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## Research Article

### AGING AND ATTENTIONAL BIASES FOR EMOTIONAL FACES

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**Abstract**—We examined age differences in attention to and memory for faces expressing sadness, anger, and happiness. Participants saw a pair of faces, one emotional and one neutral, and then a dot probe that appeared in the location of one of the faces. In two experiments, older adults responded faster to the dot if it was presented on the same side as a neutral face than if it was presented on the same side as a negative face. Younger adults did not exhibit this attentional bias. Interactions of age and valence were also found for memory for the faces, with older adults remembering positive better than negative faces. These findings reveal that in their initial attention, older adults avoid negative information. This attentional bias is consistent with older adults' generally better emotional well-being and their tendency to remember negative less well than positive information.

Across the adult life span, emotion-related goals gain in importance. According to socioemotional selectivity theory (Carstensen, Isaacowitz, & Charles, 1999), it is the assessment of time left in life that drives this shift. As endings approach and concerns about the future decrease, knowledge-related goals lose importance. In contrast, an increased present orientation emphasizes goals related to emotional satisfaction and meaning.

There is considerable evidence for a shift in goals under time constraints. Older adults prefer to spend time with emotionally meaningful social partners than to spend time with new acquaintances (Fredrickson & Carstensen, 1990; Fung, Carstensen, & Lutz, 1999; Fung, Lai, & Ng, 2001), as do younger people under experimental conditions in which time is limited (Fung et al., 1999). In their mental representations of social partners, older people place greater emphasis on emotional dimensions than on other personal dimensions (Fredrickson & Carstensen, 1990). A similar emphasis is evident in younger people who are facing the end of their lives (Carstensen & Fredrickson, 1998). Older adults are also more likely than younger adults to adopt emotion-focused strategies when attempting to deal with interpersonal dilemmas (Blanchard-Fields & Camp, 1990; Blanchard-Fields, Camp, & Casper Jahnke, 1995). Thus, it appears that the approach of endings—the penultimate of which is old age—activates a reorganization of goal hierarchies such that emotionally meaningful goals are prioritized.

In theory, attention to emotionally meaningful goals should enhance well-being (Carstensen, Fung, & Charles, in press). Indeed, in recent years—contrary to early expectations—evidence that emotional well-being increases with age has been mounting (Charles, Reynolds, & Gatz, 2001; Gross et al., 1997; Lawton, Kleban, & Dean, 1993; Mroczek, 2001; Mroczek & Kolarz, 1998; Weissman, Leaf, Bruce, & Florio, 1988). For example, in one experience-sampling study includ-

ing participants from 18 to 94 years old, the frequency and duration of negative emotions experienced in daily life decreased with age, while positive affect remained mostly constant (Carstensen, Pasupathi, Mayr, & Nesselroade, 2000).

As our comments thus far suggest, most studies investigating emotional changes with age have looked at age differences either in the selection of social goals or in subjective emotional experience. However, motivational changes may also have an impact on cognitive processes. For example, older adults may attend more to emotional information than to other kinds of information. This shift would in turn affect what is most likely to be encoded into memory. Memory rehearsal and retrieval processes may also be influenced by an emphasis on emotional goals, leading the contents of older adults' memories to reflect emotional goals more than younger adults' memories do.

Several studies suggest that memory processes do indeed become more emotion focused with age. When remembering their own past actions, such as packing a picnic basket or examining works of art, older adults report more thoughts, feelings, and evaluative statements and fewer perceptual and contextual aspects than do younger adults (Hashtroudi, Johnson, & Chrosniak, 1990). Older adults' recollections of stories contain a higher proportion of emotional material than younger adults' recollections (Carstensen & Turk-Charles, 1994). Similar biases to remember emotionally meaningful material are evident in memory for advertisements: Older people are more likely to remember advertising slogans promising emotional rewards than those promising other types of rewards (Fung & Carstensen, in press). Furthermore, asking younger or middle-aged adults to focus on their feelings and emotions when reviewing information can make their pattern of memory errors resemble that of older adults (Kennedy, Mather, & Carstensen, in press; Mather & Johnson, 2000, 2003). Thus, there are reasons to think that the cognitive performance of older adults may be affected by the heightened importance of emotionally relevant goals.

