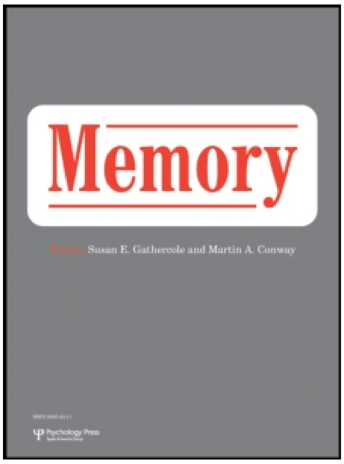

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Adult age differences in memory for name-face associations: The effects of intentional and incidental learning

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Adult age differences in memory for name–face associations: The effects of intentional and incidental learning

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Previous studies have indicated that older adults have a special deficit in the encoding and retrieval of associations. The current study assessed this deficit using ecologically valid name–face pairs. In two experiments, younger and older participants learned a series of name–face pairs under intentional and incidental learning instructions, respectively, and were then tested for their recognition of the faces, the names, and the associations between the names and faces. Under incidental encoding conditions older adults' performance was uniformly lower than younger adults in all three tests, indicating age-related impairments in episodic memory representations. An age-related deficit specific to associations was found under intentional but not under incidental learning conditions, highlighting the importance of strategic associative processes and their decline in older adults. Separate analyses of hits and false alarms indicate that older adults' associative deficit originated from high false alarm rates in the associative test. Older adults' high false alarm rates potentially reflect their reduced ability to recollect the study-phase name–face pairs in the presence of intact familiarity with individual names and faces.

Keywords: Ageing; Episodic memory; Associative memory; Learning instructions.

Old age has been shown to be associated with a decline in episodic memory performance (e.g., Craik, 1999; Light, 1991; Zack, Hasher, & Li, 2000). However, this decline is differential and depends on various factors, including whether the information to be remembered comprises indivi-

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dual pieces of information (item memory) or the relationships among these pieces (associative memory).

Previous studies have indicated that older adults tend to perform worse on tests of memory for associations relative to memory for items. For example, Chalfonte and Johnson (1996) showed no age-related deficits in memory for individual objects or individual colours. However, older adults showed poorer memory for colours in combination with specific objects. These researchers suggested that this deficit reflects an age-related decline in the ability to bind different components together (see also Mitchell, Johnson, Raye, Mather, & D'Esposito, 2000). In this vein, Naveh-Benjamin (2000) suggested an associative deficit hypothesis (ADH), which attributes age-related declines in associative memory to older adults' inability to encode and retrieve the relationships between single units of information. Several studies have since supported these suggestions by demonstrating that older adults tend to show poorer associative than item memory for word pairs (Castel & Craik, 2003; Light, Patterson, Chung, & Healy, 2004; Naveh-Benjamin, 2000), word–font pairs (Naveh-Benjamin, 2000), picture pairs (Naveh-Benjamin, Hussain, Guez, & Bar-On, 2003b), and face–spatial-location pairs (Bastin & Van der Linden, 2006; see also a meta-analysis by Old & Naveh-Benjamin, 2008a).

In the current studies we aimed to replicate and extend existing tests of the ADH. First, we wanted to assess whether older adults exhibit an associative deficit under conditions in which the information presented is meaningful and has high ecological validity. To this end, we used face–name associations that are prevalent in daily life, as numerous everyday situations require people to interact with others whose names must be both remembered and mentally linked to the corresponding faces. Older adults tend to report problems in this domain, specifically in retrieving the name of a person they have met or seen before (Cohen & Faulkner, 1984), although it is not yet clear whether older adults actually possess a specific deficit in retrieving proper names as opposed to names of objects (e.g., Maylor, 1997).

Most previous research on memory for faces and names has employed a cued-recall test, which presents participants with a series of faces, each paired with a proper name, and later requires them to report the correct name in response to a given face (e.g., Crook, Larrabee & Younjohn, 1993; Evrard, 2002). The problem with such cued-recall tasks is that it is often not clear whether older adults' performance in them reflects a deficit in memory for names (i.e., an item deficit) or for the associations between names and faces (an associative deficit).

In an attempt to tease apart these age-related item deficits from associative deficits, Naveh-Benjamin, Guez, Kilb, and Reedy (2004) presented younger and older adults with name–face pairs under intentional learning instructions. These instructions explicitly required participants to learn the pairs in preparation for three memory tests, for names, faces, and their associations, respectively. The subsequent recognition tests showed only small age-related differences in memory for names and faces, but large age-related differences in memory for the associations between names and faces. In support of the ADH, these results indicated a unique deficit in older adults' memory for associations, above and beyond their deficits (if any) in item memory.

