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Biased Recognition of Positive Faces in Aging and Amnestic Mild Cognitive Impairment

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We investigated age differences in biased recognition of happy, neutral, or angry faces in 4 experiments. Experiment 1 revealed increased true and false recognition for happy faces in older adults, which persisted even when changing each face's emotional expression from study to test in Experiment 2. In Experiment 3, we examined the influence of reduced memory capacity on the positivity-induced recognition bias, which showed the absence of emotion-induced memory enhancement but a preserved recognition bias for positive faces in patients with amnestic mild cognitive impairment compared with older adults with normal memory performance. In Experiment 4, we used semantic differentials to measure the connotations of happy and angry faces. Younger and older participants regarded happy faces as more familiar than angry faces, but the older group showed a larger recognition bias for happy faces. This finding indicates that older adults use a gist-based memory strategy based on a semantic association between positive emotion and familiarity. Moreover, older adults' judgments of valence were more positive for both angry and happy faces, supporting the hypothesis of socioemotional selectivity. We propose that the positivity-induced recognition bias might be based on fluency, which in turn is based on both positivity-oriented emotional goals and on preexisting semantic associations.

Keywords: emotion, MCI, false recognition, gist-based memory, facial expression

It is well known that emotionally significant events are better remembered than others (e.g., Hamann, 2001; Phelps, 2004). Although this emotion-induced memory enhancement is preserved in old age (e.g., Comblain, D'Argembeau, Van der Linden, & Aldenhoff, 2004; Leigland, Schulz, & Janowsky, 2004), recent evidence suggests age differences in the proportion of positive and negative information that is recalled. Relative to young adults, older adults are thought to remember relatively more positive than negative information (cf. Grühn, Smith, & Baltes, 2005). This phenomenon has been called the *positivity effect*; however, empirical evidence for it is mixed, as some studies support this finding (e.g., Charles, Mather, & Carstensen, 2003; Kennedy, Mather, & Carstensen, 2004; Mather & Carstensen, 2003), whereas others do not (e.g., Denburg, Buchanan, Tranel, & Adolphs, 2003; Grühn et al., 2005; Kensinger, Brierley, Medford, Growdon, & Corkin, 2002).

In some instances, emotional content may distort rather than enhance memory (Windmann & Kutas, 2001). In recognition tasks, memory is often biased in terms of enhanced true and false memory for emotional relative to neutral items (e.g., Johansson, Mecklinger, & Treese, 2004; Leiphart, Rosenfeld, & Gabrieli, 1993; Maratos, Allan, & Rugg, 2000). In older adults, this emotion-induced recognition bias has been shown to be preserved (Budson et al., 2006; Comblain et al., 2004; Grühn, Scheibe, & Baltes, 2007). Like the positivity effect, recent findings suggest that the degree of influence of positive and negative valence on recognition bias may differ between younger and older adults. A larger recognition bias for positive items was reported in the older adults, relying mainly on enhanced false memory (Fernandes, Ross, Wiegand, & Schryer, 2008), in contrast to a larger bias for negative items in the younger adults (Kapucu, Rotello, Ready, & Seidl, 2008). These findings have been interpreted as supporting socioemotional selectivity theory (SST; Carstensen, 1993), which associates the approach of the end of life with an enhanced striving for emotional balance and, consequently, for more positive and less negative affect. Thus, within this framework, the increased positivity-induced recognition bias in the older adults has been taken as experimental evidence for altered emotion regulation in old age (Mather, 2006). However, as a number of studies did not find age effects on biased recognition of positive items (Comblain

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et al., 2004; Grühn et al., 2007; Langeslag & Van Strien, 2008), this point deserves further investigation.

Age differences in emotional memory are likely to be related to general age-associated memory decline. For instance, it has been shown that lower recognition performance in the older adults results from disproportionately high false recognition (Comblain et al., 2004; Searcy, Bartlett, & Memon, 1999), especially in case of lure items that are perceptually or semantically related to studied items (e.g., Balota et al., 1999; Budson, Sullivan, Daffner, & Schacter, 2003; Koutstaal et al., 2003; Koutstaal & Schacter, 1997). This finding has been interpreted as reflecting older adults' reliance on memory for the general sense or gist of the previously studied information, possibly to compensate for their impaired item-specific memory (Schacter, Koutstaal, Johnson, Gross, & Angell, 1997). Thus, if positive stimuli were either semantically or perceptually more closely related, increased gist-based memory in the older adults would result in enhanced true and false recognition for this stimulus category. In this way, gist-based memory might induce an age-associated, positivity-related recognition bias.

In the present study, we investigated the effects of age, memory impairment, and valence on face recognition in four consecutive experiments. Facial stimuli were used because the discrimination of novel from previously studied faces is a particularly sensitive measure of recognition memory (Werheid & Clare, 2007) because of the high intraclass similarity of human faces (Boutet & Faubert, 2006). Moreover, emotional faces offer the advantage that emotional valence can be varied while keeping to be memorized facial identity constant.

Experiment 1

Our primary research question was whether there would be different patterns of true and false recognition between younger and older participants for faces with positive, neutral, or negative facial emotion. In accordance to previous research (Budson et al., 2006; Johansson et al., 2004), we expected in both groups an enhanced recognition bias for emotional, and especially negative, when compared with neutral faces. As the findings of previous studies were divided, it was an open question for us whether an increased recognition bias for positive faces would emerge in the older group.

Method

Participants. Twenty younger and 20 older adults participated in the experiment (see Table 1). Participants had been recruited through placards and local newspaper advertisements. None of them had previously participated in a similar experiment. All participants were in good health and free from a history of substance abuse, psychiatric disorders, cerebrovascular disease, or head injury. Preexperimental screening ensured that visual acuity (Freiburg Visual Acuity Test; Bach, 1996), global cognitive status (Mini Mental Status Examination; Folstein, Folstein, & McHugh, 1975), and mood (Geriatric Depression Scale; Yesavage et al., 1983) were in the normal range. Experiments 1–3 were approved by the Karolinska Hospital's ethical committee.

Stimulus materials. The stimulus materials consisted of 192 facial portraits gathered from different databases (Lundqvist, Flykt, & Ohman, 1998; Martinez & Benavente, 1998; Werheid, Schacht, & Sommer, 2007), which were edited to a unitary format (10.4 × 8 cm) and converted to eight-bit color scales with a gray background. The stimuli had been selected on the basis of computer-assisted, seven-step valence ratings in 16 younger adults and 18 older adults (M = 24.4 years, SD = 3.85; and M = 65.1 years, SD = 4.1, respectively). Mean valence ratings were M = 5.8 (SD = 0.51) for happy faces, M = 3.9 (SD = 0.35) for neutral faces, and M = 2.2 (SD = 0.34) for angry faces (all Fs > 20); age groups did not differ. These stimuli were assigned to two subsets, A and B, each containing 96 faces in total, 32 faces per emotion. The assignment of old–new status of the subsets to study or test session was counterbalanced across participants.

Procedure. After obtaining informed consent, participants were seated in front of a computer screen and informed that their task was to classify faces as happy, neutral, or angry by pressing one of three labeled buttons (*arrow left*, *arrow down*, *arrow right*) with their dominant hand. Also, they were instructed to watch the faces carefully because they would be asked to recognize them on the next day. After six practice items, they viewed either Set A or Set B, presented three times in blockwise-randomized order for 4 s each.