In this article, we expand investigation into the links between goals and cognitive processing to include both attention and memory. There are (at least) two ways that emotional goals might influence older adults' attention and memory. The first possibility is that all information relevant to emotional goals is made more salient. This *emotionally relevant* focus would bias attention and memory in favor of both positive and negative information. The second possibility is that information that furthers emotional goals is made more salient. This *emotionally gratifying* focus would bias attention and memory in favor of information that fosters positive emotion and against information that fosters negative emotion.

Studies that have distinguished between memory for positive and negative emotional information indicate that it is not the case that all emotionally relevant information becomes relatively more memorable with age. Instead, emotionally gratifying information becomes more memorable (for a review, see Mather, in press). When shown a series of pictures and then asked to recall them later, older adults recall a larger proportion of positive pictures and a smaller proportion

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**Table 1.** Demographic characteristics of the younger and older adults in Experiments 1 and 2

Characteristic	Group			
	Experiment 1		Experiment 2	
	Younger	Older	Younger	Older
Age range	18–35	62–94	18–35	60–81
Mean age in years	25.8 (5.6)	74.0 (6.1)*	25.4 (4.8)	71.5 (5.5)*
Years of education	15.8 (1.5)	16.5 (3.1)	16.2 (1.7)	14.8 (3.4)*
Animal Naming <sup>a</sup>	33.6 (8.5)	23.3 (7.2)*	32.5 (6.9)	24.9 (7.3)*
Digit Symbol <sup>b</sup>	66.8 (12.0)	42.1 (11.1)*	71.4 (11.1)	43.2 (9.7)*
Vocabulary <sup>c</sup>	15.8 (3.4)	19.6 (3.7)*	16.5 (3.2)	17.2 (5.3)
Physical symptoms <sup>d</sup>	11.67 (8.16)	15.25 (9.30)*	11.97 (7.99)	18.07 (8.19)*
Negative emotion <sup>d</sup>	5.63 (5.13)	2.65 (3.71)*	5.32 (5.59)	2.64 (3.39)*
Caucasian/African American ( <i>n</i> )	34/18	33/19	32/12	32/12
Male/female ( <i>n</i> )	22/30	21/31	16/28	16/28

Note. Standard deviations are in parentheses.

<sup>a</sup>Animal Naming subtest of the Western Aphasia Battery (Kertesz, 1982).

<sup>b</sup>Digit-Symbol Substitution subtest of the Wechsler Adult Intelligence Scale–Revised (Wechsler, 1981).

<sup>c</sup>Nelson-Denny Reading Test (Brown, Fishco, & Hanna, 1993).

<sup>d</sup>Scores for physical symptoms are from Sections A–L of the Cornell Medical Index (CMI; Brodman, Erdmann, & Wolff, 1949). Scores for negative emotion are from Sections M–R of the CMI. One younger adult declined to fill out the CMI.

\*Younger and older adults' means differ significantly (*t* test, *p* < .05).

of negative pictures than younger adults do (Charles, Mather, & Carstensen, 2003). As people age, memories of extremely sad and traumatic events fade more than memories of extremely happy events (Berntsen & Rubin, 2002). Memories of recent choices become biased in favor of the options selected rather than those rejected (Mather & Johnson, 2000). Thus, in general, what older adults remember is more likely to enhance current well-being than what younger adults remember.

Because the results of the memory tests in these studies reflect processes at encoding, during the retention interval, and during retrieval, they do not illuminate the specific processes affected by emotional goals. These studies do not address whether it is just during retrieval that older adults' memories gain their bias toward emotionally gratifying information or whether emotional goals affect processing from the moment information is first perceived.