The major purpose of our current experiments was to further examine the extent to which an age-related associative deficit was related to intentions to learn the information. Previous research using word–colour or word–spatial-location pairs (Chalfonte & Johnson, 1996) or word pairs (Naveh-Benjamin, 2000) had shown that older adults exhibit an associative deficit under both incidental (i.e., learn the pairs as single items) and intentional (i.e., learn the pairs as pairs) learning instructions. In general, the functioning of episodic memory can be conceived as operated and affected by two interacting components, one associative and one strategic (Moscovitch, 1992; Simons & Spiers, 2003). The associative component refers to mechanisms occurring during encoding, storage, and retrieval that bind different aspects of an event into a cohesive episode (Treisman, 1996; Zimmer, Mecklinger, & Lindenberger, 2006). The strategic component refers to the elaboration and organisation of memory features. Most importantly, these two components undergo declines in functioning in ageing (Brehmer, Li, Müller, v. Oertzen, & Lindenberger, 2007; Shing, Werkle-Bergner, Li, Lindenberger, in press a). The above pattern of results can be interpreted to mean that the associative deficit of older adults is driven by decline in the associative component (under incidental learning instructions), and even more drastic decline in the strategic component, as the deficit was larger under intentional learning instructions.

In the present experiments we wanted to assess how these two components of episodic memory would operate with ecologically relevant materials, such as associations between names and faces. Also, in the past the associative deficit has been shown under incidental learning instructions of associative information in which participants were told to pay attention only to item (word) information. Such instructions might have made participants pay more attention to item memory (the words), leaving them with fewer attentional resources to associate the two words. Older adults, who have been shown to possess reduced attentional resources (e.g., Craik, 1986; Craik & Byrd, 1982), might be particularly affected by such instructions, leading to an associative deficit even under incidental learning instructions. To rectify this issue, in the current experiments, in addition to intentional learning instructions, we also used incidental learning instructions in which we did not inform participants in advance of any subsequent memory test on the name, the face, or the name–face pairs.

In addition, we designed the current studies to extend Naveh-Benjamin et al.'s (2004) findings and to address methodological issues of that study by using a different type of memory test. In the Naveh-Benjamin et al. study, recognition tests were presented in a forced-choice format. For each given test (for faces, for names, or their associations), participants were asked to select from among two choices, one of which had been presented during the study phase. In contrast, in the current studies we employed a yes–no procedure, presenting participants with separate targets (previously presented events) and distractors (newly presented events) during a given test, asking them to identify the targets. The yes–no task, in addition to potentially broadening the ADH applicability to a different format of test, permitted us to study the deficit more analytically. Whereas the forced-choice procedure provided only a single accuracy index of performance (e.g., percentage correct responses), the yes–no test procedure provided separate measures of hits and false alarms. These separate measures may point to a possible source for any emerging associative deficit, by indicating whether the deficit is due to a relatively low hit rate (reflecting an inability to identify previously presented name–face pairs), a high false alarm rate (reflecting a tendency to falsely identify an association among previously unpaired names and faces), or both. If manifested, such a differential pattern might also have practical implications, such as, for example, for eyewitness testimony situations, indicating whether older adults tend to make more errors in correctly identifying felons, in falsely implicating innocent people, or in both (see Memon, Bartlett, Rose, & Gray, 2003; Wells & Olson, 2003).

Since the original results in the context of memory for name–face associations (Naveh-Benjamin et al., 2004) were reported for intentional learning, we first describe Experiment 1 in which participants were aware of the three upcoming tests during study. Once this deficit is established under intentional learning instructions, we proceed to describe Experiment 2 where we assessed the associative deficit involved in name–face associations under incidental instructions that withheld information of the subsequent memory tests from the participants.

Overall, these experiments investigated the role of strategic and automatic processes in the age-related associative deficit in memory for name–face pairs, assessing whether the deficit is mostly due to a decline in hit rates, an increase in false alarm rates, or both. A list of name–face pairs were presented during study to groups of younger and older adults followed by three separate yes–no recognition tests, one on the names, one on the faces, and one on the associations between the names and the faces.

EXPERIMENT 1

Method

Participants. Participants in this experiment were 24 young adults (ages 18–21), and 23 older adults (ages 65–81). The young adults were undergraduate students enrolled in an introductory psychology course at the University of Missouri who received course credit for their participation. All older adults were community dwellers who reported no major health problems and were each paid $15 for their participation. The two age groups were equated on levels of formal education ($p > .10$). A summary of all participants' demographic information appears in Table 1.

Design. The experiment used a 2 (age: older, younger; between participants) $\times$ 3 (test: face, name, associative; within participants) design.

TABLE 1
Demographic information for participants in Experiments 1 and 2

	n	*Age*	*Education*	*Proportion male*
Experiment 1				
Young	24	18.9 (0.80)	12.8 (0.93)	.45
Old	23	72.7 (5.07)	13.4 (1.60)	.32
Experiment 2				
Young	42	23.2 (1.65)	15.6 (1.87)	.52
Old	42	73.2 (1.67)	16.1 (3.71)	.50

Age and education are measured in years; means are presented, with standard deviations in parentheses.

