

An Age-Related Dissociation of Short-Term Memory for Facial Identity and Facial Emotional Expression

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Background. Memory for both facial emotional expression and facial identity was explored in younger and older adults in 3 experiments using a delayed match-to-sample procedure.

Method. Memory sets of 1, 2, or 3 faces were presented, which were followed by a probe after a 3-s retention interval.

Results. There was very little difference between younger and older adults in memory for emotional expressions, but memory for identity was substantially impaired in the older adults.

Discussion. Possible explanations for spared memory for emotional expressions include socioemotional selectivity theory as well as the existence of overlapping yet distinct brain networks for processing of different emotions.

Key Words: Aging—Delayed match-to-sample—Facial expression—Facial identity—Short-term memory.

FROM infancy to old age, memory for faces and their expressions is a critical component of social interaction. It can be of vital importance to remember who aided you and who injured you and who is likely to be friendly and who is likely to be dangerous. Research suggests that the two—memory for facial identity and memory for facial emotional expression—are dissociable. Lesion studies have demonstrated that prosopagnosics are deficient in face recognition (e.g., Damasio, Damasio, & Van Hoesen, 1982), yet some prosopagnosics can still recognize emotional clues from facial expressions (e.g., Tranel, Damasio, & Damasio, 1988). Electroencephalography studies show an event-related potential (ERP) for facial identity matching at about 200 ms post stimulus whereas the ERP for expression matching appears around 450 ms, suggesting that they are different processes (e.g., Münte et al., 1998). Neuroimaging studies of facial identity consistently find activation in the fusiform gyrus (e.g., Kanwisher, McDermott, & Chun, 1997), and activity has been reported as well in the lingual gyrus, the parahippocampal gyrus, and anterior temporal cortex (e.g., Sergent, Otha, & MacDonald, 1992). In contrast, neuroimaging of facial emotional expressions finds differing patterns of activation for different emotions (for a review, see Posamentier & Abdi, 2003).

The purpose of the present research is to compare the effects of aging on short-term or working memory for facial identity and for facial emotional expression. Studies of age and working memory, in which information is held for a short time, show a general pattern of poorer performance in older than in younger adults. Age differences have been documented in working memory for a variety of stimuli, including verbal information (Park et al., 2002; Park et al., 1996), visual images (Park et al., 2002), objects (Hartley,

Speer, Jonides, Reuter-Lorenz, & Smith, 2001), spatial locations (Myerson, Hale, Rhee, & Jenkins, 1999; Salthouse, 1995), and facial identity (Grady et al., 1995, 1998). What should we expect about age and short-term memory for facial expressions? On one hand, old age is characterized by clear declines in a variety of cognitive functions (e.g., Park, Polk, Mikels, Taylor, & Marshuetz, 2001; Salthouse, 2004) as well as a loss of cortical volume, particularly in areas that subserve memory, including frontal and temporal cortex (e.g., Raz et al., 1997). Thus, we might expect age-related impairments in memory for both facial identity and facial emotional expressions. In contrast, socioemotional selectivity theory (SST, Carstensen, 1995; Carstensen, Isaacowitz, & Charles, 1999) might lead us to predict that memory for facial emotional expression would be preserved despite age-related impairments in memory for facial identity. SST asserts that motivations change from young adulthood to old age: When people perceive time as effectively unlimited, they give priority to goals related to knowledge acquisition; in contrast, when they perceive time as limited as life is coming to an end, they prioritize goals related to emotional meaning. Differing time horizons determine the different goals, such that young adults pursue knowledge-related goals, whereas older adults pursue emotion-related goals in their later years. In the service of these emotional goals, SST posits that attention and memory function preferentially for emotional information in general and for positive relative to negative emotions in particular (Carstensen & Mikels, 2005). From this perspective, we might expect processes related to identifying and retaining emotional information to be relatively preserved in older adults.

Several investigators have explored age differences in longer term memory for facial identity and facial emotional

expressions. D'Argembeau and Van der Linden (2004) presented a series of happy or angry faces. After a 5-min retention interval, participants were given a recognition test with neutral faces and asked to identify those that they recognized. For recognized faces, they were also asked to recall the emotion shown during the encoding phase. Recollection of facial identity was poorer for older adults, but there was no difference between younger and older adults in recall of the emotion displayed for recognized faces. Savaskan and colleagues (2007) employed a similar procedure and found that both recognition of identity and recall of the emotion were lower in older adults. Grady, Hongwanishkul, Keightley, Lee, and Hasher (2007) collected recognition judgments of identity but not recall of emotion. Recognition was poorer in older adults. In younger but not older adults, recognition was better for faces characterized as emotionally negative. Ebner and Johnson (2009) also collected only recognition judgments. Faces showed the same emotion at both encoding and test. Happy faces were best recognized, equivalently for younger and older adults. Angry faces were least well recognized, with older adults performing more poorly than younger adults for both neutral and angry faces. Overall, longer term recognition of facial identity is poorer in older adults, but no simple generalization is possible about retention of emotional expression. Differences in outcomes likely reflect differences in procedures.

The present experiments used a delayed match-to-sample procedure (Galster et al., 2009; Luciana et al., 2001). Mikels and colleagues (Mikels, Larkin, Reuter-Lorenz, & Carstensen, 2005; Mikels, Reuter-Lorenz, Beyer, & Fredrickson, 2008) also used a delayed match-to-sample procedure, but the participants compared their own emotional response to one photograph with their emotional response to a subsequent photograph. In the present study, a memory set of one, two, or three photographs of faces was presented. Then, after a retention interval, a probe face was presented. The task was to indicate whether the probe matched or did not match an item in the memory set. In Experiment 1, the task was to determine if there was a match in emotional expression. The six basic emotions were used (i.e., happiness, sadness, anger, fear, disgust, and surprise). Each model in the memory set and probe was a different individual. If recognized, an emotion can be named; thus maintenance might be aided by rehearsal of a verbal memory. If older adults suffer a deficit in emotional short-term memory, verbal rehearsal might mask it. However, the evidence is that older adults are less able to recognize and label most emotions (see Ruffman, Henry, Livingston & Phillips, 2008, for a review), so their poorer labeling skills might exaggerate differences. To explore these possibilities, we also created a set of morphed faces, containing combinations of the basic emotions (e.g., happy combined with angry). We reasoned that these morphed emotional expressions would be difficult to name and, thus, would reduce the influence of the ability to label emotions and would force reliance on the emotional

information itself. In Experiment 2, the task was to match identities. Each model in the memory set was a different individual displaying a different emotion. The probe either matched or did not match the identity of a model from the memory set, but the emotion displayed by the probe was different from any in the memory set.