Therefore, in the current study, we used an experimental paradigm that allowed us to measure attentional biases. If emotionally gratifying biases influence initial attention, older adults should orient toward positive and away from negative information. To test this possibility, we used naturalistic stimuli in which emotional valence can be quickly detected—faces. On each trial, a pair of faces (one emotional and one neutral expression) was presented on a computer screen for a brief interval. Subsequently, the faces disappeared and a dot was displayed where one of the faces had been. Participants had to respond as quickly as possible to indicate which side of the screen the dot was on. This type of experimental paradigm has revealed attentional biases for sad faces among depressed individuals (Gotlib, Krasnoperova, & Neubauer, 2002) and for threatening faces among anxious individuals (Bradley, Mogg, & Millar, 2000; Bradley, Mogg, White, Groom, & de Bono, 1999). If the shift with age toward positive and away from negative emotion extends to attentional processes, biases to attend to positive faces and to avoid negative faces would be greater among older adults than among younger adults.

## EXPERIMENT 1

### Method

#### Participants

In order to have sufficient statistical power to examine effects of ethnicity, we recruited only European American or African American participants. Demographic information for the 52 younger and 52 older participants is presented in Table 1.

#### Materials

We used 60 pairs of photographs of faces. Each pair included one neutral and one emotional version of the same face. Twenty of the face pairs included a happy, 20 a sad, and 20 an angry expression.<sup>1</sup> Within each emotion category, half of the photographs were of males and half were of females. Two additional neutral faces were used to create neutral-neutral face pairs for practice trials.

#### Procedure

In the dot-probe task, each trial consisted of the following sequence: (a) A fixation point was displayed in the center of the screen for 500 ms, (b) the neutral and emotional versions of one face were displayed in the right and left positions on the screen for 1,000 ms, (c) the two faces disappeared from the screen, and (d) a small gray dot appeared in the center of the screen location where one of the photo-

1. This set of face photographs was selected by Gotlib et al. (2002) from a larger set of 1,600 photographs they had collected and normed to reveal emotional categories. The set included photographs from Paul Ekman, Wally Friesen, Laura Carstensen, Ruben Gur, Paula Niedenthal, Stephen Nowicki, Robert Zajonc, and Peter Lang.

graphs had been. The dot remained on the screen until the participant pressed one of two response keys on the keyboard.

Participants were told that the study was investigating perceptual processes and that their task was to respond to a small dot displayed on the screen as quickly and accurately as possible. If they saw the dot appear on the right side of the screen, they should press the red key (the “k” key marked with a red sticker); if they saw the dot appear on the left side, they should press the blue key (the “d” key marked with a blue sticker). They were told that each time, before the dot appeared, they would see two faces on the screen and that they did not need to respond to these faces. Instead, they should just wait for the dot and respond to it as quickly as they could. They were given four practice trials that were repeated until they were comfortable with the task. During the dot-probe task, participants saw 30 face pairs, equally divided among angry-neutral, sad-neutral, and happy-neutral pairs. Each pair was presented four times, so that the side the emotional face appeared on and the face version in whose location the dot was seen could be fully counterbalanced for each participant. After the 120 trials, participants filled out the Cornell Medical Index (CMI; Brodman, Erdmann, & Wolff, 1949) for 10 min (if necessary, they completed it at the end of the experiment). The CMI is a 195-item index of physical and mental health problems that yields a general health index as well as subscales summarizing the functioning of different organ systems or symptoms associated with specific psychological syndromes.

After this delay, participants were given a recognition memory test for the faces. When each face was presented, they were to press the blue key if they had seen the face in the previous part of the session and the red key if they had not. The test included all 60 faces. However, for 30 faces participants were shown the neutral version, and for 30 faces they were shown the emotional version. Fifteen faces of each type had previously been seen, whereas the other 15 had not previously been seen in any emotional condition. Which half had been seen in the dot-probe task was counterbalanced across participants.