Materials. Study materials comprised three sets, each consisting of 27 name–face pairs. The faces were chosen from diverse sources such as online school yearbooks, with half the faces belonging to younger adults (ages 18–25) and half to older ones (ages 65–80), with equal male and female representation. The names (first and last, half male and half female) were sampled randomly from a phone directory. For each set, two versions of 27 name–face pairings were created, matching faces and names to gender. A given display contained a face at the top of the screen with the name below it. Two random orders were created for each of these pairings, for a total of four versions; five or six participants in each age group were run in each version. The order of the sets was counterbalanced for each group. For the name and face recognition tests, distractors that did not appear during the study phase were chosen with similar characteristics of the targets.

Procedure. For each set, individually tested participants saw a succession of 27 name–face pairs on a computer monitor, at a rate of 3 seconds per pair with a .25 second interval between pairs. Study conditions were intentional, and participants were told that they must pay attention not only to each face and name, but also to the name–face pairs, because their memory for the name, the face, and their pairings would be tested. The first two pairs and the last pair were used as buffers to eliminate primacy and recency effects and were not analysed.

For each set, after the study phase and an interpolated activity of 60 seconds, three memory tests, two for the components and one for their associations, were administered to all participants. The order of the tests was counterbalanced across all participants in each age group, and any given name or face appeared on only one of the tests. The stimuli in each test appeared for 4 seconds each, during which the participant responded by saying "yes" or "no" to each stimulus presented.

Before the name test participants were told they would see a succession of 16 names, 8 that had appeared in the study phase and 8 that had not. They were instructed to say "yes" for names they remembered and "no" for those they thought were new. Likewise, prior to the face test participants were told they would see 16 human faces, 8 that had appeared in the study phase and 8 that had not. They were instructed to say "yes" to faces they have recognised from the study phase and "no" to those they did not recognise. Finally, prior to the associative test participants were told that they would see a face from the study phase with a name from the study phase, but that only half of the time would the face and name be a pair from the study phase, whereas in the other half the name would be mismatched with a face that had been part of a different pair at study. They were asked to say "yes" for "intact" pairs and "no" for "recombined" pairs. Each test was preceded by a practice test to permit clarification of participants' questions before the experimental tests began.

Results

Measures of proportion of hits minus false alarms[1] were computed for each participant and then averaged over each age group for each test (see Figure 1). This equated the component and the associative recognition tests with respect to the scale used (from chance level performance at

[1] All analyses were also run using the d' measure of signal detection theory (Snodgrass & Corwin, 1988). There was no difference in findings.

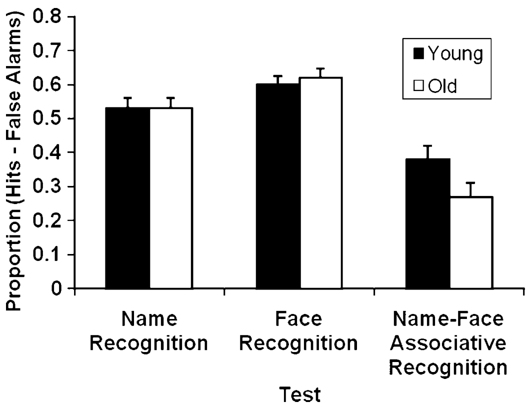

Figure 1. Memory performance under intentional learning in the name, face, and name–face association tests for younger and older adults in Experiment 1. Error bars represent standard errors around the mean.

0.0 to the highest possible score at 1.0). In addition, because a preliminary analysis of variance indicated no interaction effect of the order of the administration of the tests with any of the independent variables, in all analyses reported below (for this and the following experiment), performance was collapsed across the different orders. Performance of each group on each of the tests was better than chance ($p < .05$, using one-sample *t*-tests).