EXPERIMENT 1: MEMORY FOR EMOTIONAL EXPRESSION

Method

Participants.—The participants included 31 younger adults (9 men and 22 women) who volunteered for course credit and 31 older participants (7 men and 24 women) who volunteered for a stipend of \$15. Younger adults averaged 19.45 years of age ($SD = 1.19$ years) and had 13.31 years of education ($SD = 1.23$ years) whereas older adults averaged 72.93 years of age ($SD = 5.39$ years) and had 15.55 years of education ($SD = 3.08$ years). Additionally, younger adults had an average visual acuity of 20/24.83, measured with a Snellen chart at 20 ft (6.10 m), and rated their present health at 8.34 ($SD = 1.03$) on a 10-point scale, with 10 being excellent; older adults had an average visual acuity of 20/30.00 and rated their present health at 8.34 ($SD = 1.35$).

Stimuli.—Photographs of 35 female models from the Karolinska Directed Emotion Faces (KDEF, Lundqvist, Flykt, & Öhman, 1998) provided the pool of stimuli for simple emotional expressions. The models were without makeup or adornment and each was wearing a plain, gray t-shirt. The model's faces were photographed in color, straight on, displaying each of the six basic emotions: happy, sad, angry, afraid, surprised, and disgusted. For the morphed emotional expressions, 50:50 morphs (happy and sad each morphed with anger, surprise, and disgust) were created using Fantamorph (Abrasoftware) for each of the 35 models, resulting in a total of six morphed emotional expressions. An example of a face showing a simple emotion and a morphed emotion is given in Figure 1.

Design and procedure.—There were two introductory blocks of trials, not using the delayed match-to-sample procedure, to aid the participant in understanding the task. In the first block of 18 trials, faces of two different models were presented side by side for 2000 ms then removed. The participant had to indicate whether the two faces were displaying the same or different emotions. Feedback for correctness was given. In fact, in every case the emotions were the same. This was explained at the end of the block with the caution that there can be differences in the way two different people display the same emotion. The procedure was the same for the second subblock of practice trials except that the emotions matched on half of the trials and did not match on the other half. Following the two introductory blocks, a block of 18 practice trials introduced the delayed



Figure 1. Example of facial stimuli. *Left panel:* Simple emotion (sadness). *Right Panel:* Morphed emotion (sadness and surprise).

match-to-sample procedure with a memory set size of two, again with feedback on each trial.

After the practice trials, there were six blocks of experimental trials with two blocks at each memory set size: one, two, or three facial photographs. The two blocks at each memory set size incorporated both a block with simple emotional expressions and also a block with morphed emotional expressions. Both the order of the set sizes and the order of the expression type (simple or morphed) within a set size were counterbalanced across participants. Each experimental block comprised 60 trials. For Set Size 1, eight models were used; for Set Size 2, 16 models, and for Set Size 3, 24 models. There were 12 photographs of each model, six displaying simple emotions and six displaying morphed emotions. The models used for Set Size 3 included those from Set Size 2 and those for Set Size 2 included those from Set Size 1.

Each trial began with one, two, or three gray rectangles on a black background displayed where the memory set items would appear. After 1000ms, the gray rectangles were replaced by the memory set items arrayed horizontally across the screen. The memory set was displayed for 1000ms (Set Size 1), 2000ms (Set Size 2), or 3000ms (Set Size 3). The items were then removed, leaving a black screen present for the retention interval of 3000ms. Next, the probe stimulus appeared and remained until a response was sensed. The participant pressed one of two adjacent keys to indicate whether the probe matched one of the memory set items or did not match any of them; on half of the trials, the emotional expression of the probe model matched that of one from the memory set. No feedback was given on experimental trials, and the six emotional expressions appeared equally often. The models were chosen for

each trial at random, without replacement, so that every individual seen on a trial was different.

Results

The first analyses examined the proportion of correct judgments as a function of the age group (younger or older), the Set Size (1, 2, and 3), and the emotional expression manipulation (simple and morphed). Significance was set at 0.05 for all tests. When tests for sphericity were significant, a Greenhouse-Geisser correction was applied, and the corrected probability is reported. There was a significant main effect of set size, $F(2, 120) = 173.65$, $p < .001$, $\eta_p^2 = .74$, such that accuracy at Set Size 1 ($M = 0.72$, $SE = 0.01$) was greater than that at Set Size 2 ($M = 0.62$, $SE = 0.01$), which was in turn greater than that at Set Size 3 ($M = 0.58$, $SE = 0.01$). There was also a significant main effect of the expression manipulation, $F(1,60) = 178.61$, $p < .001$, $\eta_p^2 = .75$, such that accuracy for morphed emotional expressions ($M = 0.58$, $SE = 0.01$) was less than that for simple emotions ($M = 0.70$, $SE = 0.01$). The main effect of age group was not significant, $F(1,60) = 2.82$, $p = .098$, $\eta_p^2 = .04$, as older adults ($M = 0.63$, $SE = 0.02$) were only slightly less accurate than younger adults ($M = 0.65$, $SE = 0.01$). The two-way interaction of set size and morphing approached significance, $F(2, 120) = 3.05$, $p = .052$, $\eta_p^2 = .05$, possibly because accuracy approached floor level with three morphed faces. The two-way interaction of age group and morphing was nonsignificant, $F(1,60) = 2.94$, $p = .12$, $\eta_p^2 = .04$. The two-way interaction of age group and set size was clearly nonsignificant, $F(2, 120) = 0.82$, $p = .44$, $\eta_p^2 = .01$, as was the three-way interaction of age group with set size and morphing, $F(2, 120) = 0.87$, $p = .42$, $\eta_p^2 = .01$. Descriptive statistics for accuracy as a function

of age group, set size, and morphing are shown graphically in the upper panel in Figure 2. Examination of Figure 2 suggests the presence of an interaction of age group and set size for simple emotions. This simple interaction effect did not approach significance, $F(2, 120) = 1.20, p = .30, \eta_p^2 = .02$. Figure 2 also suggests there may have been floor effects, particularly for morphed stimuli at larger set sizes. To explore this we tested whether accuracy was significantly better than chance for morphed stimuli at Set Size 2 and 3 for both older and younger adults, using one-tailed tests. For older adults accuracy at both set sizes was significantly above chance: Set Size 2, $t(30) = 4.93, p < .001$; Set Size 3, $t(30) = 3.35, p = .002$. For younger adults the difference was significant at Set Size 2, $t(30) = 5.77, p < .001$, and approached significance at Set Size 3, $t(30) = 1.65, p = .054$.

