, younger adults exhibited high levels of false alarms to conjunction pairs in each of the experiments reported that far exceed false alarm rates for entirely new pairs. In addition, at least for older face pairs, repetition increased younger adults' false alarms to conjunction pairs. However, we do suggest that older adults relied on familiarity as a basis for recognition decisions more than did younger adults. Perhaps the best evidence for this in the current study comes from Experiment 3. In that experiment, older adults exhibited significant increases in false alarms to conjunctions of repeated items for both older and younger face pairs. That is, whereas repetition of faces increased discriminability for younger adults, older adults exhibited near-floor levels of discriminability for pairs consisting of repeated items and had very high levels of false alarms. We suggest that older adults were less able than were younger adults to offset the influence of familiarity with recollection of previously studied face pairs. These and other data are consistent with the idea that recollection, but not familiarity, is sensitive to aging (see also, Hay & Jacoby, 1999; Jacoby, 1999; Jennings & Jacoby, 1997; but see Healy et al., 2005, for model-dependent differences in measures of familiarity in associative recognition).

We must note that these conclusions are based on analyses of intact responses to intact and conjunction pairs and corresponding estimates of discriminability. However, a similar interpretation is warranted when taking into account the pattern of responding to new pairs. In particular, in each experiment, older adults had more false alarms to new face pairs than younger adults (cf. Searcy, Bartlett, & Memon, 1999; $Fs \geq 4.42$, $\eta_p^2 s \geq .07$), consistent with a general pattern that older adults exhibit more false memories than younger adults (see Jacoby & Rhodes, 2006, for a review). To explore this in more detail, we reanalyzed data from each experiment by subtracting the proportion of intact responses to new pairs from intact responses to intact and conjunction pairs. In each of the experiments, the primary result of subtracting intact responses to new items was to reduce age-related differences in endorsements of conjunctions while increasing age-related differences in endorsements of intact pairs. Specifically, collapsing across experiments, the corrected data showed that younger adults ($M = .63$) were reliably more likely to endorse intact pairs than were older adults ($M = .49$), $F(1, 165) = 17.70$, $\eta_p^2 = .10$. In contrast, although younger adults ($M = .34$) mistakenly endorsed fewer conjunction pairs than did older adults ($M = .39$), the difference was not reliable, $F(1, 165) = 2.88$, $p = .09$, $\eta_p^2 = .02$. Given that intact pairs should be equally familiar as conjunctions, differences in endorsements of intact pairs suggest that older adults' deficits in recollection may be at the heart of the age-related associative recognition deficits reported in the current study (cf. Light et al., 2004). That is, these data suggest that younger adults may be able to use recollection to a greater extent than are older adults, resulting in fewer incorrect endorsements of new pairs and more correct endorsements of intact pairs. In addition, older adults may be relying on recollections that are faulty, leading to high levels of false alarms to new pairs and to lower levels of hits to intact pairs when such a correction is applied.

Several other points are worth noting in regard to the current study. First, participants often mistakenly endorsed conjunction pairs with high levels of confidence. Although data from Experiment 2 showed that participants exhibited greater confidence for intact pairs relative to conjunction pairs, this pattern was only apparent for younger adults in Experiment 3. Older adults' confidence judgments in that experiment did not discriminate between intact pairs and conjunction pairs. This suggests that older adults' responses to both types of pairs relied on what was qualitatively the same type of information, with older adults less able to call on information that distinguished between intact and conjunction pairs than younger adults (cf. Kelley & Sahakyan, 2003; Rhodes & Kelley, 2005). At present, few studies of aging and associative recognition have also examined confidence (but see, e.g., Healy et al., 2005), so these conclusions must be treated as tentative.

The current study also manipulated the age of the individuals presented in the face pairs, with the possibility that associative recognition judgments differed depending on the match between the participant's age and the target face (e.g., Anastasi & Rhodes, 2005). However, we found mixed support for such an own-age bias. For example, combining data across experiments, younger adults exhibited reliably greater discriminability ($d'$) for younger face pairs ($M = 0.89$) than for older ($M = 0.56$) face pairs, $F(1, 113) = 8.21$, $\eta_p^2 = .09$. In addition, results from Experiment 3 showed that younger adults exhibited increases in false alarms to conjunctions of older faces presented four times compared with false alarms for those presented one time. This effect was not present for younger faces, suggesting that younger adults may be less able to bring recollection to bear on recognition decisions involving older faces and, in fact, may rely on familiarity just as much as older adults for such pairs, perhaps because they are

[7] This may even be an underestimate of age-related deficits in associative recognition, given the relatively high level of education of the older adults tested.

difficult to elaboratively encode and, thus, do not support recollection. In contrast, older adults showed increases in false alarms with repetition for both younger and older faces and, across experiments, exhibited no differences in discriminability for younger ($M$ = 0.27) and older ($M$ = 0.22) face pairs ($F < 1$). Thus, whereas younger adults demonstrated an own-age bias, older adults exhibited no differences in memory for same- and other-aged faces. This pattern is probably not an artifact of floor effects. In particular, when analyses of older adults were restricted to participants with overall $d'$ values of 0.50 or above, the reported pattern still held for the two groups. Therefore, own-age biases may be less prevalent for older adults than for younger adults (cf. Fulton & Bartlett, 1991). Data reported here are not conclusive in that regard, particularly given that others (e.g., Anastasi & Rhodes, 2005) have reported own-age biases for older adults, but the issue certainly warrants further investigation.