The first analysis conducted was a two-way analysis of variance (ANOVA): 2 (Age: young, old) × 3 (Test: face, name, associative). This analysis revealed no significant main effect of age, $F(1, 45) = 0.35$, $MSe = .035$, *ns*, with younger participants ($M = .50$, $SD = .11$) performing at the same level as older participants ($M = .48$, $SD = .12$). The effect of test was significant, $F(2, 90) = 46.29$, $MSe = .022$, $p < .001$. Performance on the face test was highest ($M = .61$, $SD = .18$), followed by that on the name test ($M = .53$, $SD = .21$) and the association test ($M = .33$, $SD = .22$). Importantly, the two-way interaction was significant, $F(2, 90) = 3.14$, $MSe = .022$, $p < .05$. Two additional two-way ANOVAs, each including age (young vs old) and one of the component tests (name or face) vs the associative one, showed similar patterns of interaction, with older adults performing more poorly on the associative test than on each of the component tests, $F(1, 45) = 4.81$, $MSe = .027$, $p < .05$, when the face and the associative tests were used, and, $F(1, 45) = 3.12$, $MSe = .025$, $p = .08$, when the name and the associative tests were used. To directly assess age-related differences in component and associative memory, a follow-up interaction comparison with age as one variable and the average performance on the component tests (name and face) vs the associative test as the other variable, showed a significant interaction, $F(1, 45) = 4.63$, $MSe = .029$, $p < .05$. Follow-up contrasts showed that whereas older adults performed as well as younger ones on the average of the component tests ($M = .56$, $SD = .12$, and $M = .59$, $SD = .10$, for young and old, respectively), $F(1, 45) = 0.63$, $MSe = .023$, *ns*, older adults performed more poorly than did young adults on the associative test ($M = .38$, $SD = .21$, and $M = .27$, $SD = .20$, for young and old, respectively) and this difference approached significance, $F(1, 45) = 3.23$, $MSe = .041$, $p = .07$. This finding provides evidence of an age-related associative deficit.

In order to further assess the associative deficit of older adults, the proportion of hits and false alarms were examined separately. These data are presented in Table 2. Name and face tests were again averaged into one overall "component" test measure. In terms of hits, a 2 (age) × 2 (test: component, associative) ANOVA did not reveal a significant main effect of age, $F(1, 45) = 1.33$, $MSe = .022$, *ns*, with similar hit rates by the

TABLE 2
Mean proportion hits and false alarms, Experiment 1 and Experiment 2

Group	*Name test*		*Face test*		*Associative test*	
	Hits	*FAs*	*Hits*	*FAs*	*Hits*	*FAs*
Experiment 1						
Young	.69 (.16)	.16 (.11)	.72 (.14)	.13 (.10)	.68 (.16)	.30 (.15)
Old	.69 (.13)	.16 (.10)	.78 (.13)	.15 (.12)	.72 (.13)	.45 (.14)
Experiment 2						
Young	.72 (.17)	.16 (.09)	.76 (.12)	.22 (.10)	.70 (.13)	.31 (.14)
Old	.54 (.22)	.24 (.17)	.76 (.14)	.42 (.17)	.61 (.17)	.49 (.21)

Standard deviations in parentheses. FAs = false alarms.

younger ($M = .70$, $SD = .14$) and the older ($M = .73$, $SD = .11$) adults. The effect of test was also not significant, $F(1, 45) = 1.05$, $MSe = .012$, *ns*, with similar hit rates on the component ($M = .72$, $SD = .14$) and the associative ($M = .70$, $SD = .12$) measures. Finally, the ANOVA did not reveal a significant interaction, $F(1,45) = 0.05$, $MSe = .012$, *ns*.

A similar two-way ANOVA was conducted with false alarm rates as the dependent variable; name and face tests were again averaged into one overall ‘‘component’’ test measure. The analysis yielded a significant main effect of age, $F(1, 45) = 7.63$, $MSe = .018$, $p < .01$, with older adults showing higher false alarm rates ($M = .30$, $SD = .11$, and $M = .22$, $SD = .12$) for old and young, respectively. This effect is qualified by the two-way interaction reported below. The effect of test was also significant, $F(1, 45) = 115.64$, $MSe = .010$, $p < .01$, with higher false alarm rate in the associative than in the component test ($M = .38$, $SD = .14$, and $M = .15$, $SD = .08$, respectively). Interestingly, the analysis yielded a significant interaction, $F(1, 45) = 11.33$, $MSe = .010$, $p < .01$. Further contrasts showed that while older adults produced similar proportions of false alarms as did the younger adults on the component test measure ($M = .14$, $SD = .09$, and $M = .15$, $SD = .08$, for young and old, respectively), $F(1, 45) = .07$, $MSe = .015$, *ns*, age differences were significant on the associative measure, $F(1, 45) = 12.16$, $MSe = .02$, $p < .01$, with older adults showing higher false alarm rates ($M = .30$, $SD = .15$, and $M = .45$, $SD = .14$, for young and old, respectively). Thus, it appears that the associative deficit of the older adults in this experiment stemmed from high rates of false alarms on the associative test.

Discussion

The results of this experiment show that the ADH applies to associations between a face and a name. Older adults under intentional learning instructions exhibited a deficit in memory for names bound to faces, while showing similar memory performance to that of young adults in memory for faces or names. These results replicate those reported by Naveh-Benjamin et al. (2004) and extend it to situations when a yes–no recognition procedure is used. Furthermore, in contrast to most previous studies in which the age-related associative deficit was accompanied by some decline in component memory, the age-related associative deficit shown here was accompanied by intact component memory in older adults, as indicated by their equivalent performance to young adults in the separate tests of memory for names and faces. This pattern appears to rule out any age-related deficit in component memory as the source for the associative deficit of older adults in the current experiment.