## Results

### *Dot-probe reaction times<sup>2</sup>*

Mean reaction times are presented in Table 2. Attentional bias scores were computed separately for positive and negative faces for each participant. We subtracted the mean probe-detection times for probes appearing on the same side as an emotional face from the mean probe-detection times for probes appearing on the other side. Positive values on this measure thus indicate a bias to attend to emotional faces, and negative values indicate a bias to attend to neutral faces. Bias scores are presented in Figure 1. One-sample *t* tests revealed that younger adults were not significantly more or less likely to attend to emotional than neutral faces. However, older adults were significantly faster when the dot was in the location of a positive face than when it was in the location of a neutral face ( $M = 11.03$ ),  $t(51) = 2.19$ ,  $p < .05$ , and significantly slower when the dot was in the location of a neg-

ative face than when it was in the location of a neutral face ( $M = -12.13$ ),  $t(51) = -3.19$ ,  $p < .01$ .

Comparing younger and older adults' bias scores revealed a significant difference for negative faces,  $t(102) = 2.33$ ,  $p < .05$ , but only a marginally significant difference for positive faces,  $t(102) = -1.91$ ,  $p = .059$ . Thus, although older adults showed a bias to attend to neutral rather than negative faces and to positive rather than neutral faces, younger adults did not show this type of bias.<sup>3</sup>

### *Recognition memory*

Recognition accuracy was calculated as the proportion of new faces falsely identified as previously seen faces (false alarms) subtracted from the proportion of previously seen faces correctly identified as such (hits).<sup>4</sup> A 2 (valence at encoding: positive, negative)  $\times$  2 (face version at test: emotional, neutral)  $\times$  2 (age: younger, older) analysis of variance (ANOVA) on these corrected recognition scores revealed a main effect of valence at encoding,  $F(1, 101) = 9.51$ ,  $MSE = 0.05$ ,  $p < .01$  (see Table 3), indicating that participants had better recognition accuracy for faces previously seen with positive ( $M = .44$ ,  $SE = .02$ ) than with negative ( $M = .37$ ,  $SE = .02$ ) expressions. Participants were also more accurate at recognizing emotional ( $M = .43$ ,  $SE = .02$ ) than neutral ( $M = .39$ ,  $SE = .02$ ) faces,  $F(1, 101) = 4.20$ ,  $MSE = 0.05$ ,  $p < .05$ , but an interaction of age and face version at test,  $F(1, 101) = 4.53$ ,  $MSE = 0.05$ ,  $p < .05$ , revealed that this effect was driven by younger adults ( $M = .51$ ,  $SE = .03$ , for emotional faces vs.  $M = .43$ ,  $SE = .03$ , for neutral faces) and that the test version did not affect accuracy for older adults ( $M = .35$ ,  $SE = .03$ , for emotional faces vs.  $M = .34$ ,  $SE = .03$ , for neutral faces).

Furthermore, all three factors interacted,  $F(1, 101) = 7.22$ ,  $MSE = 0.05$ ,  $p < .01$ . To clarify this interaction, we conducted separate 2 (valence at encoding: positive, negative)  $\times$  2 (face version at test: emotional, neutral) ANOVAs for younger and older adults. Younger adults, as already noted, were more accurate for emotional than neutral test faces,  $F(1, 50) = 7.70$ ,  $MSE = 0.05$ ,  $p < .01$ . The face version at test interacted with the valence at encoding, however,  $F(1, 51) = 4.08$ ,  $MSE = 0.04$ ,  $p < .05$ , with a more dramatic effect of test version for faces seen with positive expressions at encoding ( $M = .57$ ,  $SE = .04$ , for emotional faces vs.  $M = .43$ ,  $SE = .05$ , for neutral faces) than for faces seen with negative expressions at encoding ( $M = .46$ ,  $SE = .04$ , for emotional faces vs.  $M = .42$ ,  $SE = .03$ , for neutral faces). The main effect of valence at encoding was not significant. In contrast, the main effect of valence at encoding was significant for older adults,  $F(1, 51) = 6.82$ ,  $MSE = 0.04$ ,  $p < .05$ , with better accuracy for faces previously seen with positive expressions ( $M = .38$ ,  $SE = .03$ ) than for faces previously seen with negative expressions ( $M = .31$ ,  $SE = .03$ ). No other effects were significant. Thus, as expected, older adults had significantly better accuracy in the positive than in the negative encoding condition, whereas this effect was not significant for younger adults. But the age