It must also be noted that unlike previous studies, participants in the current study were instructed to specifically identify conjunction pairs—as opposed to reporting such pairs as new (even though both items were previously presented). This added option might reduce conjunction errors, perhaps by encouraging a more stringent criterion for identifying items (cf. Multhaup, 1995). Though response option was not explicitly manipulated in the current study, both younger and older adults still exhibited relatively high levels of false alarms to conjunction pairs, despite having the option to identify these pairs as separate. There were, however, age differences in the frequency with which the separate option was exercised. For example, across experiments, younger adults ($M$ = .29) were reliably more likely to identify a pair as separate than were older adults ($M$ = .26), $F(1, 165) = 4.30$, $\eta_p^2 = .03$, an effect that varied based on the type of pair. Specifically, whereas no age difference existed for separate responses to intact pairs ($F < 1$), younger adults ($M$ = .50) were significantly more likely to correctly identify conjunctions as separate than were older adults ($M$ = .31), $F(1, 165) = 49.37$, Cohen's $d$ =1.09. Thus, younger adults correctly identified conjunction pairs at well above chance levels, in contrast to older adults. This is, perhaps, not surprising given that older adults predominantly made intact responses to conjunction pairs, limiting the opportunity to make a separate response. Future research would benefit from researchers directly manipulating response options in order to determine whether more options have the effect of reducing associative recognition errors.

Overall, the present study outlines situations in which younger and older adults have difficulty remembering and using associative information in order to avoid false recognition and further demonstrates the generality of previously documented associative recognition deficits with nonverbal materials. Although the high levels of false alarms to conjunction pairs indicates that similar processing mechanisms (i.e., global familiarity in the absence of recollection) contributed to associative recognition failure for both groups, we suggest that these data indicate a great dependency on familiarity for older adults. In general, models and theories of cognitive aging that incorporate dual-process theories, coupled with stimuli that lead to highly generalizable findings for younger and older adults, can provide important insight into how aging influences the control of memory for associative information.

## References


Anastasi, J. & Rhodes, M. G. (2005). An own-age bias in face recognition for children and older adults. *Psychonomic Bulletin & Review, 12,* 1043–1047.

Bastin, C., & Van der Linden, M. (2006). The effects of aging on the recognition of different types of associations. *Experimental Aging Research, 32,* 61–77.

Bloom, L. C., & Mudd, S. A. (1991). Depth of processing approach to face recognition: A test of two theories. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 17,* 556–565.

Bower, G. H., & Karlin, M. B. (1974). Depth of processing pictures of faces and recognition memory. *Journal of Experimental Psychology, 103,* 751–757.

Castel, A. D. (2005). Memory for grocery prices in younger and older adults: The role of schematic support. *Psychology and Aging, 20,* 718–721.

Castel, A. D. (2007). Aging and memory for numerical information: The role of specificity and expertise in associative memory. *Journals of Gerontology, Series B: Psychological Sciences and Social Sciences, 62,* 194–196.

Castel, A. D., & Craik, F. I. M. (2003). The effects of aging and divided attention on memory for item and associative information. *Psychology and Aging, 18,* 873–885.

Chalfonte, B., & Johnson, M. K. (1996). Feature memory and binding in young and older adults. *Memory & Cognition, 24,* 403–416.

Coin, C., & Tiberghien, G. (1997). Encoding activity and face recognition. *Memory, 5,* 545–568.

Craik, F. I. M. (1982). Selective changes in encoding as a function of reduced processing capacity. In F. Klix, S. Hoffman, & E. Van der Meer (Eds.), *Cognitive research in psychology* (pp. 152–161). Berlin, Germany: Deutscher Verlag der Wissenschaften.

Fulton, A., & Bartlett, J. C. (1991). Young and old faces in young and old heads: The factor of age in face recognition. *Psychology and Aging, 6,* 622–630.

Hay, J. F., & Jacoby, L. L. (1999). Separating habit and recollection in young and older adults: Effects of elaborative processing and distinctiveness. *Psychology and Aging, 14,* 122–134.

Healy, M. R., Light, L. L., & Chung, C. (2005). Dual-process models of associative recognition in young and older adults: Evidence from receiver operating characteristics. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 31,* 768–788.