Furthermore, whereas previous studies on the ADH have generally analysed only an overall accuracy measure of performance on each test, the current results suggest that such a method may be missing important information about the mechanisms behind the associative deficit. The results of the current experiment indicate that older adults' associative deficit was entirely due to their increased false alarms but not to a decrease in hit rates. According to the dual-process account (Jacoby, 1991; Yonelinas, 2002), memory for past events can be based on retrieval accompanied by specific contextual details (recollection) or on the feeling of knowing that an event is old or new without necessarily recollecting specific details (familiarity). In the ageing literature, converging evidence indicates that ageing disrupts recollection to a greater extent than does familiarity (Healy, Light, & Chung, 2005; Jacoby & Hay, 1998; Souchay, Moulin, Clarys, Taconnat, & Isingrini, 2007). Given that the distractors of our associative test comprised familiar stimuli that were presented at study but rearranged in pairing only at test, the ability to reject them is essentially a test of recollection (a recall-to-reject notion; Gallo, Sullivan, Daffner, Schacter, & Budson, 2004). In this light, the increase in false alarms of older adults in identifying the relationships between a name and a face could be due to their over-reliance on the familiarity of the components—the name or the face—that they remembered equally as well as did young adults, combined with a deficit in the recollection of the exact name–face associations. This issue is discussed further in the General Discussion.

Older adults' different patterns of hits and false alarms in the associative test are related to eyewitness studies wherein older adults were shown to perform almost as well as young adults in identifying culprits when the culprit was present in a given line-up, but tended to commit false identifications at high rates when the culprit did not appear in the line-up (Wells & Olson, 2003).

EXPERIMENT 2

The results of Experiment 1 indicated that older adults exhibit a deficit in memory of name–face associations under intentional learning instructions. In Experiment 2 we assess whether older adults will show a similar deficit under incidental learning conditions. Such results will indicate that at least part of the age-related associative deficit is related to the operation of automatic processes. However, if the deficit is not demonstrated under incidental learning conditions, it would point to the predominantly strategic origins of the deficit.

Method

Participants. Data were collected from 42 older adults between 70 and 76 years of age and 42 younger adults between 20 and 26 years of age. All participants were residents of Berlin, Germany. The older adults lived independently in the community and travelled to the laboratory by themselves for testing. Participants were again roughly equated on their level of education ($p >$ .05). In order to optimise the incidental nature of the memory test, none of the participants in this experiment had taken part in other experiments similar to Experiment 1 and none of the younger adults was a psychology major. All participants received 17 Euros for their participation. Additional demographic information is provided in Table 1.

Design. This experiment consisted of a 2 (age: younger, older; between participants) $\times$ 3 (test: face, name, associative, within participants) design.

Materials and procedure. The materials and procedure for the memory task were similar to those used in Experiment 1, except for a number of minor changes. First, a set of 48 name–face pairs were used (for references of face stimuli, see Ebner, 2008; Minear & Park, 2004). Each pair was presented for 3 seconds with .5 seconds of a blank slide before the next pair appeared. Each test included 32 stimuli with 16 targets and 16 distractors. The nature of stimuli was the same as in Experiment 1. However, in contrast to Experiment 1, participants were not made aware of the upcoming tests until the testing session began. Instead, before study they were instructed to respond with ‘‘fit’’ or ‘‘fit very well’’ to each name–face pair to indicate subjective evaluations of whether the name and the face fitted together. They were further told that there were no correct or wrong answers on this task and the aim of the test was to examine subjective perception of how names and faces match together. Post-test informal inquiries indicated that overall, during the study phase, participants did not anticipate the upcoming memory tests.

Results

As in Experiment 1, memory performance was measured in terms of the proportion of hits minus the proportion of false alarms produced by each participant. Figure 2 presents memory performance for each age group for each of the tests. Performance of each group on each of the tests was better than chance ($p < .05$, using one-sample t-tests).

The first ANOVA performed was 2 (age) $\times$ 3 (test: name, face, associative). There was a significant main effect of age, $F(1, 82) = 105.78$, $MSe = .036$, $p < .01$. Specifically, younger adults ($M = .50$, $SD = .11$) performed better than did older adults ($M = .25$, $SD = .11$). There was also a significant main effect of test, $F(2, 164) = 39.64$, $MSe = .024$, $p < .001$, with scores on the name ($M = .43$, $SD = .22$) and the face ($M = .44$, $SD =$ .19) tests similar to each other, $F(1, 82) = 0.17$, $MSe = .025$, *ns*, and both higher than the scores on the associative ($M = .25$, $SD = .21$) test, $F(1, 82) = 57.46$, $MSe = .024$, $p < .01$ and $F(1, 82) = 63.80$, $MSe = .024$, $p < .01$, respectively. The interaction between age and test was not significant, $F(2, 164) = 1.36$, $MSe = .024$, *ns*. To assess the