Approximately 24 hr following the study session, participants were again asked to view a series of facial portraits on a computer screen. Now they randomly viewed 192 portraits, half of which

Table 1
Overview of Participants Included in Experiments 1 and 2

	Younger adults		Older adults			
Variable	*M*	*SD*	*M*	*SD*	*t*	*p*
Experiment 1 (n = 40)						
Age	24.4	4.2	66.2	5.1	−28.30	.001
Gender (male:female)	6:14		8:12			
Education (years)	11.9	0.5	11.8	1.5	0.28	.787
Vocabulary test	33.3	2.3	34.6	2.1	−0.57	.566
Experiment 2 (n = 40)						
Age	24.5	3.5	66.4	6.2	−26.20	.001
Gender (male:female)	10:10		11:9			
Education (years)	11.7	1.3	11.0	1.1	0.54	.594
Vocabulary test	32.8	4.0	33.4	1.1	−0.31	.756

had been studied previously, and half of which were novel. Participants' task was to decide whether they had seen a portrait of the depicted person the day before and to indicate their decision by pressing one of two keys (*Alt* or *Alt Gr*) labeled with "old" or "new," respectively. Key labeling was counterbalanced across participants in both sessions. Each session lasted about 1 hr, including two short breaks.

Preprocessing and data analysis. Emotion classification during the study session was analyzed by 2 × 2 mixed factor analyses of variance (ANOVAs), including the within-factor emotion (angry vs. neutral, happy vs. neutral, angry vs. happy) and the between-factors age (old vs. young). Analyses involving all three steps of the emotion factor (happy, neutral, angry) had initially been conducted for all dependent variables. They invariably revealed main effects of emotion (all Fs > 3.3) and are, for brevity's sake, not reported here.

Recognition performance during the test session was analyzed by computing the percentage of correctly recognized faces (hit rates) and erroneously recognized faces (i.e., false positives) for angry, neutral, and happy faces. Discrimination accuracy [$Pr = p(\text{hits}) - p(\text{false positives})$] and recognition bias [$Br = p(\text{false positives})/p(1 - Pr)$] were calculated for each emotion category according to Snodgrass and Corwin (1988; two-high-threshold model) and analyzed by the 2 × 2 factorial ANOVAs described above. Significant Age × Emotion interactions were followed up by *t* tests. The alpha level was set at .05 for all statistical analyses.

Results

Emotion classification. During the study session, the mean percentage of correct classifications was 95.7% (*SD* 3.5) in the younger adults and 95.4% (*SD* 4.6) in the older adults. The percentage of correctly classified items was higher for happy faces ($M = 98.1\%$, $SD = 3.7$) than for neutral faces ($M = 96.3\%$, $SD = 6.4$), $F(1, 38) = 4.22$, $p = .047$, and for neutral faces compared with angry faces ($M = 91\%$, $SD = 9.3$), $F(1, 38) = 9.52$, $p = .004$. This pattern is known from previous research (Leppänen & Hietanen, 2004). There were no age differences or interactions. As methodology and performance level of the study session were identical in Experiments 1–3, and as age differences did not emerge, these results are only reported here.

True recognition. Measures of recognition performance according to age and emotion are displayed in Table 2 and Figure 1. Hit rates were enhanced for angry compared with neutral faces, $F(1, 38) = 42.3$, $p < .001$, and for angry compared with happy faces, $F(1, 38) = 24.85$, $p < .001$, without further significant effects. Hit rates were also higher for happy than for neutral faces, $F(1, 38) = 8.05$, $p < .007$. Additionally, this comparison revealed an Age × Emotion interaction, $F(1, 38) = 4.65$, $p < .037$, because of higher hit rates for happy versus neutral faces in the older adults, $t(19) = 2.85$, $p < .01$, but not in the younger adults.

False recognition. Older adults showed considerably enhanced false recognition compared with the younger adults in all emotion categories (all Fs > 8). Angry compared with neutral novel faces yielded more false positives than neutral ones, $F(1, 38) = 4.57$, $p < .039$. When comparing happy and neutral faces, there was no main effect of emotion, but there was a significant Age × Emotion interaction, $F(1, 38) = 5.73$, $p < .022$. Subsidiaries revealed that older adults showed higher false-positive rates for happy than for neutral faces, $t(19) = 2.82$, $p < .011$, an effect that was not seen in the younger adults. No age differences were found when comparing angry versus happy faces.

Discrimination accuracy. All pairwise ANOVAs involving *Pr* revealed lower overall discrimination ability in the older adults (all Fs > 5.7). Angry faces were better remembered than neutral faces, $F(1, 38) = 11.87$, $p < .001$, and happy faces, $F(1, 38) = 7.94$, $p < .008$, but discrimination of happy and neutral faces did not differ.

Recognition bias. Bias scores for angry faces were larger than for neutral faces, $F(1, 38) = 20.34$, $p < .001$, without any age differences or interactions. When comparing happy and neutral faces, there was no main effect of emotion ($F < 2$), but there was a main effect of age, $F(1, 38) = 5.71$, $p < .022$, revealing a larger bias for happy and neutral faces in older participants. The Age × Emotion interaction in this comparison did not reach significance,

Table 2
Recognition of Emotional Faces in Two Age Groups in Experiment 1

	Younger adults		Older adults		Group difference	
Face type	*M*	*SD*	*M*	*SD*	*t*	*p*
Angry						
Hits	0.84	0.15	0.81	0.15	0.62	.538
False positives	0.12	0.13	0.23	0.13	−2.64	.012
Accuracy (*Pr*)	0.72	0.18	0.58	0.14	2.64	.012
Bias (*Br*)	0.44	0.34	0.55	0.27	−1.14	.263
Neutral						
Hits	0.69	0.16	0.65	0.16	0.82	.420
False positives	0.09	0.07	0.17	0.14	−2.20	.034
Accuracy (*Pr*)	0.61	0.18	0.49	0.14	2.36	.024
Bias (*Br*)	0.23	0.17	0.32	0.25	−1.39	.174
Happy						
Hits	0.70	0.17	0.74	0.15	−0.60	.549
False positives	0.07	0.06	0.22	0.19	−3.28	.002
Accuracy (*Pr*)	0.63	0.18	0.52	0.17	2.06	.047
Bias (*Br*)	0.21	0.23	0.43	0.29	−2.67	.011

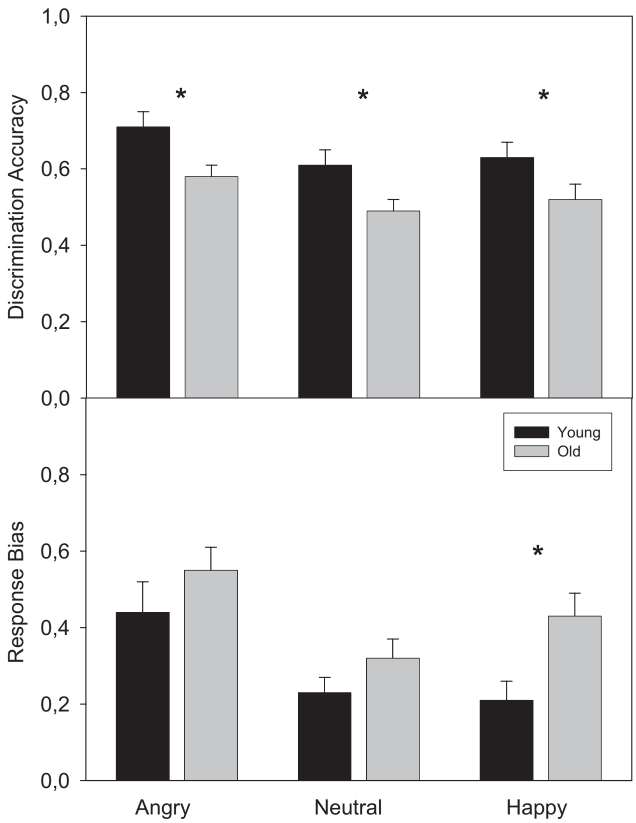

Figure 1. Memory performance and bias (*M* and *SE*) for faces with angry, neutral, and happy expressions in younger and older adults (Experiment 1). Asterisks represent significant group differences ($p < .05$).

$F(1, 38) = 2.91$, $p < .096$, despite the above-reported increase of true and false recognition for happy versus neutral faces in the older adults. Angry compared with happy faces elicited a larger recognition bias for angry faces, $F(1, 38) = 15.03$, $p < .001$, and a main effect of age, $F(1, 38) = 4.47$, $p < .041$, indicating for both happy and angry faces a larger bias in the older adults.