Hockley, W. E., & Consoli, A. (1999). Familiarity and recollection in item and associative recognition. *Memory & Cognition, 27,* 657–664.

Jacoby, L. L. (1991). A process dissociation framework: Separating intentional from automatic uses of memory. *Journal of Memory and Language, 30,* 513–541.

Jacoby, L. L. (1999). Ironic effects of repetition: Measuring age-related differences in memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 25,* 3–22.

Jacoby, L. L., & Rhodes, M. G. (2006). False remembering in the aged. *Current Directions in Psychological Science, 15,* 49–53.

Jennings, J. M., & Jacoby, L. L. (1997). An opposition procedure for detecting age-related deficits in recollection: Telling effects of repetition. *Psychology and Aging, 12,* 352–361.

Kelley, C. M., & Sahakyan, L. (2003). Memory, monitoring, and control in the attainment of memory accuracy. *Journal of Memory and Language, 48,* 704–721.

Light, L. L., Patterson, M. M., Chung, C., & Healy, M. R. (2004). Effects of repetition and response deadline on associative recognition in young and old adults. *Memory & Cognition, 32,* 1182–1193.

Light, L. L., Prull, M. W., La Voie, D. J., & Healy, M. R. (2000). Dual process theories of memory in old age. In T. J. Perfect & E. A. Maylor (Eds.), *Models of cognitive aging* (pp. 238–300). New York: Oxford University Press.

Madden, D. J. (2007). Aging and visual attention. *Current Direction in Psychological Science, 16,* 70–74.

Minear, M., & Park, D. C. (2004). A lifespan database of adult facial stimuli. *Behavior, Research Methods, Instruments, & Computers, 36,* 630–633.

Multhaup, K. S. (1995). Aging, source, and decision criteria: When false fame errors do and do not occur. *Psychology and Aging, 10,* 492–497.

Naveh-Benjamin, M. (2000). Adult age differences in memory performance: Tests of an associative deficit hypothesis. *Journal of Experimental Psychology*: *Learning, Memory, and Cognition, 26,* 1170–1187.

Naveh-Benjamin, M., Brav, T. K., & Levy, O. (2007). The associative memory deficit of older adults: The role of strategy utilization. *Psychology and Aging, 22,* 202–208.

Naveh-Benjamin, M., Guez, J., Klib, A., & Reedy, S. (2004). The associative memory deficit of older adults: Further support using face-name associations. *Psychology and Aging, 19,* 541–546.

Naveh-Benjamin, M., Guez, J., & Shulman, S. (2004). Older adults' associative deficit in episodic memory: Assessing the role of decline in attentional resources. *Psychonomic Bulletin & Review, 11,* 1067–1073.

Naveh-Benjamin, M., Hussain, Z., Guez, J., & Bar-On, M. (2003). Adult age differences in episodic memory: Further support for an associative deficit hypothesis. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 29,* 826–837.

Perfect, T. J. & Harris, L. J. (2003). Adult age differences in unconscious transference: Source confusion or identity blending. *Memory & Cognition, 31,* 570–580.

Rhodes, M. G., & Kelley, C. M. (2003). The ring of familiarity: False familiarity due to rhyming primes in item and associative recognition. *Journal of Memory and Language, 48,* 581–595.

Rhodes, M. G., & Kelley, C. M. (2005). Executive processes, memory accuracy, and memory monitoring: An aging and individual difference analysis. *Journal of Memory and Language, 52,* 578–594.

Ryan, J. D., Leung, G., Turk-Browne, N. B., & Hasher, L. (2007). Assessment of age-related changes in inhibition and binding using eye movement monitoring. *Psychology and Aging, 22,* 239–250.

Searcy, J. H., Bartlett, J. C., & Memon, A. (1999). Age differences in accuracy and choosing in eyewitness identification and face recognition. *Memory & Cognition, 27,* 538–552.

Shipley, W. C. (1940). A self-administering scale for measuring intellectual impairment and deterioration. *Journal of Psychology: Interdisciplinary and Applied, 9,* 371–377.

Spencer, W. D., & Raz, N. (1995). Differential age effects on memory for content and context. *Psychology and Aging, 10,* 527–539.

Vargha-Khadem, F., Gadian, D. G., Watkins, K. E., Connelly, A., Van Paesschen, W., & Mishkin, M. (1997, July 18). Differential effects of early hippocampal pathology on episodic and semantic memory. *Science, 277,* 376–380.

Watkins, M. J., Ho, E., & Tulving, E. (1976). Contexts effects in recognition memory for faces. *Journal of Verbal Learning and Verbal Behavior, 15,* 505–517.

Winograd, E., & Rivers-Bulkeley, N. T. (1977). Effects of changing context on remembering faces. *Journal of Experimental Psychology: Human Learning and Memory, 3,* 397–405.

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