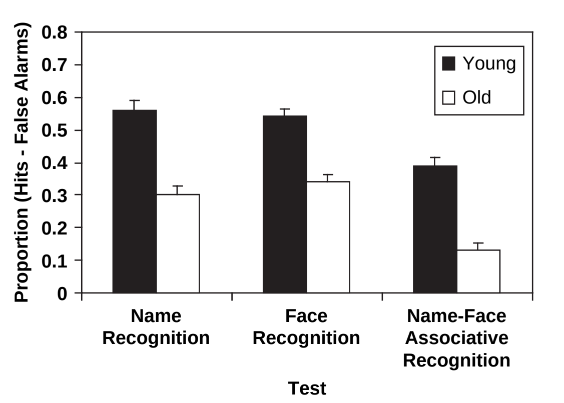

Figure 2. Memory performance under incidental learning in the name, face, and name–face association tests for younger and older adults in Experiment 2. Error bars represent standard errors around the mean.

associative deficit hypothesis, a follow-up interaction comparison with age as one variable, and the average performance on the component tests (name and face) vs the associative test as the other variable, was carried out and showed no significant interaction, $F(1, 82) = 1.60$, $MSe = .022$, *ns*. Younger and older adults reduced their performance in the associative test relative to the component test to a similar degree. Specifically, hit minus false alarm measures were .39 and .11 for younger and older adults on the associative test, and .55 and .31 for younger and older adults on the component test, respectively.

As in Experiment 1, the proportion of hits and false alarms were examined separately. These data are presented in Table 2. In terms of hits, a 2 (age) × 2 (test: component, associative) ANOVA revealed a significant main effect of age, $F(1, 82) = 13.49$, $MSe = .026$, $p < .01$, where younger adults ($M = .72$, $SD = .13$) performed better than did older adults ($M = .63$, $SD = .16$). There was also a significant main effect of test, $F(1, 82) = 4.34$, $MSe = .015$, $p < .05$, with scores on the component test ($M = .70$, $SD = .14$) higher than those on the associative test ($M = .65$, $SD = .15$). Finally, there was no significant interaction between age and type of test, $F(1, 82) = .02$, $MSe = .015$, *ns*, reflecting the fact that hit rate was lower in the associative test ($M = .70$, and $M = .61$, for young and old, respectively) than in the component test ($M = .74$, and $M = .65$, for young and old, respectively) to the same degree in the younger and older participants. These results are similar to those obtained in Experiment 1.

A 2 (Age) × 2 (test; component vs associative) ANOVA with proportion of false alarms as the dependent measure was also conducted. The analysis revealed a significant main effect of age, $F(1, 82) = 38.06$, $MSe = .029$, $p < .01$, where younger adults ($M = .25$, $SD = .10$) had lower false alarm rates than did older adults ($M = .41$, $SD = .18$). There was also a significant main effect of test, $F(1, 82) = 52.29$, $MSe = .016$, $p < .01$, with false alarm scores on the component test ($M = .26$, $SD = .14$) lower than those on the associative test ($M = .40$, $SD = .18$). Finally, the interaction between age and test was not significant, $F(1, 82) = 1.43$, $MSe = .016$, *ns*, indicating that although older adults had higher false alarm rates, these were similar for the component test ($M = .18$ and $M = .33$ for young and old, respectively) and for the associative test ($M = .31$ and $M = .49$, for young and old, respectively).

Discussion

The results of Experiment 2 showed that although older adults' overall memory performance was lower than that of the young adults, older adults did not exhibit a specific associative deficit on any of the measures used (including hits minus false alarms, as well as separate measures of hits and false alarms) when they learned the information incidentally. This result is different from a couple of past studies (e.g., Chalfonte & Johnson, 1996; Naveh-Benjamin, 2000) that have shown the existence of such a deficit under incidental learning conditions. One possibility is that this result is related to the specific stimuli used in this experiment. In particular, since associations of names and faces happen frequently in daily life, older adults have considerable practice and experience with this type of binding, which they eventually may process automatically (e.g., Hasher & Zacks, 1979). The studies by Chalfonte and Johnson (1996) and Naveh-Benjamin (2000), in contrast, employed stimuli that people do not need to bind as often in everyday life, like words and colours, colours and spatial locations, or two unrelated words. The binding of these components is not automatic, possibly explaining why older adults' associative deficit emerged with such stimuli in these studies even under incidental learning instructions.

Another possible reason for the difference in the current findings from previous literature concerns methodological issues. Specifically, in previous research (e.g., Naveh-Benjamin, 2000) the incidental associative learning condition was one in which participants did not expect an associative memory test, but were told about the upcoming item memory test. The focus on the item information in the incidental associative learning condition might have helped participants improve their item memory performance while degrading their encoding of associative information. This could have been especially true for older adults who were shown to have fewer cognitive resources (e.g., Craik, 1986; Craik & Byrd, 1982), leading to their associative deficit under incidental learning conditions. In contrast, in the current experiment the participants in the incidental learning condition were not required to intentionally encode either item or associative information. Therefore, both were likely encoded incidentally, and in this case older adults showed no deficit in automatic binding processes.