2. For each response time analysis in this study, both older and younger adults' responses faster than 200 ms were excluded (this removed less than 0.1% of the responses for each group in each analysis). To remove slow reaction time outliers, we used separate cutoff scores for younger and older adults to exclude 10% of the responses from each age group (Ratcliff, 1993). Excluding incorrect responses for the dot-probe task led to discarding no more than an additional 1.0% of responses.

3. In the analyses we report here, the positive expressions were all happy expressions, whereas half of the negative expressions were angry and half were sad. In follow-up analyses of just the negative trials for the dot-probe task in Experiments 1 and 2, the type of negative expression did not yield any significant effects; attention to negative faces was consistent across sad and angry trials. Older adults avoided attending to both sad and angry faces, whereas younger adults did not show an attentional bias for either type of face.

4. One younger participant was excluded from the memory analyses because his responses consisted of extremely rapid alternating “yes” and “no” responses.

**Table 2.** Mean reaction times (in milliseconds) on the dot-probe task for younger and older adults

Group	Positive-neutral face pair		Negative-neutral face pair	
	Dot in location of positive face	Dot in location of neutral face	Dot in location of negative face	Dot in location of neutral face
Experiment 1				
Younger	425 (24)	426 (24)	424 (24)	422 (24)
Older	785 (24)	796 (24)	800 (23)	788 (23)
Experiment 2				
Younger	435 (25)	438 (25)	439 (25)	438 (24)
Older	779 (25)	789 (25)	794 (25)	777 (24)

Note. Standard errors are in parentheses.

differences were somewhat hard to interpret because younger adults did show an advantage for positive faces when the test version was positive.

The response time data for the memory test suggest that there may have been a speed-accuracy trade-off for the older adults. A 2 (valence at encoding: positive, negative) × 2 (face version at test: emotional, neutral) × 2 (trial type: target, distractor) × 2 (age: younger, older) ANOVA revealed an interaction of valence at encoding and age,  $F(1, 100) = 5.91$ ,  $MSE = 50,609.59$ ,  $p < .05$ , with older adults responding faster for faces seen previously with positive expressions ( $M = 1,589$  ms,  $SE = 47$  ms) than for those seen previously with negative expressions ( $M = 1,697$  ms,  $SE = 48$  ms). The speed advantage was less pronounced for younger adults ( $M = 1,145$  ms,  $SE = 47$  ms, for positive faces vs.  $M = 1,177$  ms,  $SE = 48$  ms, for negative faces). There were no other interactions with age. Excluding response times for incorrect responses yielded the same pattern of significant effects. Older adults' bias to respond faster to positive faces may have reduced their accuracy for these faces.

*Impact of race, gender, and negative emotion*

We reran the analyses for dot-probe reaction times, recognition accuracy, and recognition response times with race and gender as addi-

tional factors. The significant effects described for the original analyses remained significant and were not qualified by either race or gender.

As can be seen in Table 1, the CMI revealed a general pattern in which older adults had more physical symptoms than younger adults, but younger adults had more manifestations of negative emotion. Including the CMI total negative-emotion score as a covariate did not eliminate the age difference in attentional biases,  $F(1, 100) = 7.60$ ,  $MSE = 1,072.22$ ,  $p < .01$ . In additional analyses, we included scores from just the depression and anxiety subscales as covariates, as in clinical populations, depression and anxiety are associated with attentional biases. The age difference remained significant with these more specific covariates, as well. The recognition results were not affected by the CMI covariates either.