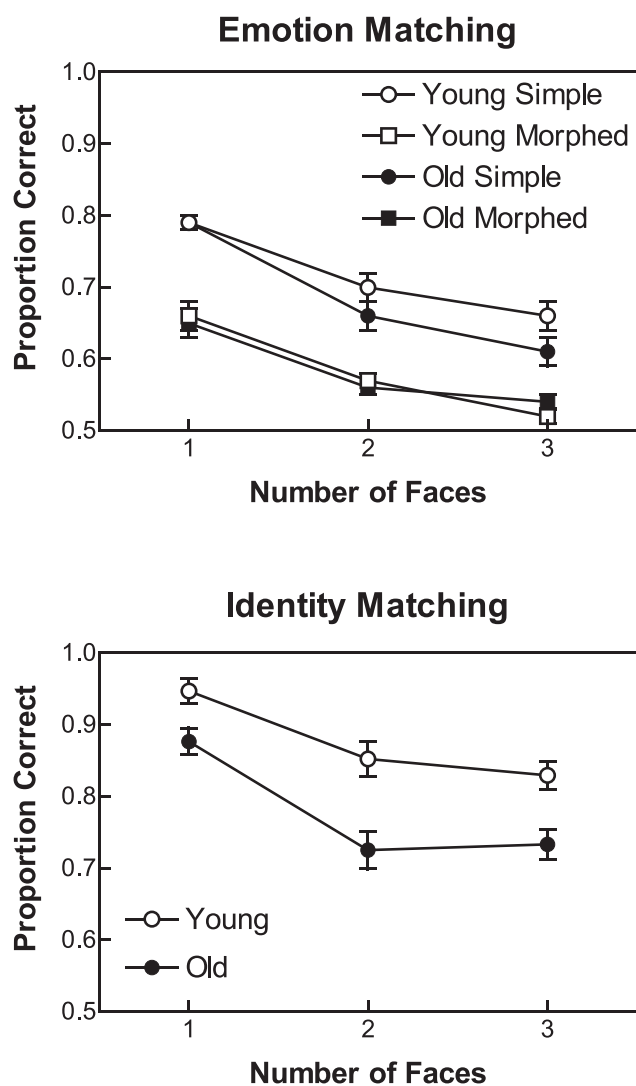


Figure 2. *Top Panel:* Accuracy in facial emotional expression matching (Experiment 1) as a function of age group, simple or morphed emotional expression, and set size. *Bottom Panel:* Accuracy in facial identity matching (Experiment 2) as a function of age group and set size. Bars show standard errors.

The second set of analyses examined the signal-detection parameters, d' and β , as a function of the same factors. Descriptive statistics are given in Table 1 (statistics for hits and false alarms for all three of the experiments reported here are available in the Supplementary Materials). The sensitivity, d' , reflects the discriminability of matches and mismatches, whereas the criterion, β , reflects any tendency to favor match responses (indicated by a value greater than 1) or mismatch responses (indicated by a value less than 1). Analysis of d' showed significant main effects of set size, $F(2, 120) = 159.28, p < .001, \eta_p^2 = .73$, and morphing, $F(2, 120) = 169.67, p < .001, \eta_p^2 = .74$, but no effect of age group, $F(1, 60) = 2.37, p = .13, \eta_p^2 = .04$. There was also an interaction of set size and morphing, $F(2, 120) = 4.49, p = .015, \eta_p^2 = .07$. The difference between simple and morphed expressions was smaller at Set Size 3, probably due to a floor effect. No other effects were significant including the interaction of age group and set size, $F(2, 120) = 0.37, p = .69, \eta_p^2 = .01$. Analysis of β showed a significant main effect of set size, $F(2, 120) = 7.26, p = .001, \eta_p^2 = .11$; pairwise comparisons showed that there was a decrease in β from Set Size 1 ($M = 1.12, SE = 0.05$) to Set Size 2 ($M = 0.98, SE = 0.03$) and Set Size 3 ($M = 0.96, SE = 0.02$), which did not differ. Analysis of β also showed a significant main effect of age group, $F(1, 60) = 13.22, p = .001, \eta_p^2 = .18$, as younger adults were more biased in favor of a match response ($M = 1.11, SE = 0.03$) than were older adults ($M = 0.94, SE = 0.03$). There was a significant two-way interaction of set size and age group, $F(2, 120) = 4.20, p = .017, \eta_p^2 = .06$, as well as of set size and morphing, $F(2, 120) = 4.19, p = .017, \eta_p^2 = .06$. These were qualified by an interaction of age group with set size and morphing, $F(2, 120) = 4.52, p = .013, \eta_p^2 = .07$. Young adults viewing simple expressions decreased their bias toward a match response as set size increased; no other condition was affected by set size.