A second methodological aspect that is different from previous studies is the specific cover task required to be carried out by the participants during encoding. Participants were asked to subjectively rate whether the name and face of each pair fitted together, an assessment that could have led to a processing of the relationships between the two components, thus reducing age differences in the relative cost of the associative test.

Finally, another potential reason for the lack of an interaction between age and test in this experiment is the relatively poor performance of older adults on the associative test. To assess whether a potential floor effect might be involved here in preventing an age × test interaction, we conducted the analysis on the overall measure of accuracy (proportion hits minus proportion false alarms) while excluding participants who performed close to floor (less than 0.1 in any of the tests). The results of this analysis replicated those performed on the full sample, and in particular did not indicate an interaction between age and test, $F(2, 122) = 0.07$, $MSe = .024$, *ns*. This lends further support to our interpretation of the current results as indicating that older adults do not have a specific associative deficit in binding names and faces under incidental learning conditions.

GENERAL DISCUSSION

The two experiments reported here both replicate and extend previous results reported in the literature. Older adults have difficulty in memory for bound information, in this case for the associations between a name and a face when learning is intentional (see Naveh-Benjamin et al., 2004). Interestingly, this deficit was not found under incidental learning instructions when participants did not anticipate the subsequent memory tasks, despite the fact that the performance of older adults was lower in all three types of memory tests (face, name, and associative tests). An additional contribution of the current study is in pointing analytically to potential factors underlining the associative deficit of older adults. As mentioned in the Introduction, most studies of age-related differences in memory for items and associations that employed recognition tests looked only at a general accuracy measure, either proportion correct in forced-choice tests (e.g., Bastin & Van der Linden, 2006; Naveh-Benjamin et al., 2004) or proportion of hits minus false alarms (e.g., Naveh-Benjamin, 2000). The current study indicated an interesting pattern when the age-related associative deficit shown under intentional learning instructions was analysed further. In particular, when responses were analysed separately in terms of hits and false alarms, specific deficits emerged in older adults' performance. The results of Experiment 1 show that the associative deficit exhibited by the older adults was due exclusively to their tendency to falsely remember distractor pairs; that is, they produced especially high rates of false alarms on the associative test, but not particularly low hit rates (see also Shing et al., in press a, in press b).

As mentioned above, researchers generally agree that the effective operation of episodic memory requires interactions between the strategic and associative components of memory (Miller & Cohen, 2001; Moscovitch, 1992; O'Reilly & Norman, 2002; Prull, Gabrieli, & Bunge, 2000; Simons & Spiers, 2003). Furthermore, these two components show age-related changes in functioning (Brehmer et al., 2007; Shing et al., in press a). One possible explanation of our findings concerns older adults' deficit in employing strategic processes to encode associative information. In the present study the relative contribution of effortful strategic processes was manipulated across two experiments. The fact that an age-related associative deficit was found under intentional but not under incidental learning is in line with suggestions that older adults do not do as well as younger ones in initiating and efficiently using appropriate strategies to encode associations, in this case between names and faces. This conclusion is supported by a recent study employing a direct manipulation of strategies (Naveh-Benjamin, Keshet Brav, & Levy, 2007; see also Shing et al., in press a, for a lifespan comparison).

At the same time, in the absence of intentional learning older adults showed a general decline in their ability to remember information by mere exposure. Both empirical evidence (e.g., Eichenbaum, 2004) and computational theories (e.g., McClelland, McNaughton, & O'Reilly, 1995) suggest that the hippocampus supports fast, incidental episodic memory processes. Ageing compromises the hippocampus and related regions (Raz et al., 2005; Wilson, Gallagher, Eichenbaum, & Tanila, 2006), which in turn may negatively affect the binding of information. Furthermore, neurocomputational modelling results concerning cognitive ageing in general (Li, Lindenberger, & Sikström, 2001) and older adults' associative deficit in particular (Li, Naveh-Benjamin, & Lindenberger, 2005) suggest that ageing-related declines in neuromodulation could result in less distinctive memory representations. Similarly, the hippocampal ageing model (Wilson et al., 2006) suggests that ageing-related memory decline could arise from a lack of distinction between newly learned information and existing memory traces, possibly due to deteriorating functional connectivity between the entorhinal cortex and the hippocampus. Less distinctive memory representations due to one or both of these reasons may underlie illusory familiarity, resulting in older adults' higher false alarm rates. Overall, the differential age-related decline in associative memory, which was shown only under intentional encoding instructions and only for types of retrieval involving distractor pairs, increases the likelihood that the origin of the associative deficit is a result of age-related differences in the interaction between encoding and retrieval processes.