Discussion

In Experiment 1, we found enhanced biased recognition bias for emotional, and especially negative, compared with neutral faces in both age groups, confirming earlier research (e.g., Budson et al., 2006; Johansson et al., 2004). In the older adults, we additionally found enhanced true and false recognition for positive faces, mainly relying on enhanced false memory.

The positivity-induced recognition bias in the older adults relied on both enhanced true-and-false recognition for happy faces, similar to recent research using words (Kapucu et al., 2008) or scenic pictures (Fernandes et al., 2008). Mood effects would be a possible explanation for this positivity-induced recognition bias, as positive mood is known to induce a more liberal response tendency (e.g., Isen & Daubman, 1984; Levine & Bluck, 2004). Older people, with their reduced item-specific memory, might be more vulnerable to such influences. However, Fernandes et al. (2008) made concurrent measurements of recognition memory and actual mood, and they showed that the correlations were inconsistent and small.

Within the framework of SST (Carstensen, 1993), the enhanced recognition bias may reflect a focus on positive information, subserving an age-related emphasis on achieving emotional balance. The original version of the SST predicted relatively enhanced true recognition for positive faces in the older adults for the older group (Charles et al., 2003; Experiment 1), or relatively reduced recognition for negative faces (Charles et al., 2003; Experiment 2), as a result of enhanced attention to positive items during encoding (Mather & Carstensen, 2003). Our results are only partly in accordance with these early SST predictions because we found not only enhanced hit rates but also enhanced false-positive rates for happy faces. In recent research, a broader definition of the positivity effect has been proposed, including recognition bias changes as evidence of older adults' greater receptiveness to positive stimuli (Spaniol, Voss, & Grady, 2008). The results of our first experiment are in accordance with this widened concept of the positivity effect.

As mentioned in the introduction, emotional memory in old age should be seen in the context of reduced memory capacity, which was also found in our present study. In this perspective, increased true and false recognition of positive faces might represent a compensatory memory strategy when performing our rather difficult face-recognition task. Older participants are known to rely on gist rather than on item-specific memory (e.g., Kensinger, Garoff-Eaton, & Schacter, 2007). Gist may either be based on perceptual similarity, which might be higher for happy than for angry faces, or on semantic associations (cf. Balota et al., 1999; Budson et al., 2003; Koutstaal et al., 2003). Closer semantic associations might, for example, arise from a spontaneous inference from a smiling face to a person's familiarity.

The interpretation of our results as an age-related enhanced bias for happy compared with neutral faces was limited in this first experiment, however, by the fact that the Group × Emotion interaction only approached significance, although it was highly significant when true and false recognition were separately examined. This might result from the fact that bias scores are dual composites, thereby accumulating errors of measurement of both underlying parameters. To confirm our results, and to follow up the above described alternative interpretations of our findings, we conducted three further experiments.

Experiment 2

In the second experiment, we aimed to inspect the influence that emotional valence had on recognition for emotional faces by changing the faces' emotional expression from study to test. A somewhat similar technique had been earlier used by Mather and Carstensen (2003) when investigating age differences in attentional processing during encoding of positive, neutral, or negative faces using a dot probe paradigm. In this study, older participants directed their attention to positive rather than to neutral faces, and to neutral rather than to negative faces. This attentional bias for positive faces translated into a recognition advantage for faces that had been encoded as happy in older but not in younger adults, thereby confirming the predictions of SST. However, two issues remained open with regard to the purpose of the present study. First, the study focused on discrimination accuracy and did not consider biased recognition. Second, the study did not compare recognition performance for positive versus negative faces at retrieval.

More recently, Thomas and Hasher (2006) examined attentional bias and incidental recognition memory of older and younger participants for distracting positive, negative, and neutral words. Younger adults were more distracted by negative stimuli than by positive or neutral stimuli, and they correctly recognized more negative than positive words. Older adults, however, paid equal attention to all stimuli but showed reliable recognition only for positive words. Thus, although an attentional bias toward negative words carried over into recognition performance for younger adults, older adults' bias appeared to be limited to remembering positive information.

In the present experiment, we aimed to extend these findings by investigating whether the positivity-related recognition bias persisted for faces that were emotional during either encoding or retrieval. We systematically varied the facial expressions displayed by given identities at study and test. If an increased recognition bias for positive faces in the older group emerged even though the face had been encoded as neutral, this would contradict the view that this phenomenon relied on the enhanced attention that older adults paid to positive faces during encoding.

Method

Participants. Twenty younger and 20 older adults participated in the experiment. Recruitment procedures and inclusion criteria were similar to Experiment 1. Eight older adults were recruited from a panel of volunteers at the Karolinska Hospital Memory Clinic, but they did not differ from the German participants in any of the performance measures reported below (all Fs < 1).

Stimuli and procedure. Of the 96 target identities used in Experiment 1, two different portraits were selected, depicting the same person but displaying different facial expressions. The study session comprised 32 angry, 32 happy, and 32 neutral faces. During the test session, the 96 target identities were presented again, but this time each displayed their other expression. Half of the faces studied with an emotional expression displayed the respective other expression in the test session (AH, HA), the other half displayed a neutral expression (AN, HN). We did not include a condition in which the same facial emotion was repeated because preexperiments had shown that repetition would result in large performance gains, thereby overshadowing possible age and emotion effects. The procedure during the study and test sessions was the same as in Experiment 1. To ensure that the task was well understood, we explicitly instructed the participants that although the displayed face could have a new facial expression, it was their task to decide whether the same person had appeared in previously viewed portraits.

Data analysis and preprocessing. True recognition was analyzed by obtaining hit rates for target conditions that had been emotional at study (AN, HN), or at test (NA, NH). Thus, neutral faces served as a control condition against which valence effects were weighted. False recognition was analyzed for each emotion category, as for Experiment 1. Discrimination accuracy (*Pr*) and recognition bias (*Br*) were calculated by relating hit rates in conditions AN, HN, NA, and NH to false-positive rates for the respective emotion category during the test session. For example, *Pr* (NA) was calculated by subtracting false positives (A) from hits (NA). Mean hit rates, discrimination accuracy, and recognition bias were analyzed by means of $2 \times 2 \times 2$ repeated measures ANOVAs including the within-factors valence (happy vs. angry) and session (study vs. test) and the between-factor age (old vs. young).

Results

True recognition. Measures of recognition performance are displayed in Table 3 and Figure 2, grouped according to age and emotion. ANOVA revealed a main effect of session, $F(1, 38) = 6.96$, $p < .012$. Thus, targets that had been emotional during encoding elicited higher hit rates than those that had been neutral during encoding. The Age $\times$ Valence interaction approached significance, $F(1, 38) = 3.3$, $p < .077$, reflecting a tendency toward higher hit rates for angry versus happy faces in the younger adults, $F(1, 38) = 4.26$, $p < .053$, but not in the older adults.

False recognition. Again, false-positive rates were considerably higher in older adults ($M = 0.26$, $SD = 0.12$) than in the younger adults ($M = 0.15$, $SD = 0.10$), $t(19) = 3.27$, $p < .002$, as evidenced in all pairwise comparisons below. Comparing false-positive rates for the angry and neutral groups of novel faces revealed main effects of emotion, $F(1, 38) = 27.0$, $p < .001$, indicating more false-positive answers for angry ($M = 0.24$, $SD = 0.10$) compared with neutral ($M = 0.16$, $SD = 0.11$) faces. An Age $\times$ Emotion interaction, $F(1, 38) = 5.17$, $p < .029$, showed that this difference was present in the younger participants (angry: $M = 0.22$, $SD = 0.10$ vs. neutral: $M = 0.11$, $SD = 0.10$), $t(19) = 6.35$, $p < .001$, but not in the older participants (angry: $M = 0.26$, $SD = 0.10$ vs. neutral: $M = 0.21$, $SD = 0.12$), $t(19) = 1.63$, $p < .119$. Comparing happy versus neutral novel faces, a main effect of emotion, $F(1, 38) = 16.32$, $p < .001$, revealed that happy faces ($M = 0.16$, $SD = 0.11$) yielded more false-positive answers than neutral ones. A significant Age $\times$ Emotion interaction, $F(1, 38) = 7.85$, $p < .008$, indicated that this difference was significant in the older adults (happy: $M = 0.30$, $SD = 0.15$ vs. neutral: $M = 0.21$, $SD = 0.12$), $t(19) = -5.22$, $p < .001$, but not in the younger adults (happy: $M = 0.13$, $SD = 0.11$ vs. neutral: $M = 0.11$, $SD = 0.10$), $t(19) = 1.75$, $p < .1$. The comparison of false-positive answers with angry versus happy novel faces again revealed an Age $\times$ Emotion interaction, $F(1, 38) = 14.97$, $p < .001$, indicating higher false-positive rates to angry versus happy faces in the younger participants ($t = 6.98$, $p < .001$) but not in the older participants ($t = -1.51$, $p < .148$).