**EXPERIMENT 2**

In this experiment, we used a forced-choice instead of a yes/no recognition test in order to assess memory accuracy in a context in which response biases were less likely to have an impact. In this forced-choice test, old faces were paired with new faces of the same emotional valence. During the first phase, participants completed the same dot-probe task as in Experiment 1.

**Method**

*Participants*

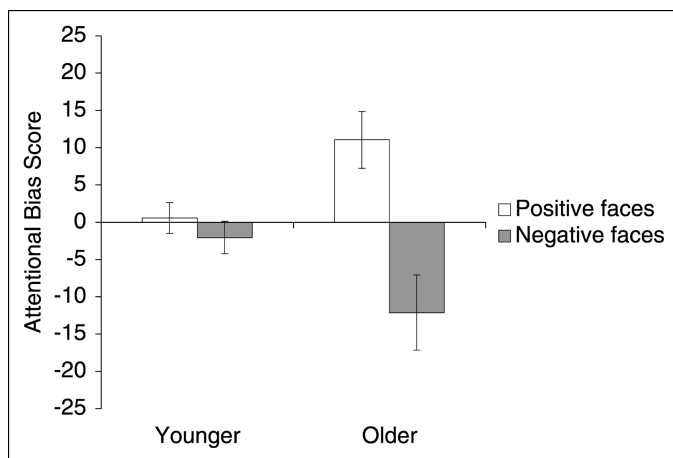
As in Experiment 1, all participants were either European or African American (see Table 1 for demographic characteristics of the 44 younger and 44 older participants).

*Materials*

The same face photographs as in Experiment 1 were used.

*Procedure*

The dot-probe task from the first phase in Experiment 1 was used again, followed by the same 10-min delay interval. Instead of using a yes/no recognition test, however, we used a forced-choice recognition test. The faces seen on the memory test were the same as in Experiment 1, and whether faces were old or new was also counterbalanced across participants. However, in this test, two different faces with the



**Fig. 1.** Attentional bias scores for positive and negative faces in Experiment 1. Results are shown separately for older and younger adults. Error bars display the standard error of the mean.

**Table 3.** Proportion of faces correctly recognized and average response time on the memory test in Experiment 1

Measure and group	Positive encoding		Negative encoding	
	Emotional test	Neutral test	Emotional test	Neutral test
Corrected recognition (% hits – % false alarms)				
Younger	.57 (.04)	.43 (.05)	.46 (.04)	.42 (.03)
Older	.35 (.04)	.41 (.04)	.34 (.04)	.28 (.04)
Response time (in milliseconds)				
Younger	1,143 (47)	1,146 (53)	1,156 (48)	1,197 (48)
Older	1,543 (47)	1,634 (53)	1,672 (48)	1,723 (53)

*Note.* Positive encoding = pictures seen with positive and neutral expressions during the dot-probe task; negative encoding = pictures seen with negative and neutral expressions during the dot-probe task; emotional test = emotional face version seen at test; neutral test = neutral face version seen at test. Standard errors are in parentheses.

same emotional expression were presented on the screen at the same time; one of these faces had been seen before and one had not.