For the simple emotional expressions, we also examined accuracy for the six individual emotions for those trials on which the probe matched an item in the memory set. The results are shown in Figure 3. There were significant main effects of emotion, $F(5, 300) = 22.96, p < .001, \eta_p^2 = .32$, and set size, $F(2, 120) = 79.01, p < .001, \eta_p^2 = .62$, but not of age group, $F(1, 60) = 2.95, p = .09, \eta_p^2 = .06$. The interaction of emotion and set size was significant, $F(10, 600) = 6.75, p < .001, \eta_p^2 = .12$; the interaction of age group and emotion was not, $F(5, 300) = 0.46, p = .80, \eta_p^2 = .01$. The results can be seen in Figure 3. Pairwise comparisons on the effects of emotion at Set Size 1 showed that accuracy was greatest for happy expressions and lowest for fear, with the other emotions intermediate. At Set Size 2, accuracy was greater for happy expressions than others. At Set Size 3, there was little differentiation. This interaction was not qualified by the three-way interaction of emotion and set size with age group as it was not significant, $F(10, 600) = 0.65, p = .77, \eta_p^2 = .01$. A similar

Table 1. Means for Signal-detection Statistics in Experiment 1

Statistic	Age group	Emotion	Set Size		
			1	2	3
d'	Younger	Simple	1.77 (0.08)	1.12 (0.11)	0.81 (0.09)
		Morphed	0.88 (0.09)	0.39 (0.06)	0.10 (0.08)
	Older	Simple	1.68 (0.09)	0.95 (0.11)	0.58 (0.10)
		Morphed	0.96 (0.10)	0.31 (0.07)	0.20 (0.08)
β	Younger	Simple	1.44 (0.12)	1.15 (0.06)	0.89 (0.04)
		Morphed	1.07 (0.05)	0.96 (0.04)	1.13 (0.08)
	Older	Simple	0.97 (0.13)	0.96 (0.06)	0.91 (0.04)
		Morphed	0.88 (0.06)	0.96 (0.04)	0.98 (0.08)

Note. Standard errors in parentheses.

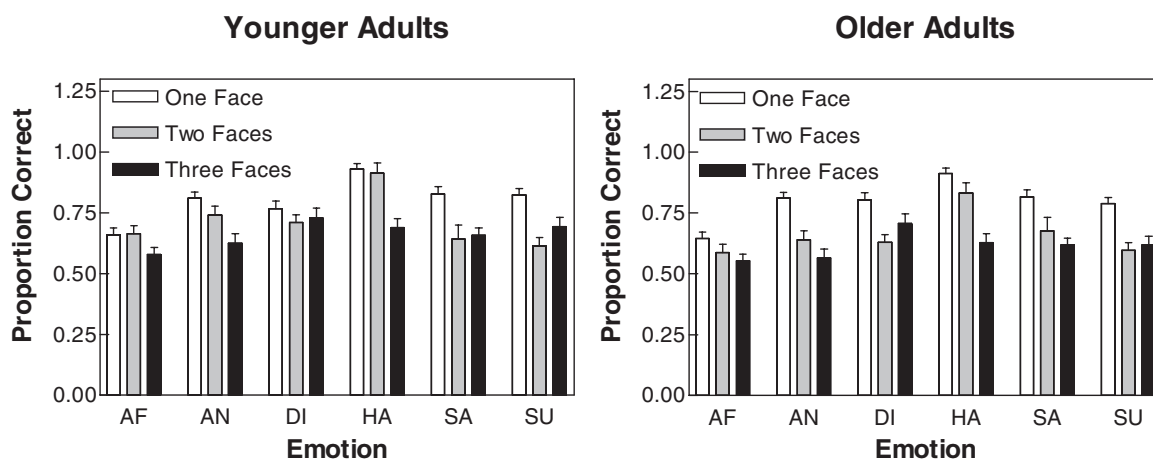


Figure 3. Accuracy in Experiment 1 as a function of probe emotion and set size for younger adults (left panel) and older adults (right panel). Set Size 1, white bars; Set Size 2, gray bars; Set Size 3, black bars. Abbreviations: AF, afraid; AN, angry; DI, disgusted; HA, happy; SA, sad; SU, surprised.

analysis for morphed expressions yielded no significant effects. Nonmatch trials were not examined because of the large number of ways in which the memory set items and probe could differ.

Discussion

Accuracy decreased as set size increased, and morphed expressions were judged less accurately than simple emotional expressions. The principal result, though, is very clear. Older adults were not significantly less accurate than younger adults, and manipulations of set size and morphing did not qualify that conclusion. It appears that short-term memory for emotional expression does not show the age-related differences found in working memory for verbal material, spatial locations, visual images, and objects. Consistent with previous findings, accuracy was greatest for happy expressions in both age groups at least at Set Size 1 and 2—that is, both groups showed a positivity bias (Löckenhoff & Carstensen, 2007).

Morphed stimuli were included to provide emotional expressions that would not be familiar, simple emotions.

Performance was equivalent for younger and older adults at all set sizes, which would suggest that the absence of age differences with simple emotions was not due to the older adults’ greater familiarity. Because performance for both groups was close to chance, especially at Set Size 3, it might be argued that older adults would have performed more poorly except that the age difference was obscured by a floor effect. First, performance for older adults was significantly above chance (and in fact slightly better than younger adults). More importantly, no age difference was seen at Set Size 2 where performance was significantly above chance or at Set Size 1 where performance was clearly above chance but nowhere near ceiling. Thus, we believe it is warranted to conclude that memory for morphed stimuli was equivalent in younger and older adults.

The question addressed in Experiment 2 was whether a similar or different result would be found when comparisons are based on facial identity rather than facial expression. Because Grady and colleagues (1998) found that older adults were significantly less accurate than younger adults in a delayed match-to-sample task, we expected to find the same.

EXPERIMENT 2: MEMORY FOR IDENTITY

Experiment 2 was very similar to Experiment 1 except that the task was to indicate whether the identity of the probe matched the identity of any of the memory set photographs. In addition, there were no morphed stimuli. Morphs were included in Experiment 1 to create unfamiliar emotions that would not be easily labeled. In contrast to simple emotions, the faces seen would all be unfamiliar already.

Method

Participants.—There were 32 younger adult participants (3 men and 29 women) who volunteered for course credit and 30 older participants (9 men and 21 women) who volunteered for a stipend of \$15. Younger adults averaged 20.04 years of age ($SD = 1.11$ years) and had 12.92 years of education ($SD = 1.06$ years) whereas older adults averaged 74.43 years of age ($SD = 6.53$ years) and had 15.68 years of education ($SD = 2.77$ years). Additionally, younger adults had an average visual acuity of 20/21.40 ($SD = 6.25$), measured with a Snellen chart at 6.10 m, and rated their present health at 8.66 ($SD = 1.24$) on a 10-point scale, with 10 being excellent; older adults had an average visual acuity of 20/32.33 ($SD = 10.14$) and rated their present health at 8.18 ($SD = 1.29$).