Discrimination accuracy. As expected, older adults showed lower discrimination accuracy than younger adults, $F(1, 38) = 13.45$, $p < .001$. Further, there was a main effect of session, $F(1, 38) = 29.18$, $p < .001$, indicating that accuracy was higher for faces that had been emotional during encoding.

Recognition bias. Main effects of valence, $F(1, 38) = 6.8$, $p < .013$, and session, $F(1, 38) = 4.5$, $p < .041$, indicated a larger recognition bias for angry faces and a larger recognition bias for faces that were emotional during retrieval. Importantly, there was an Age $\times$ Valence interaction, $F(1, 38) = 13.27$, $p < .001$, and a triple interaction of all factors, $F(1, 38) = 9.65$, $p < .004$. Subsidiary 2×2 ANOVAs were first conducted for the factor session, opposing conditions involving emotion at study (AN; HN) versus emotion at retrieval (NA; NH). The ANOVA in-

Table 3
Face Recognition Performance According to Emotional Expression at Encoding and Retrieval in Two Age Groups in Experiment 2

	Younger adults		Older adults		Group difference	
Encoding/retrieval type	*M*	*SD*	*M*	*SD*	*t*	*p*
			Encoding emotional			
Encoding angry (AN)						
Hits	0.71	0.19	0.63	0.18	1.42	.164
Accuracy (*Pr*)	0.60	0.21	0.41	0.16	3.08	.004
Bias (*Br*)	0.26	0.29	0.39	0.24	−1.57	.126
Encoding happy (HN)						
Hits	0.66	0.18	0.61	0.17	0.91	.367
Accuracy (*Pr*)	0.55	0.22	0.39	0.13	2.64	.012
Bias (*Br*)	0.21	0.20	0.36	0.21	−2.35	.024
			Encoding neutral			
Retrieval angry (NA)						
Hits	0.65	0.22	0.53	0.18	1.75	.088
Accuracy (*Pr*)	0.42	0.20	0.28	0.15	2.61	.013
Bias (*Br*)	0.44	0.26	0.36	0.15	1.08	.289
Retrieval happy (NH)						
Hits	0.59	0.19	0.59	0.18	0.05	.958
Accuracy (*Pr*)	0.46	0.22	0.29	0.18	2.72	.010
Bias (*Br*)	0.23	0.19	0.43	0.21	−3.18	.003

Note. AN = faces studied with an angry expression displayed a neutral expression; HN = faces studied with a happy expression displayed a neutral expression; NA = faces studied with a neutral expression displayed an angry expression; NH = faces studied with a neutral expression displayed a happy expression.

cluding emotion at study yielded a main effect of age, reflecting a larger recognition bias for older adults than for younger adults, $F(1, 38) = 4.1$, $p < .05$. The ANOVA including conditions that were emotional at test showed an Age × Valence interaction, $F(1, 38) = 17.65$, $p < .001$, which was due to a age difference in recognition bias to NH faces, $t(19) = 3.18$, $p < .003$, but not in NA faces. The opposite contrast, opposing both groups, revealed in the younger group a larger recognition bias for NA faces than for NH faces, $t(19) = 3.97$, $p < .001$, which was not found in the older group.

Discussion

In the second experiment, we aimed to extend our previous findings by investigating whether the positivity-related recognition bias persisted for faces that were either emotional during encoding or during retrieval.

We found that the increased recognition bias in the older group was specific to faces that were neutral at study but happy at test. This pattern of results confirms a previous study using verbal stimuli (Thomas & Hasher, 2006), revealing that older adults recognized positive words better despite the fact that they paid equal attention to all stimuli during encoding. Like this study, our finding that emotion at retrieval was the critical criterion for occurrence of enhanced biased recognition in the older adults contradicts the view that the positivity-induced recognition bias in the older adults relied on the enhanced attention that older participants paid to positive faces during encoding.

Emotion during encoding enhanced true recognition in both groups, however, irrespective of emotional valence. This finding confirms previous research that reported an age independent tendency toward higher true and false recognition of faces encoded as angry compared with faces encoded as happy (cf. Grühn et al., 2005; Johansson et al., 2004).

Our findings are in accordance with recent wider definitions of the SST, in which the positivity effect was thought to include older adults' preference for old answers to faces that were only positive at retrieval (cf. Fernandes et al., 2008; Kapucu et al., 2008). On this view, affirmative responses to positive faces subserved emotion regulation.

The results of Experiment 2 are also in accordance with the view that enhanced gist-based memory in old age may account for the bias. As in Experiment 1, older participants' overall memory performance was reduced compared with the younger participants, mainly because of enhanced false recognition. One possibility might be that older participants, in the absence of veridical memory representations, might base their judgments on perceptual similarity, which might be higher for happy compared with angry faces. However, when comparing the result pattern of Experiments 1 and 2, reducing overall perceptual similarity of faces presented at study and test by changing emotional expression in Experiment 2 did not affect the positivity-induced recognition bias, suggesting that perceptual similarity of happy compared with angry faces was, at least, not the main underlying factor. Alternatively, a closer semantic association of positive emotion and familiarity (e.g., smile–friend) might be used by older participants to compensate for reduced item-specific memory when attempting to recognize a face (e.g., Budson et al., 2003; Koutstaal et al., 2003). For example, "smile" would be closely associated with "friend." These semantic associations may have been formed by real-life

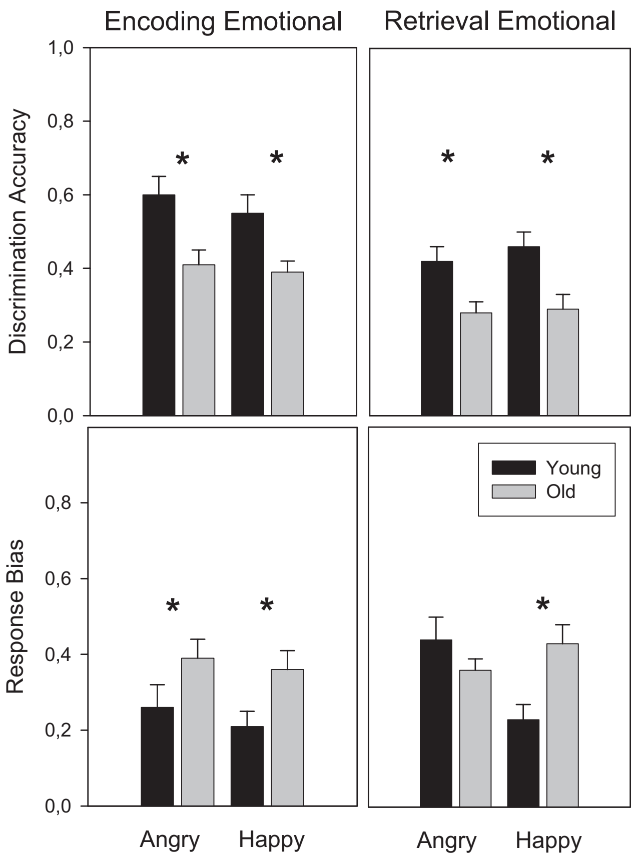

Figure 2. Memory performance and bias (*M* and *SE*) for faces with angry versus happy expressions during encoding or retrieval in younger and older adults (Experiment 2). Note that faces that were emotional during encoding were neutral during retrieval and vice versa. Asterisks represent significant group differences ($p < .05$).

experiences because people more often smile at other persons strongly if they are familiar than if not.