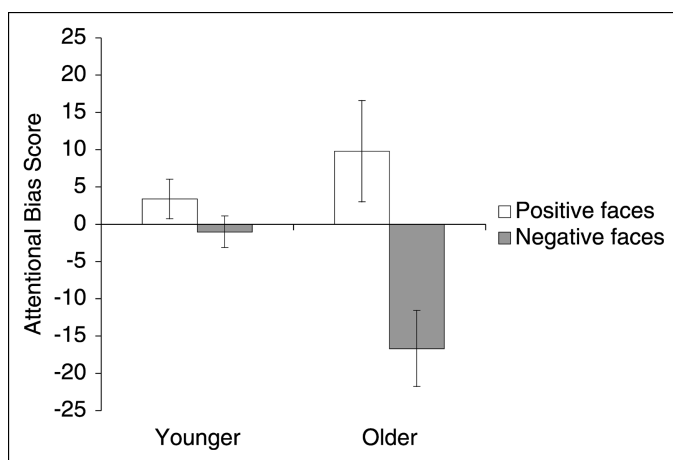
**Results**

*Dot-probe reaction times*

Bias scores were calculated as in Experiment 1 and are displayed in Figure 2. As in Experiment 1, neither of the bias scores was significant for the younger adults. Also as before, older adults had a significant bias favoring neutral relative to negative faces,  $M = -16.68, t(43) = -3.26, p < .01$ , and this bias was significantly greater than for younger adults,  $t(86) = 2.83, p < .01$ . Thus, the dot-probe component of this experiment replicates our previous experiment’s finding that older adults, but not younger adults, have a tendency to orient away from negative expressions. In this experiment, however, there were no significant effects for the positive-face bias scores.

*Forced-choice memory accuracy*

A 2 (valence at encoding: positive, negative) × 2 (face version at test: emotional, neutral) × 2 (age: younger, older) ANOVA revealed a



**Fig. 2.** Attentional bias scores for positive and negative faces in Experiment 2. Results are shown separately for older and younger adults. Error bars display the standard error of the mean.

main effect of valence at encoding,  $F(1, 86) = 6.23, MSE = 0.02, p < .05$ . Means are displayed in Table 4. Participants were more accurate at identifying which face was old when that face had been seen at encoding with a positive expression ( $M = .74, SE = .02$ ) than when it had been seen with a negative expression ( $M = .71, SE = .02$ ). Participants were also more accurate when the test pair was emotional ( $M = .74, SE = .02$ ) than when it was neutral ( $M = .71, SE = .02$ ),  $F(1, 86) = 4.32, MSE = 0.11, p < .05$ .

Of primary interest, however, was an interaction of valence at encoding, face version at test, and age,  $F(1, 86) = 4.95, MSE = 0.03, p < .05$ . To clarify this three-way interaction, we conducted separate Valence at Encoding × Face Version at Test ANOVAs for the younger and older groups. There were no significant effects for the younger adults. In contrast, older adults were significantly more accurate for faces seen with positive expressions ( $M = .68, SE = .04$ ) than for faces seen with negative expressions ( $M = .63, SE = .04$ ) at encoding,  $F(1, 43) = 4.58, MSE = 0.09, p < .05$ . An interaction of valence at encoding and face version at test,  $F(1, 43) = 6.68, MSE = 0.02, p < .05$ , revealed that for faces previously seen with positive expressions, memory accuracy was greater when the test version of the face was emotionally positive ( $M = .72, SE = .04$ ) rather than neutral ( $M = .63, SE = .04$ ). In contrast, for faces previously seen with negative expressions, memory accuracy did not vary much between emotionally negative ( $M = .62, SE = .03$ ) and neutral ( $M = .64, SE = .03$ ) test versions. Thus, older adults were most accurate at discriminating old and new faces when they saw two happy faces.

A 2 (valence at encoding: positive, negative) × 2 (face version at test: emotional, neutral) × 2 (age: younger, older) ANOVA on the response times did not reveal any significant effects. Thus, despite the fact that older adults responded to the positive faces about as quickly as to the negative faces, they were more accurate in recognizing the positive faces.

*Impact of race, gender, and negative emotion*

As in Experiment 1, including race and gender as factors in the analyses did not qualify the significant effects. In addition, as in Experiment 1, using either overall negative-emotion, depression, or anxiety scores from the CMI as covariates did not eliminate the significant age difference in attentional biases for negative faces. These covariates did not affect the forced-choice recognition results either.