Design and procedure.—Following a practice block, there were three blocks of 60 experimental trials: memory set sizes of one, two, and three. (There were half as many trials as in Experiment 1 due to the omission of blocks with morphed stimuli.) The order of the set sizes was counterbalanced across participants. The task in Experiment 2 was to indicate whether the identity of the probe model matched the identity of any member of the memory set. The timing was identical to Experiment 1. The identities of the memory set were chosen randomly, sampling without replacement, and every individual in the memory set and probe displayed a different emotional expression. The practice block comprised 18 trials identical to the experimental trials except that feedback was provided whereas it was not for the experimental trials.

Results

Analysis of accuracy as a function of age group and set size showed significant main effects of age group, $F(1, 60) = 24.09, p < .001, \eta_p^2 = .29$, and set size, $F(2, 120) = 36.55, p < .001, \eta_p^2 = .38$. Younger adults ($M = 0.87, SE = 0.01$) were significantly more accurate than older adults ($M = 0.78, SE = 0.01$). Pairwise comparisons showed that accuracy was significantly better at Set Size 1 ($M = 0.91, SE = 0.01$) than at Set Size 2 ($M = 0.78, SE = 0.02$) or Set Size 3 ($M = 0.78, SE = 0.01$) which did not differ. No other effects were significant, specifically the interaction of age and set size was nonsignificant, $F(2, 120) = 2.06, p = .13, \eta_p^2 = .03$. Accuracy as a function of age group and set size is shown graphically in the lower panel of [Figure 2](#).

Analysis of d' showed significant main effects of age group, $F(1, 60) = 32.29, p < .001, \eta_p^2 = .35$, and set size, $F(2, 120) = 53.03, p < .001, \eta_p^2 = .47$. Sensitivity was greater for younger adults ($M = 2.78, SE = 0.12$) than for older adults ($M = 1.81, SE = 0.12$). Sensitivity was also greater for Set Size 1 ($M = 3.22, SE = 0.12$) than that for Set Size 2 ($M = 1.93, SE = 0.14$) or 3 ($M = 1.73, SE = 0.11$), which did not differ. The interaction of age group and set size was nonsignificant, $F(2, 120) = 1.04, p = .35, \eta_p^2 = .02$. Analysis of β showed only a significant effect of age group, $F(1, 60) = 12.66, p < .001, \eta_p^2 = .17$, such that younger adults were substantially more biased in favor of a match response ($M = 1.94, SE = 0.18$) than were older adults ($M = 1.03, SE = 0.18$). No other effects were significant. Specifically, the interaction of age group and set size was nonsignificant, $F(2, 120) = 0.22, p = .76, \eta_p^2 = .00$.

Discussion

In contrast to Experiment 1 in which younger and older adults did not differ, older adults were significantly less accurate at matching facial identity than were younger adults. Processing two or three faces was as difficult for young adults as was processing a single face for older adults. This reduced accuracy is consistent with the findings reported by [Grady and colleagues \(1998\)](#). The age difference, however, was not exacerbated as the set size increased. Also, in contrast with the prior facial emotion-matching task, performance did not continue to decrease from Set Size 2 to Set Size 3. Performance remained well above chance even at larger set sizes.

Discussion of Experiments 1 and 2

The results show an age-related dissociation of short-term or working memory for emotional expressions and for identity. Younger and older adults were equally able to retain the emotional expressions of people who were observed over a retention interval; however, the ability of older adults to maintain the identity of the people was impaired in comparison to younger adults. These results converge with clinical, electrophysiological, and brain-imaging results showing that memory for emotional expression and memory for identity are dissociable. Further, consistent with previous findings using measures of longer term memory, these results suggest that the two types of memory have different trajectories with increasing age. The results with emotion can be seen as consistent with previous findings with measures of longer term memory: Although older adults were less accurate at recognizing individuals, when only correct recognitions were considered, [D'Argembeau and Van der Linden \(2004\)](#) found that recall of the originally seen emotion (happiness or anger) was as good in older adults as in younger adults. Nevertheless, the evidence of maintained longer term memory for emotional expressions despite aging remains speculative as [Savaskan and colleagues](#)

(2007) found that recall of the emotion was poorer in older adults.

We used young adult faces, so the models differed in age from the older adults but not from the younger adults. It might be argued that there were different-age (versus own-age) effects. See Rhodes and Anastasi (2012) for a comprehensive review of findings on own-age bias. First, Ebner and Johnson (2009) found no evidence of an own-age bias in memory for emotional expressions. More important, if older adults had more difficulty recognizing emotions expressed by younger adults, that would have exaggerated rather than reduced any age difference in accuracy. Ebner, Johnson, and Fischer (2012) found that, in fact, both younger and older adults were better at identifying emotions expressed by younger adults than by older adults. Nevertheless, if the use of different-age stimuli selectively impaired older adults in the identity task (Experiment 2), then this could have produced the age differences in that task.

There was an asymmetry between Experiment 1, in which there were only six emotions to be matched, and Experiment 2, in which as many as 24 distinct models were used. One might expect, then, that proactive interference would be greater in emotion matching than identity matching. If older adults were more affected by proactive interference it would have exaggerated age-group differences in Experiment 1. No differences were found. If, however, younger adults were more affected, it could have impaired their performance, reducing them to the level of the older adults.

To address these possible problems, we carried out a third experiment. In this experiment participants completed both the emotion-matching task and the identity-matching task. The experiment was a replication of Experiments 1 and 2, but with important changes. We used photographs of both younger and older adults from the FACES database (Ebner, Riediger, & Lindenberger, 2010). Because of restrictions on the use of these stimuli, we were not able to use morphed stimuli. We equated the number of unique models of each age to the number of emotions, with six of each. Finally, in an effort to improve performance and remove possible floor effects, we doubled the study time for the memory set: 2 s for Set Size 1, 4 s for Set Size 2, and 6 s for Set Size 3, and we also provided accuracy feedback on every trial.