However, we felt that further evidence was needed for the assumption that the recognition bias for happy faces might reflect a compensatory strategy. Therefore, in Experiment 3, we included older patients with mild memory impairment to investigate whether they would show a positivity-induced recognition bias.

Experiment 3

In our third experiment, we investigated two groups of old adults, one within the normal age range of cognitive ability, and the other with amnestic mild cognitive impairment (aMCI). The aMCI syndrome is characterized by reduced episodic memory performance, yet with preserved abilities of everyday life (Petersen, 2004). Comparing these patients with age-matched adults with normal memory capacity allows one to examine the relationship of emotion and memory interactions while controlling for possible general effects of aging.

Earlier studies investigating emotion–memory interactions in patients with mnestic impairment have mostly investigated patients with Alzheimer's disease (AD). Although some studies have showed the enhancing effect of emotion on episodic memory to be diminished in AD (Abrisqueta-Gomez, Bueno, Oliveira, & Bertolucci, 2002; Budson et al., 2004; Kensinger et al., 2002), others showed similar memory enhancement in patients and controls (Boller et al., 2002; Kazui, Mori, Hashimoto, & Hirono, 2003; Moayeri, Cahill, Jin, & Potkin, 2000). However, large differences in general performance levels imply the risk of either floor or ceiling effects in one of the groups (cf. Hamann, 2001). In the present study, we sought to avoid this problem by investigating a patient group with very mild memory impairment.

Our main research questions concerned whether the recognition bias for faces that were happy at test persisted in the aMCI group. The rationale was as follows. In aMCI patients, episodic memory is impaired. Thus, in accordance to previous research in mild AD, memory enhancement by emotion at encoding might be reduced or abolished. Patients with aMCI would need to compensate for their memory deficits. Because their other cognitive abilities, such as executive functions or semantic knowledge, were intact, their ability to use gist-based strategies and to show a positivity effect should not be impaired in comparison with older controls (Mather & Knight, 2005; Petrican, Moscovitch, & Schimmack, 2008).

Method

Participants. Fourteen patients with a diagnosis of aMCI and 14 healthy controls—matched according to age, gender, and years of education—participated in the study. Two aMCI patients were later excluded from data analysis: one patient because of low emotion classification performance during the study session and one patient because medical follow-up investigations indicated a progressive degenerative disease other than AD. The remaining 26 participants (12 patients, 14 controls) were submitted to data analysis.

Patients were recruited from the Karolinska Hospital Memory Clinic and were carefully selected according to the revised consensus criteria for single-domain aMCI (Winblad et al., 2004), which depend on deterioration of cognitive ability in objective memory tests and preservation of basic activities of daily living. Extensive neurological examination prior to participation ensured that they were free from any other neurological or psychiatric disorders, including dementia and depression. To exclude patients with vascular pathology out of the age range, a specialized neurologist who was blind to the purpose of the study examined a magnetic resonance imaging scan not older than 6 months. Older controls were drawn from panels of healthy volunteers at the Karolinska Hospital. All other screening procedures and inclusion criteria were similar to Experiments 1 and 2.

All participants underwent a neuropsychological investigation of episodic memory (Rey Auditory Verbal Learning Test; Rey, 1964), semantic memory (Vocabulary test [SRB-1]; Dureman, 1960; and Information subtest of the Wechsler Intelligence Scale–Revised; Wechsler, 1981), short-term and working memory (Digit Spans of the Wechsler Memory Scale–Revised; Wechsler, 1987), and executive functions (Trail Making Test A and B; Reitan, 1959). As shown in Table 4, aMCI participants displayed an isolated episodic memory deficit, whereas all other domains, namely semantic knowledge and executive functions, were preserved. Stimulus materials, design, and analysis were the same as in Experiment 2.

Table 4
Demographic Data and Performance in the Neuropsychological Test Battery of Older Adults With and Without Amnestic Mild Cognitive Impairment (aMCI) in Experiment 3

Variable	aMCI *M*	aMCI *SD*	Control *M*	Control *SD*	*t*	*p*
Age	66.6	7.5	67.4	5.9	0.32	.750
Gender (male:female)	6:6		7:7			
Education (years)	10.4	2.1	10.4	1.8	−0.03	.979
MMSE	27.2	1.8	29.8	0.6	5.16	.001
Vocabulary test	22.0	4.2	23.3	2.0	−0.62	.551
WAIS Information	18.5	4.1	19.5	4.4	−0.52	.606
RAVLT Learning subscore	32.9	8.8	53.8	7.3	6.17	.001
RAVLT Recall subscore	5.4	4.2	12.0	2.3	4.85	.001
Digit Spans	6.5	1.9	6.6	1.4	0.35	.732
TMT-A	53.2	25.4	45.4	18.5	−0.85	.404
TMT B-A	57.3	31.4	46.5	22.6	−0.96	.346

Note. MMSE = Mini Mental Status Examination; Vocabulary test = Swedish equivalent to the National Adult Reading Test; WAIS Information = Information subtest of the Wechsler Intelligence Scale–Revised; RAVLT = Rey Auditory Verbal Learning Test (Rey, 1964); Learning subscore = sum of recalled items during five learning trials (maximum = 75); Recall subscore = delayed recall after 15 min (maximum = 15); Digit Spans = Digit Spans of the Wechsler Memory Scale–Revised (Wechsler, 2001); TMT-A = Trail Making Test, time to perform (Version A); TMT B-A = Trail Making Test, time difference between A and B in seconds.

Results

True recognition. Measures of recognition performance for each group and emotion category are displayed in Table 5 and Figure 3. The 2 × 2 × 2 factorial ANOVA comparing emotional valence during study (AN vs. HN) and test (NA vs. NH) did not yield any significant results in either group.

False recognition. Across emotion categories, false-positive rates were higher in aMCI patients than in controls. When comparing false-positive rates for angry versus neutral faces, a Group × Emotion interaction, $F(1, 24) = 6.82$, $p < .015$, revealed that false-positive rates for angry compared with neutral faces were enhanced in controls ($M = 0.24$, $SD = 0.09$ vs. $M = 0.15$, $SD = 0.07$), $t(13) = 4.47$, $p < .001$, but not in patients ($M = 0.24$, $SD = 0.18$ vs. $M = 0.26$, $SD = 0.20$), $t(11) = -0.49$, $p < .628$. In the opposite contrast, comparing happy versus neutral faces, happy novel faces ($M = 0.36$, $SD = 0.15$) yielded more false-positive answers than neutral faces ($M = 0.21$, $SD = 0.14$), $F(1, 24) = 11.64$, $p < .002$. No group difference or interaction emerged here. Comparing angry ($M = 0.24$, $SD = 0.14$) and happy faces again revealed a main effect of emotion, $F(1, 24) = 7.21$, $p < .013$. Thus, both groups erroneously recognized happy novel faces more often than neutral and angry faces.

Discrimination accuracy. As indicated in Table 5, lower performance was found in aMCI patients compared with controls, $F(1, 24) = 10.59$, $p < .003$. A main effect of session, $F(1, 24) = 10.11$, $p < .004$, indicated superior discrimination for faces that had been emotional during study. A Group × Session interaction, $F(1, 24) = 21.63$, $p < .001$, revealed that this effect was only present in controls, $F(1, 13) = 15.38$, $p < .002$, but not in patients. The groups did not differ in recognizing faces that were emotional at test.