**Table 4.** Accuracy and response times on the forced-choice memory test in Experiment 2

Measure and group	Positive encoding		Negative encoding	
	Emotional test	Neutral test	Emotional test	Neutral test
Percentage correct				
Younger	.82 (.04)	.80 (.04)	.81 (.03)	.76 (.03)
Older	.72 (.04)	.63 (.04)	.62 (.03)	.64 (.03)
Response time (in milliseconds)				
Younger	1,691 (105)	1,768 (102)	1,701 (99)	1,720 (98)
Older	2,517 (105)	2,453 (102)	2,452 (99)	2,547 (98)

*Note.* Positive encoding = pictures seen with positive and neutral expressions during the dot-probe task; negative encoding = pictures seen with negative and neutral expressions during the dot-probe task; emotional test = emotional face version seen at test; neutral test = neutral face version seen at test. Standard errors are in parentheses.

### *Do negative faces cause interference?*

An alternative explanation of our finding that older adults were slower to respond to negative than to neutral faces is that older adults spent more time processing the negative faces and so experienced more interference when the dot appeared in the location of a negative face. If this were the case, the reaction times for dots appearing in the location of neutral faces should have been unaffected by whether they appeared with negative faces or not (or, if anything, should have been slowed down by appearing with a negative face). As can be seen in Table 2, however, in both experiments older adults were faster to respond to dots in the location of neutral faces in the negative than in the positive condition,  $F(1, 94) = 5.85$ ,  $MSE = 809.76$ ,  $p < .05$ . Including Experiment 1 versus 2 as a factor in the ANOVA did not yield an interaction,  $F < 1$ ,  $p > .5$ , and there was no significant effect of valence condition on reaction times to neutral faces for younger adults,  $F = 1.43$ ,  $p > .2$ . Thus, the older adults' slower reaction times to negative than to neutral faces appear to have been due to attention shifting to the neutral faces, rather than to interference from slower processing of the negative faces.

## DISCUSSION

In two experiments, older adults' attention was biased against emotionally negative faces. This bias was revealed by the fact that when shown a pair of photographs of the same person, older adults were slower to respond to a dot probe displayed in the location of an angry or sad version of the face than in the location of a neutral version. Like younger adult controls in studies of depressed or anxious participants' attentional biases (e.g., Bradley et al., 2000; Gotlib et al., 2002), the younger adults in our study did not show any significant attentional biases. We obtained the same pattern of results for men and women and for European and African Americans.

Because the experimental design called for simultaneous presentation of both a neutral and an emotional version of each face, this may have reduced our ability to see memory differences as a function of emotional valence. Nevertheless, the results for memory accuracy were generally consistent with the idea that older adults have a memory bias favoring positive relative to negative information. In the yes/no recognition test of Experiment 1, older adults had better memory for faces previously seen with positive expressions than for those seen with negative expressions. They also had a bias to respond signifi-

cantly faster to the previously positive faces than to the previously negative faces, which may have affected their accuracy for the positive faces. To reduce the possible impact of response biases, in Experiment 2 we used a forced-choice memory test. Participants were shown pairs of faces matched for their emotional expression and asked which face they had seen before. Older adults were most accurate at discriminating between happy new and happy old test faces, indicating that they recognized positive faces better than negative faces. The type of emotional expression did not make a significant difference for younger adults.

On a health questionnaire, the older adults in our study indicated experiencing fewer negative emotions, such as depression and anger, than the younger adults did. This is consistent with the finding that negative affect decreases across the life span (Carstensen et al., 2000; Charles et al., 2001; Gross et al., 1997). Nevertheless, including negative emotion as a covariate in our analyses did not affect the results. Thus, the age differences in attentional biases cannot simply be explained by greater levels of depression among younger than older adults. Instead, we propose that it is older adults' increased emphasis on emotional goals that directs their attention away from information that is not emotionally gratifying. Evidently, it is not only subjective emotional experience that changes with age, but also basic cognitive processes affecting what external information is most salient and most likely to be remembered.

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