EXPERIMENT 3

Method

Participants.—Participants were 24 younger adults and 24 older adults from the same populations as Experiments 1 and 2. Younger adults (20 women) averaged 20.38 years of age ($SD = 0.90$ years), had an average of 14.13 years of education ($SD = 0.88$ years), and gave an average health rating of 8.52 ($SD = 0.70$). Older adults (18 women) averaged 75.41 years of age ($SD = 7.09$), had an average of 15.97 years of education ($SD = 2.57$ years), and gave an

average health rating of 8.00 ($SD = 1.26$). Average visual acuity was 20/19.58 for younger adults ($SD = 2.47$) and was 20/37.86 for older adults ($SD = 15.08$). All participants received a stipend of \$15.

Stimuli.—The models were six younger women ($M = 24.00$ years) and six older women ($M = 74.17$ years). Each was unadorned and was wearing a plain, gray t shirt. Each was photographed in color, frontally, in six emotional poses: happy, sad, angry, afraid, disgusted, and neutral. (Surprise, which had been used in Experiments 1 and 2 was not included in this database and was replaced by neutral photographs.)

Design and procedure.—There were two tasks: emotion matching and identity matching. Half of the participants completed emotion then identity; the other half, the reverse. Within each task there were blocks of Set Size 1, 2, and 3. The order of set sizes for the first task was counterbalanced across participants. For each participant the order of set sizes for the second task was the reverse of that for the first, that is, an ABCCBA order. The procedure was nearly identical to that in Experiments 1 and 2 except that the time to study the memory set was doubled and accuracy feedback was given on every trial. In addition, in a random mix, half of the trials had young adult models whereas the other half had older adult models. The same training procedures to introduce the emotion-matching used in Experiment 1 were also used in Experiment 3.

Results

To parallel Experiments 1 and 2, separate analyses were carried out for the emotion-matching task and for the identity matching task. Analyses of variance (ANOVAs) on proportion correct, d' , and β were carried out with set size and age of model as within-subjects factors and age group as a between-subjects factor. The effect of task order did not interact with any other factor for either task so results involving task order are not reported.

Emotion-matching task.—For accuracy there were significant main effects of set size, $F(2, 94) = 21.41, p < .001, \eta_p^2 = .31$, and age of model, $F(1, 47) = 8.99, p = .004, \eta_p^2 = .16$. Performance declined with increasing set size and was poorer for older models ($M = 0.78, SE = 0.01$) than for younger models ($M = 0.82, SE = 0.01$). The main effect of age group was nonsignificant, $F(1, 47) = 0.44, p = .51, \eta_p^2 = .01$. No other effects approached significance. Specifically, the interaction of age group and set size—shown graphically in the upper panel of Figure 4 (also see Figure 4a in the Supplementary Materials)—did not approach significance, $F(2, 94) = 2.08, p = .13, \eta_p^2 = .04$, nor did the interaction of age group (age of participant) and age of model, $F(1, 47) = 0.63, p = .43, \eta_p^2 = .01$. For d' there were significant main effects of set size, $F(2, 94) = 16.36, p < .001, \eta_p^2 = .26$, and age of model, $F(1, 47) = 8.38,$

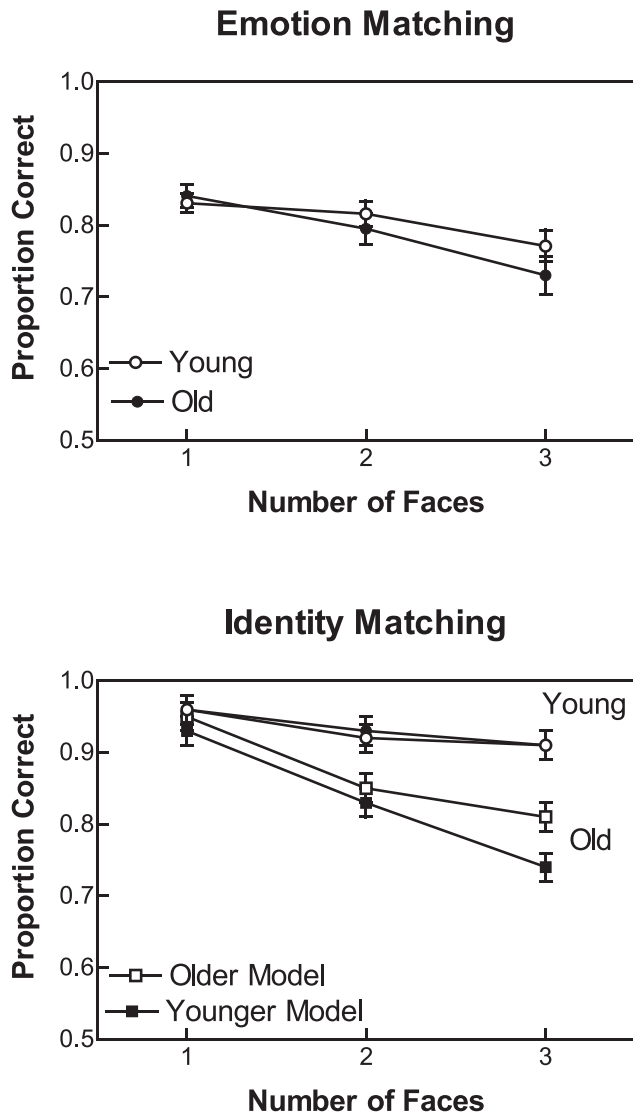


Figure 4. *Top panel:* Experiment 3, emotion-matching task accuracy as a function of age group and set size. *Bottom panel:* Experiment 3, identity-matching task accuracy as a function of age group, set size, and age of model. Bars show standard errors.

$p = .006$, $\eta_p^2 = .15$. Pairwise comparisons showed that sensitivity declined with increasing set size (for Set Size 1, $M = 2.38$, $SE = 0.11$; for Set Size 2, $M = 2.03$, $SE = 0.12$; for Set Size 3, $M = 1.65$, $SE = 0.12$) and was lower for older models ($M = 1.89$, $SE = 0.10$) than for younger models ($M = 2.15$, $SE = 0.10$). The main effect of age was nonsignificant, $F(1, 47) = 0.36$, $p = .55$, $\eta_p^2 = .01$. No other effects approached significance. Specifically, the interaction of age group and set size was not significant, $F(2, 94) = 1.97$, $p = .14$, $\eta_p^2 = .04$, nor was the interaction of age group (age of participant) and age of model, $F(1, 47) = 1.28$, $p = .26$, $\eta_p^2 = .03$. For β there was a significant main effect of age group, $F(1, 47) = 5.29$, $p = .03$, $\eta_p^2 = .20$, with younger participants more biased toward a match response ($M = 1.30$, $SE = 0.07$) than older adults ($M = 1.07$, $SE = 0.07$).