Recognition bias. Bias scores were not significantly different between patients and controls, but they were larger for faces that were emotional in the test session: all $F\text{s}(1, 24) \geq 4.5$, all $p\text{s} < .044$. A Session × Valence interaction, $F(1, 24) = 8.93$, $p < .006$, emerged because bias scores were enhanced for faces that were happy compared with angry during retrieval, $F(1, 24) = 8.02$, $p < .009$. Subsidiary analyses revealed a main effect of session for only happy faces, $F(1, 24) = 8.77$, $p < .007$, not for angry faces. Thus, both groups showed enhanced bias scores for faces that were happy during retrieval.

Discussion

The central finding of Experiment 3 was that both aMCI patients and older controls showed the positivity-induced recognition bias. Although the memory advantage for faces that had been emotional during study was abolished in aMCI, in accordance to previous research involving memory-impaired patients (Abrisqueta-Gomez et al., 2002; Budson et al., 2004; Kensinger et al., 2002), the enhanced bias at retrieval for faces that were happy was preserved in both groups.

The finding, stating that the bias persisted in aMCI patients despite impaired episodic memory, is in accordance with our hypothesis that a tendency to count smiling faces familiar reflects a stimulus-driven, compensatory memory strategy. On the basis of the results of Experiments 1 and 2, we had hypothesized that this strategy might rely on a stronger semantic association of positive faces and familiarity. However, the relative increase of biased recognition for happy faces might also reflect a relatively reduced bias for angry faces, resulting from lower false-response rates to negative faces. Suppressed false recognition might, for example, arise because angry faces appeared more distinctive or difficult to judge than happy faces (cf. Rajaram, 1996) and might therefore more often be correctly rejected on the basis of a distinctiveness heuristic (Budson, Sitarski, Daffner, & Schacter, 2002; Israel & Schacter, 1997; Pierce, Sullivan, Schacter, & Budson, 2005).

Our results are also compatible with recent versions of SST, which assert that older adults with and without memory impair-

Table 5
Face Recognition Performance of Older Adults With and Without Amnestic Mild Cognitive Impairment (aMCI) in Experiment 3

Variable	Older adults with aMCI		Older adults without aMCI		Group difference	
	M	*SD*	*M*	*SD*	*t*	*p*
Overall performance						
Hits	0.48	0.20	0.53	0.13	−0.80	.431
False positives	0.31	0.12	0.23	0.06	2.09	.047
Accuracy	0.17	0.12	0.30	0.12	−2.72	.012
Bias	0.38	0.17	0.34	0.10	0.88	.389
Encoding emotional						
Encoding angry (AN)						
Accuracy (*Pr*)	0.18	0.14	0.43	0.18	3.85	.001
Bias (*Br*)	0.31	0.22	0.33	0.25	0.10	.922
Hits	0.45	0.20	0.59	0.22	1.70	.102
Encoding happy (HN)						
Accuracy (*Pr*)	0.23	0.12	0.41	0.13	3.69	.001
Bias (*Br*)	0.35	0.26	0.27	0.14	−0.99	.330
Hits	0.49	0.23	0.56	0.15	0.91	.372
Retrieval emotional						
Retrieval angry (NA)						
Accuracy (*Pr*)	0.23	0.19	0.25	0.16	0.29	.776
Bias (*Br*)	0.33	0.24	0.33	0.14	−0.10	.924
Hits	0.47	0.26	0.48	0.19	0.11	.912
Retrieval happy (NH)						
Accuracy (*Pr*)	0.09	0.29	0.26	0.25	1.64	.114
Bias (*Br*)	0.49	0.15	0.40	0.16	−1.46	.158
Hits	0.51	0.24	0.57	0.16	0.78	.444

Note. AN = faces studied with an angry expression displayed a neutral expression; HN = faces studied with a happy expression displayed a neutral expression; NA = faces studied with a neutral expression displayed an angry expression; NH = faces studied with a neutral expression displayed a happy expression.

ment might have more tendency than younger adults to give "old" responses to happy faces because affirmative responses to positive stimuli subserve their goal to achieve a balanced emotional state. Recent research has shown that patients with reduced executive function show smaller positivity effects (Mather & Knight, 2005; Petrican et al., 2008). This finding has been taken as evidence that the positivity effect involves goal-related self-regulation (Knight et al., 2007; Mather & Carstensen, 2005). In our study, patients' cognitive deficits were restricted to the mnestic domain, so the finding of a preserved positivity-induced recognition bias is in accordance with these findings. It would be valuable for future research to compare MCI patients with memory impairment to MCI patients with additional executive dysfunction, to investigate whether a dissociation of the positivity-induced recognition bias and emotion-induced memory enhancement would emerge.

The above discussed possible interpretations of our findings are sharing an important common aspect. Where memory traces are weak, in the older as well as in memory-impaired patients, other factors can exert a greater impact on old–new decisions. In our task, these influencing factors may be participants' emotional goals, perceptual (dis)similarity, or semantic associations. To examine which of these aspects could account for the positivity-induced recognition bias, we conducted a further experiment.

Experiment 4

In this experiment, we aimed to further investigate whether the increased recognition bias for happy compared with angry faces at retrieval in older adults and aMCI patients reflected gist-based compensatory strategies or socioemotional selectivity. Support for the hypothesis of a compensatory strategy comes from previous research using semantically associated words or pictures of objects showing that older adults use their semantic knowledge to fill gaps in their item-specific memory (Balota et al., 1999; Budson et al., 2003; Koutstaal et al., 2003; Koutstaal & Schacter, 1997). The impact of semantic associations on memory is typically assessed through the use of verbal stimuli with well-known semantic associations. However, to our knowledge, the semantic connotations of emotional faces have not been explored so far. We hypothesized that familiarity would rather be associated with happy than with angry faces, possibly because, in real life, people more often smile at other persons strongly if they are familiar with them than if they are not. Such semantic associations should not be affected by age. However, for the subsequent recognition task, we hypothesized that age differences should emerge, because the older participants were more likely to use this semantic association to reconstruct their fragmentary memories in a compensatory manner.

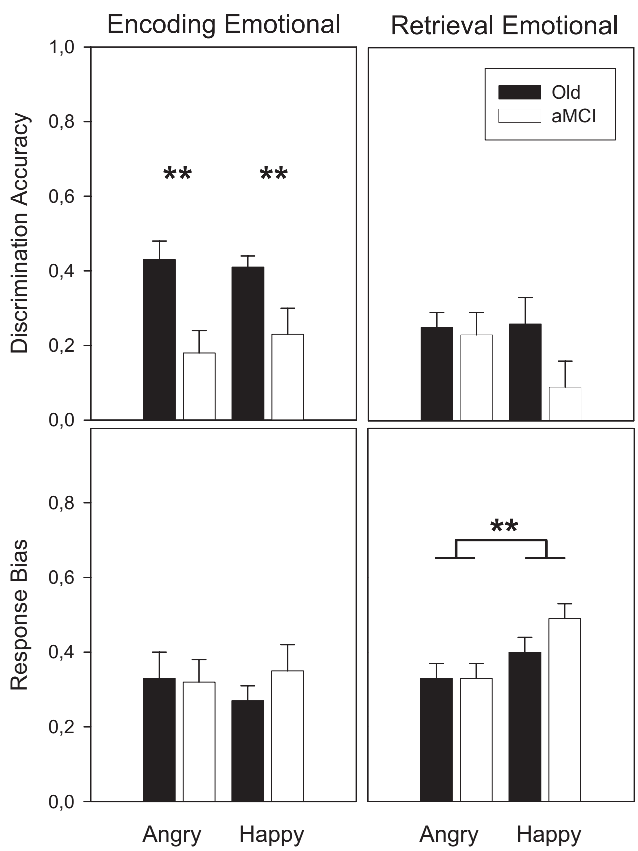

Figure 3. Memory performance and bias (*M* and *SE*) for faces with angry versus happy expressions during encoding or retrieval in older adults with and without amnestic mild cognitive impairment (Experiment 3). Note that faces that were emotional during encoding were neutral during retrieval and vice versa. In the upper left panel, the double asterisks indicate a highly significant group difference ($p < .01$). In the lower right panel, the two asterisks represent a higher bias for happy emotion compared with angry emotion, irrespective of group. aMCI = amnestic mild cognitive impairment.