Taken together, while older adults' decline in the associative component may be a consequence of reduced distinctiveness of internal memory representations, they also suffer from a declining contribution of the strategic processes. The latter may be used by younger adults to increase the distinctiveness of memory representations, possibly by biasing the competition between memory representations via signals from prefrontal areas (Miller & Cohen, 2001). Future studies need to make use of paradigms that vary the relative contributions of both sets of processes to better understand their interactions (cf. Werkle-Bergner, Müller, Li, & Lindenberger, 2006).

Another potential explanation of the current results involves the importance of a reduction in attentional resources in older adults' episodic memory decline (e.g., Craik & Byrd, 1982). It might be that in Experiment 1, where participants were instructed to study names, faces, and associations among them, older adults were not able to allocate enough attentional resources to all three features, so after attending to the name and face separately, the creation of associations was neglected. Although this is a plausible explanation, several studies indicate that whereas general memory decline may be related to a decrease in attentional resources with age, older adults' differential decline in associative memory is not necessarily related to such a decrease in attentional resources (e.g., Naveh-Benjamin, Guez, & Marom, 2003a; Naveh-Benjamin et al., 2003b, 2004; but see different results by Castel & Craik, 2003).

As mentioned before, the pattern of differentially high false alarms in older adults' performance in the associative test in Experiment 1 is in line with the distinction made in the literature between familiarity, a sense of "knowing" without conscious awareness of relevant contextual information, and recollection, conscious retrieval accompanied by contextual information (e.g., Light, Prull, La Voie, & Healy, 2000; Yonelinas, 2002; see also Jacoby, 1991). Previous research has provided evidence that, whereas familiarity remains mostly unaffected in old age, recollection is strongly impaired in older adults (e.g., Light et al., 2000; Prull, Dawes, Martin, Rosenberg, & Light, 2006). Using these terms, it is possible that older adults' tendency to erroneously accept re-paired associations as intact (resulting in a high false alarm rate) is related to the age-related changes in the mechanism of familiarity and recollection. In particular, whereas the item memory tests may have been at least partially performed based on familiarity, the associative tests required recollection; together with an inability to recollect the originally studied pairs, older adults' high levels of familiarity with individual items might have led them to high rates of incorrect recognition of recombined pairs (cf. Daselaar, Fleck, Dobbins, Madden, & Cabeza, 2006). Furthermore, older adults' disproportionally higher false alarm rates on the associative test in Experiment 1 but not in Experiment 2 could have been due to the higher levels of familiarity with item information in Experiment 1 where they intentionally tried to encode the name and the face components, relative to Experiment 2, when learning of the components was incidental. This could have led to older adults' higher false alarms rates in the associative test of Experiment 1 but not Experiment 2 (see similar results by Old & Naveh-Benjamin, 2008b, under intentional learning conditions for person–action associations). The current findings are also compatible with the notion that older adults tend to be "captured" by misleading information such that they may forgo engaging in recollection (Jacoby & Rhodes, 2006). Such deficits may reflect a decline in strategic processes that underlie cognitive control at retrieval (Rugg & Wilding, 2000).

An applied implication of the current results arises from the fact that while older adults show a deficit in remembering the associations between names and faces, this deficit seems to happen mostly under intentional learning conditions. Given that, in daily life, such learning often happens incidentally (e.g., when people are introduced to each other in a social situation), the current results may indicate that, in general, older adults may not have a specific problem in learning the name–face associations, although their overall memory performance in terms of the name, the face, and the association (as indicated in Experiment 2) may be relatively poor in comparison to that of younger adults. Second, older adults, at least under intentional learning conditions, may not have as much of a problem correctly recognising that a given person's name is actually what it is, but may have problems such as attributing a wrong name to a given face. As mentioned earlier, this finding is somewhat similar to results reported in eyewitness research, which show that older adults generally perform nearly as well as do young adults at identifying culprits when the culprit is present in a given line-up, but tend to commit false identifications at high rates when the culprit does not appear in the line-up (Wells & Olson, 2003). Finally, in terms of intervention studies, the current results indicate that in order to improve older adults' memory for associations between names and faces, specific strategies could be employed to promote relationships between the name and the face. However, these interventions do not necessarily need to promote the familiarity of the name or the face, as this might increase false memory for the associations.

In summary, the current experiments extend the ADH to memory for ecologically relevant stimuli, showing that older adults have a specific deficit in memory for name–face associations. However, this deficit was exhibited under intentional but not under incidental learning instructions. This finding highlights the role of strategic processes in the associative deficit, suggesting that older adults may have trouble initiating efficient associative strategies when trying to intentionally encode information. Furthermore, employing a yes–no recognition paradigm, which allowed the separate analysis of hits and false alarms, facilitated the identification of the locus of the age-related associative deficit of older adults in the current experiments, which seems to be driven more by high false alarm rates than by low hit rates.

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