Identity-matching task.—The results are shown graphically in the lower panel of Figure 4. There were significant main effects of age group, $F(1, 47) = 25.53$, $p < .001$, $\eta_p^2 = .35$, set size, $F(2, 94) = 40.51$, $p < .001$, $\eta_p^2 = .46$, and age of model, $F(1, 47) = 6.70$, $p = .01$, $\eta_p^2 = .12$. Accuracy was greater for younger participants ($M = 0.93$, $SE = 0.01$) than for older participants ($M = 0.85$, $SE = 0.01$). Performance declined with increasing set size and was better with younger models ($M = 0.90$, $SE = 0.01$) than with older models ($M = 0.88$, $SE = 0.01$). In contrast to emotion matching in Experiments 1 and 3 and identity matching in Experiment 2, the interaction of age group and set size was strongly significant, $F(2, 94) = 12.11$, $p < .001$, $\eta_p^2 = .20$, as seen in the lower panel of Figure 4. Older adults showed a greater decline in accuracy with increasing set size, $F(2, 48) = 49.39$, $p < .001$, $\eta_p^2 = .67$, than did the younger adults, $F(2, 46) = 4.09$, $p = .04$, $\eta_p^2 = .15$. Post hoc tests showed that for younger adults there was no significant change between Set Size 2 and Set Size 3 whereas for older adults the decline was significant. The interaction of age group and age of model was also significant, $F(1, 47) = 9.58$, $p = .003$, $\eta_p^2 = .17$. For younger adults, younger and older models were recognized equally well (for both, $M = 0.93$, $SE = 0.01$) whereas for older adults, accuracy for older models ($M = 0.87$, $SE = 0.01$) was significantly greater than that for younger models ($M = 0.83$, $SE = 0.01$), $t(24) = 4.28$, $p < .001$. The interaction of age group, set size, and age of model did not approach significance, $F(2, 94) = 0.81$, $p = .45$, $\eta_p^2 = .02$. For d' there were significant main effects of age group, $F(1, 47) = 27.02$, $p < .001$, $\eta_p^2 = .36$, and set size, $F(1, 47) = 30.40$, $p < .001$, $\eta_p^2 = .39$. Younger adults ($M = 3.54$, $SE = 0.12$) showed greater sensitivity than older adults ($M = 2.64$, $SE = 0.12$). Sensitivity decreased from Set Size 1 ($M = 3.70$, $SE = 0.09$) to Set Size 2 ($M = 2.97$, $SE = 0.13$) to Set Size 3 ($M = 2.61$, $SE = 0.14$). There were significant interactions of age group and set size, $F(2, 94) = 6.79$, $p = .003$, $\eta_p^2 = .13$, and age group and age of model, $F(1, 47) = 5.39$, $p = .02$, $\eta_p^2 = .10$. The decline in sensitivity with increasing set size was significant for older adults, $F(2, 48) = 46.99$, $p < .001$, $\eta_p^2 = .66$, but not for younger adults, $F(1, 47) = 3.25$, $p = .06$, $\eta_p^2 = .12$. The age of the model did not affect younger adults, $F(1, 23) = 0.37$, $p = .55$, $\eta_p^2 = .02$, but did affect older adults, $F(1, 24) = 7.46$, $p = .01$, $\eta_p^2 = .24$, for whom sensitivity was greater for older models ($M = 2.80$, $SE = 0.15$) than for younger models ($M = 2.48$, $SE = 0.15$). For β there were significant effects of age group, $F(1, 47) = 6.82$, $p = .01$, $\eta_p^2 = .13$, and age of model, $F(1, 47) = 31.65$, $p < .001$, $\eta_p^2 = .40$. Younger participants showed a bias to respond match ($M = 1.21$, $SE = 0.07$) whereas older adults showed little bias ($M = 0.96$, $SE = 0.07$). Participants were much more biased toward match responses for older models ($M = 1.32$, $SE = 0.08$) whereas the bias was toward mismatch responses for younger models ($M = 0.85$, $SE = 0.04$).

Emotion matching: meta-analysis of Experiment 1 and 3.—For emotion matching in Experiment 3 and for matching of simple emotions in Experiment 1, an incipient interaction was observed between age group and set size, with accuracy declining slightly faster with increasing set size for older adults than for younger adults. In neither experiment, however, was the interaction significant. To explore this interaction further we combined the two data sets for an omnibus analysis. ANOVA was conducted on accuracy as a function of age group, set size, and the experiment (1 or 3). In this very powerful analysis, the interaction of age group and set size was small but significant, $F(2, 214) = 3.34$, $p = 0.04$, $\eta_p^2 = .03$. There was a strong effect of experiment, $F(1, 107) = 62.57$, $p < .001$, $\eta_p^2 = .37$, with accuracy lower in Experiment 1 ($M = 0.70$, $SE = 0.01$) than in Experiment 3 ($M = 0.80$, $SE = 0.01$). The overall effect of age group was not significant, $F(1, 107) = 3.14$, $p = .08$, $\eta_p^2 = .03$