As mentioned above, two alternative compensatory strategies might account for our results. The age-related asymmetry of biased recognition for happy and angry faces might be due instead to reduced false recognition for angry faces in the older adults if these angry faces would be considered as more "memorizable." To test this hypothesis, ratings of difficulty and distinctiveness should be obtained for the facial stimuli. If our pattern of results result from old adults' use of a distinctiveness heuristic in angry faces, judgments of distinctiveness or difficulty should be enhanced for these faces.

We also wanted to test the hypothesis derived from SST, that older adults, either with or without memory impairment, might prefer to give affirmative responses to happy faces because of a general age-related preference for positive stimuli subserving emotion regulation. Therefore, we wished to obtain judgments of emotional valence for angry and happy faces used in our experiments to assess whether a positivity effect would emerge for our set of facial stimuli, which could also explain the positivity-induced recognition bias.

To follow up on these hypotheses, we modified the recognition task used in our previous experiments. We changed the study task into semantic differential scales (Osgood, Suci, & Tannenbaum, 1957). The semantic differential is a method to measure the connotations of concepts that avoids the possibly misleading effects of direct questioning. Judgments obtained with this method often show a high degree of concordance between participants.

We also changed the encoding task into an incidental learning task. Thus, when completing the semantic differential scales, the participants were not aware that there was to be a subsequent recognition task (in contrast to Experiments 1–3, in which the subsequent recognition task had been explicitly announced). Disproportional age-related difficulties in intentional learning might, however, have exaggerated the age differences in question. As incidental learning is more typical than intentional learning for face memorization, this could provide a test for the robustness of our result pattern under real-life conditions.

Method

Participants. Twelve younger adults (seven women, five men; mean age = 26.6 years, *SD* = 3.3) and twelve older adults (six women, six men; mean age = 65.2 years, *SD* = 3.7) participated in the experiment, none of them had been previously involved in a face recognition experiment. The study was approved by the ethical committee of the Charité CBF, Berlin.

Thirty-two portraits—depicting 16 persons (eight female, eight male) with either a happy or an angry facial expression, who were randomly selected from our stimulus pool—were presented as color prints. One portrait from each stimulus pair was assigned to Set A, the other to Set B. Portraits 1–8 of each set were target faces; Portraits 9–16 served as novel faces.

Participants were initially asked to participate in a face rating. They received a booklet with horizontally arranged, visually analogous scales, which were labeled at each pole. For each portrait, the participants were asked to rate from 0 to 100 whether the person depicted appeared familiar or unfamiliar, whether they found the portrait distinctive or common, whether the face's emotional expression was easy or difficult to judge, and whether it was positive or negative. Order and position of the verbal labels, together with the polarity of the scales, were counterbalanced across participants. Half of the participants received the target faces of Set A during study and the target and novel faces of Set B at test, the other half vice versa.

Three to four weeks later, they were mailed a booklet with color prints showing a mix of the eight previously presented portraits together with the other portrait of that person and an equal number of novel faces. Participants were asked to perform old–new judgments on every face and to send the booklet back in the enclosed envelope. They were informed that the experiment investigated not only their judgments on faces but also subsequent memory performance. It was explained that the experimenters had not mentioned the subsequent memory task to avoid intentional encoding and rehearsal and that participation was voluntary.

Data analysis and preprocessing. Semantic differential ratings were obtained by calculating mean ratings for each portrait on each of the four scales. For the recognition task, true recognition (hits), discrimination accuracy (*Pr*), and recognition bias (*Br*) were analyzed by obtaining hit rates for faces that were either happy or angry at retrieval. False-recognition rates were obtained according to emotion during retrieval. All dependent variables were submitted to the 2 × 2 repeated measures ANOVAs including the within-factor valence (happy vs. angry at test) and the between-factor group (old vs. young).

Results

Semantic differential ratings. Mean and standard deviation of the ratings for each dimension and group are displayed in Table 6 and Figure 4. The 2 × 2 ANOVA for the familiarity ratings revealed a main effect of emotion, $F(1, 22) = 5.22$, $p < .032$, but no other significant effects, indicating that happy faces were by both groups considered more familiar than angry faces. For ratings of emotional valence, a main effect of emotion, $F(1, 22) = 65.18$, $p < .001$, and a main effect of age, $F(1, 22) = 4.51$, $p < .045$, indicated more positive ratings for the older adults. No significant effects were found for the difficulty and distinctiveness dimensions (all Fs < 2.4).

Recognition performance. All but one participant returned the booklet. Descriptive data on recognition performance are displayed in Table 6. The 2 × 2 factorial ANOVAs of hit rates and discrimination accuracy did not reveal any significant results for any Fs < 0.4, with the exception of an age difference in discrimination accuracy that approached significance, $F(1, 21) = 2.71$, $p < .115$. False-positive rates were larger for older than for younger participants, $F(1, 21) = 4.337$, $p < .050$. The Age × Emotion interaction was nearly significant, $F(1, 21) = 3.211$, $p < .088$. Analysis of recognition bias scores showed a nearly significant effect of age, $F(1, 21) = 4.165$, $p < .054$. Importantly, a significant Age × Emotion interaction, $F(1, 21) = 5.473$, $p < .029$, indicated an enhanced recognition bias for happy faces in the older adults compared with the younger adults, a bias that was not found for angry faces (for t tests and p values, see Table 6 and Figure 5).

Discussion

In the present experiment, we aimed to test possible explanations of the age-related bias for happy faces by obtaining the semantic differential ratings of valence, familiarity, difficulty, and distinctiveness during the study part and by relating possible age differences to subsequent recognition. The age-related, positivity-induced recognition bias was replicated under incidental learning conditions and in an ecologically valid setting involving a long retention interval and a change of context.

The first important result emerging from semantic differential ratings is that positive faces were, by both groups, considered more familiar than negative faces, despite the fact that participants were aware of never having seen the portraits. This might be evidence of a closer semantic association of positive emotion and familiarity. In contrast, distinctiveness and difficulty ratings differed neither between emotion categories nor between age groups. Thus, suppression of false-positive answers to angry faces that emerge from a distinctiveness heuristic in the older group was unlikely to

Table 6
Demographics, Semantic Differential Ratings, and Face Recognition Performance According to Emotional Expression at Encoding and Retrieval in Experiment 4

	Younger adults		Older adults		Group difference	
Variable	*M*	*SD*	*M*	*SD*	*t*	*p*
Age	26.6	3.6	65.2	3.7	25.89	.001
Gender (male:female)	5:7		5:7			
Semantic differential ratings (1–100)						
Angry faces						
Valence	27	18	32	16	0.74	.466
Familiarity	38	28	35	31	0.25	.805
Distinctiveness	51	20	41	24	−1.10	.283
Difficulty	50	24	43	22	0.42	.677
Happy faces						
Valence	75	23	84	08	1.19	.275
Familiarity	60	27	45	29	1.55	.136
Distinctiveness	57	21	48	21	−1.10	.280
Difficulty	55	36	54	29	−0.90	.376
Retrieval angry (HA)						
Hits	.36	.13	.34	.34	0.36	.720
False positives	.13	.11	.15	.18	−0.33	.748
Accuracy (*Pr*)	.24	.20	.20	.24	0.44	.664
Bias (*Br*)	.15	.10	.15	.16	−0.09	.928
Retrieval happy (AH)						
Hits	.33	.15	.35	.17	−0.37	.715
False positives	.09	.10	.26	.17	−2.86	.009
Accuracy (*Pr*)	.24	.21	.09	.20	1.71	.101
Bias (*Br*)	.11	.11	.28	.15	−3.09	.006

Note. HA = faces studied with an happy expression displayed an angry expression; AH = faces studied with an angry expression displayed a happy expression.