Discussion

Despite the changes in procedure, the results of Experiment 3 replicated those of Experiment 1 and 2. There was no effect of age group and no interaction of age group and set size for the emotion-matching task whereas there were strong effects of both for the identity matching task. However, based on the joint analysis of Experiments 1 and 3, we must soften our previous conclusion: Memory for emotions is better preserved in older adults than is memory for identity. For identity matching the interaction of age group and set size that was seen in Experiment 3 but not seen in Experiment 2 was probably due to a ceiling effect. We replicated the earlier results despite equating the number of identity stimuli with the number of emotion stimuli. By increasing the study time we removed any possibility of a floor effect, with performance well above chance in all conditions. We did not find a difference in the way younger and older participants responded to younger and older models in the emotion-matching task: Emotions expressed by younger models were better recognized than those by older models in both age groups. This is consistent with the finding by [Ebner and colleagues \(2012\)](#) that both younger and older adults were better at identifying emotions expressed by younger adults than by older adults. We did, however, find effects in the identity matching task: Older adults showed an own-age bias with older models better recognized than younger models. From an extensive meta-analysis [Rhodes and Anastasi \(2012\)](#) concluded that the own-age bias in memory for identity is driven by greater recent experience with individuals in one's own age group than in other age groups. They note that one mechanism by which the own-age bias might work is that greater experience leads to encoding of the configuration of the features of the face rather than to a focus on component features which are less diagnostic at retrieval. By contrast in emotion matching component features such as the mouth, the

eyes, or the brow may be diagnostic, so neither younger nor older adults would engage in the configural processing that would lead to own-age bias. Changes with age such as those in the skin, the relative size of the eyes, and the shape of the lips may make it more difficult to determine the emotion expressed by an older adult, accounting for the slight superiority of younger models in emotion matching. [Rhodes and Anastasi](#) found that the own-age bias in memory for identity occurred at all ages; we cannot account for its complete absence in the younger adults. The most important point, however, is the age bias did not in any way qualify the earlier finding using only younger models that younger and older adults differ more in short-term memory for identity than in short-term memory for emotion. Indeed, the presence of age biases in identity matching but not in emotion matching is further evidence for the distinctness of these two modes of memory.

GENERAL DISCUSSION

Why might memory for emotional expression be relatively unimpaired in old age, whereas other short-term or working memories show clear age-related decline? One explanation might be based on the fact that there are only six basic emotions. For no other type of memory is the set of possibilities so small. An older adult will have had thousands of more opportunities to recognize and retain those six emotions and this may have eliminated age differences. This explanation founders, however, because it predicts that age differences should have been observed with morphed emotions, with which older adults would have no more experience than younger adults. Moreover, recognition of most emotions is poorer in older adults ([Ruffman et al., 2008](#)). An alternative explanation is that memory for emotion is better preserved because of its evolutionary importance. It is difficult to argue for evolutionary pressures that operate beyond the age of reproduction but it might be that individuals better able to remember emotions expressed by their children or grandchildren would have a greater likelihood that their genes were passed on. A third explanation is provided by socioemotional selectivity theory (SST; [Carstensen, 1995](#)), which holds that emotion-related goals are central in older adults. Attention and memory function preferentially in the service of these emotional goals. Memory for observed emotional expressions could serve in this way and might receive a disproportionate allocation of processing resources, compensating for any underlying decline. Nevertheless, in pursuit of emotional goals in a social context, it would be far more important to remember the identity of someone who had expressed an emotion toward a person as well as what the emotion was than to recall the emotion alone. Our results may reflect that. If we suppose that memory for identity is unavoidably impaired in old age but that memory for emotion is relatively intact, then a task such as ours that called directly on memory for

emotion would not show age differences. An identity task would be affected but, to the extent a person was identified, the memory for the emotion that person expressed would be intact.

A related puzzle is how short-term or working memory for emotion can be maintained while areas of the frontal and temporal cortex important in memory show significant loss of tissue in old age (Raz et al., 1997). Neuroimaging studies of working memory for verbal material, spatial locations, and objects suggest that underlying neural substrates are focused in areas of lateral frontal cortex, with differences in the lateralization and precise location varying by type of memory (Jonides et al., 1996). In contrast, neuroimaging studies of recognition of emotional expressions implicate a variety of regions that are different for different emotions, though with some overlap (Fusar-Poli et al., 2009; Posamentier & Abdi, 2003): Fearful faces show activation in the amygdala and periamygdalar cortex (the amygdala is also activated by other facial expressions, which may reflect responses by different nuclei within the amygdala); happy faces show activation in the medial temporal gyrus, basal ganglia, superior parietal lobule, and calcarine sulcus (e.g., Breiter et al., 1996; Morris et al., 1996); disgusted faces show activation in basal ganglia and insular cortex; angry faces elicit activation in orbitofrontal cortex, anterior cingulate cortex, and posterior temporal lobe (e.g., Blair et al., 1999; Sprengelmeyer et al., 1998); and sad expressions evoke activity in the amygdala and middle and inferior temporal cortex (Blair et al., 1999). From these findings, it is clear that the recognition of emotional expressions involves interlocking but dissociable distributed networks and memory is probably subserved by the same networks. By contrast working memory for verbal and spatial information involves explicit maintenance and rehearsal in more restricted networks (Jonides et al., 1996; Postle, Awh, Jonides, Smith, & D'Esposito, 2004).

In contrast to visual or spatial memory, we propose a very different model for the way the match or mismatch decision is made in the emotion-matching procedure used here. We speculate that the memory set items elicit activity in one or more emotional expression networks. When the probe arrives, the resulting activity is interrogated for whether that pattern has been recently activated. First, this can be a relatively passive process so it might not show declines evident in more active, intentional memory. Second, it would involve limbic areas rather than lateral prefrontal cortex on which other modes of short-term memory depend. Third, such a process would be able to handle not only simple, common emotional expressions but the unique, morphed expressions that had not been previously seen as well. Fourth, because the systems are distributed, degradation in one or another component could occur without noticeably impairing performance, which is based on the pattern of activity. Thus, age-related changes in cortex could occur without affecting memory for emotional expression, as we observed.

It might also be argued that emotion matching as studied in these experiments is an artificial situation. In real life, one recognizes an individual and recalls the emotion that the individual expressed. There is survival value in being able to determine who bears good will and who bears ill will. It is much rarer to recall the emotion that was expressed without concern for who expressed it. It might occur when praise or blame came from multiple sources and the important information was the emotion expressed and not the particular individual expressing it. However, although artificial, the situation is necessary to determine whether the two types of memory are distinct. The results show that memory for emotional expression and memory for identity are indeed distinct.

SUPPLEMENTARY MATERIAL

Supplementary materials can be found at: <http://psychogerontology.oxfordjournals.org/>

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CONFLICT OF INTEREST

The authors report no conflicts of interest.

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