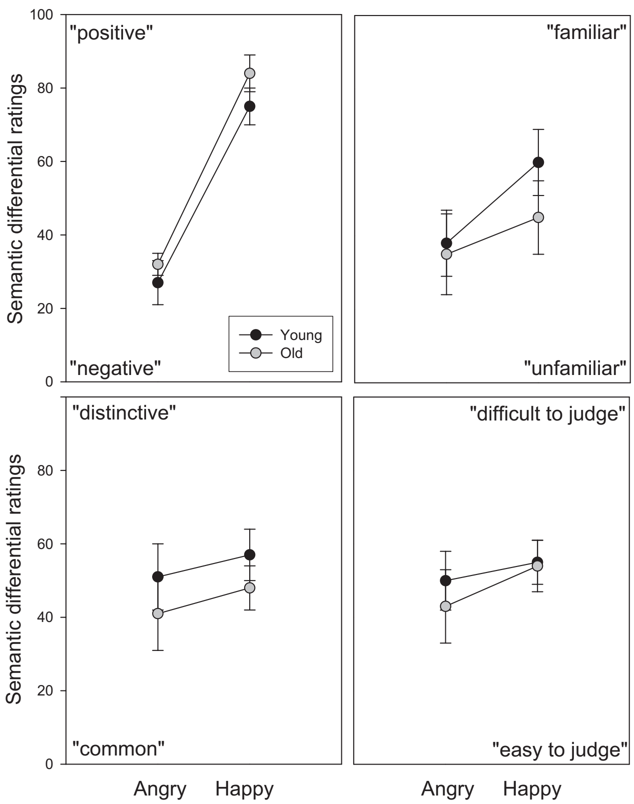

Figure 4. Semantic differential ratings (*M* and *SE*) for faces with angry versus happy facial expressions in younger and older adults (Experiment 4).

account for the pattern of results found in our series of experiments.

The second important finding obtained from semantic differential ratings was that both angry and happy faces were rated by older participants as more positive than by younger participants. Having said that, it has to be noted that semantic differentials were only obtained for targets and not for novel faces; the occurrence of a significant positivity shift in rating the valence of such a small set of faces and in relatively small samples of participants is remarkable and supports the view that age-specific emotional processing may contribute to our findings.

General Discussion

Retracing the chain of experiments in the present study, we set off from the finding of a recognition bias favoring positive faces in older adults in our first experiment. The finding of a positivity bias in face recognition extended previous research using words (Kapucu et al., 2008) or scenic pictures (Fernandes et al., 2008). To investigate which processes might underlie this age-specific phenomenon, we conducted three further experiments. In Experiments 2 and 3, we changed facial emotion from study to test, and we found that emotion at test was a necessary factor for occurrence of the bias. The "change of emotion" design allowed the dissociation of biased recognition from memory-enhancement effects that were emotion induced during encoding, which occurred in both younger and older healthy participants, the latter being in accordance with a broad body of previous research (e.g., Comblain et al., 2004; Denburg et al., 2003; Grühn et al., 2005; Johansson et al., 2004; Kensinger et al., 2002; Leigland et al., 2004).

Our finding that emotion at test considerably influenced memory is in accordance with neuroimaging research. Several studies showed that activation in hippocampal and emotion processing areas, such as the amygdalar complex, is not confined to encoding but also occurs during retrieval (Dolcos, LaBar, & Cabeza, 2005; Smith, Henson, Dolan, & Rugg, 2004; Smith, Stephan, Rugg, & Dolan, 2006). Sharot, Delgado, and Phelps (2004) suggested that amygdala activity at retrieval may enhance the subjective vividness of memories. Such a "spurious" reinforcement of hippocampal activity by amygdalar afferences might result in biased old–new judgments, especially in highly difficult recognition tasks (as in our study), in which veridical memory representations are rather weak.

Recognition performance of patients with mild memory impairment, assessed in our third experiment, provided a further, neuropsychological dissociation of emotion-induced memory enhancement, which was blunted, and the positivity-related recognition bias, which was preserved. The absence of memory enhancement is in line with previous studies involving patients with mild AD, which reported the enhancing effect of emotion on episodic memory to be diminished (Abrisqueta-Gomez et al., 2002; Budson et al., 2004; Kensinger et al., 2002). Investigating a sample of very mildly impaired patients allowed us to confirm these results while avoiding floor or ceiling effects in either group.

Our finding of abolished emotion-induced memory enhancement in aMCI patients is in accordance with recent research on brain pathology in neurodegenerative disease. In Alzheimer's disease, mediotemporal areas that are crucial for memory as well as emotion processing are affected by atrophy and accumulation of cellular abnormalities, such as plaques and tangles, at an initial stage already. Recent research shows that these signs of neurodegeneration are not restricted to the hippocampus but also involve the amygdalar complex (e.g., Herholz et al., 2004; Mufson, Ginsberg, Ikonomovic, & DeKosky, 2003). Markesbery et al. (2006) found both mediotemporal atrophy involving the hippocampus and the amygdalar complex to be already augmented in patients with MCI. It should, however, be taken into account that the aMCI

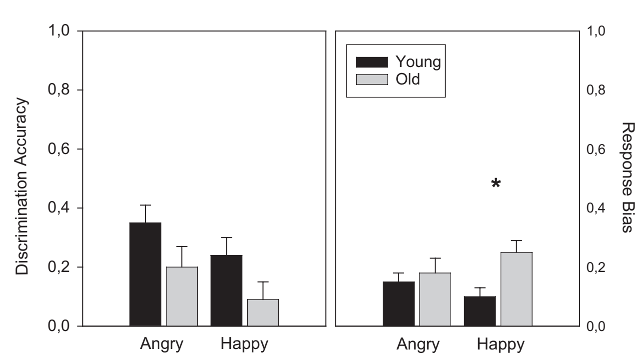

Figure 5. Memory performance and biased responding (*M* and *SE*) for faces with angry versus happy expressions in younger and older adults (Experiment 4). Note that happy faces were angry during encoding and vice versa. An asterisk indicates a significant group difference ($p < .05$).

group investigated here might have included participants with benign senescent forgetfulness, without future conversion to dementia. Comparing converters and nonconverters with respect to emotion-induced memory enhancement and positivity bias would be an interesting topic for further research. Of comparable interest would be the question of whether this bias would persist in patients with mild AD. On the one hand, impairments in executive functions and "forgetting about forgetting" might impair the ability to use memory strategies. On the other hand, as emotional processing is relatively intact in AD patients (e.g., Roudier et al., 1998), the positivity-related recognition bias might be preserved.

In the first three experiments, we found evidence that the positivity-induced bias was related to some type of additional processing of positive stimuli during retrieval. This additional processing was associated with old age and had been replicated in older adults, either with or without memory impairment. By introducing semantic differential scales into the study session in Experiment 4, we sought to scrutinize which specific features or associations might in older adults trigger the propensity to count a positive stimulus as previously encountered. The resulting performance pattern rendered the possibility of a distinctiveness heuristic unlikely but provided evidence for two other possible explanations of the positivity-related bias.

The finding of enhanced judgments of familiarity for positive faces is compatible with the view that positive faces trigger a compensatory memory strategy. In accordance with the results reported by Kensinger et al. (2007), positive faces may elicit enhanced gist, in comparison with negative faces. Remarkably, enhanced familiarity judgments were found in both age groups, though the positivity-related bias was age-specific. A similar asymmetric pattern was found in earlier studies using other types of related stimulus materials and arguing that age-independent perceptual or semantic associations were only used by older adults as a compensatory strategy in old–new decision tasks (Balota et al., 1999; Budson et al., 2003; Koutstaal et al., 2003; Koutstaal & Schacter, 1997). Although plausible, and possibly at first sight more parsimonious than the SST approach, an inference needs to be made: Semantic knowledge is thought to be used only by the older adults because they do need it more, disposing of less item-specific memory than young adults. As our experiment does not provide direct evidence for this assumption, further research is needed to follow up this point.

The finding that valence ratings were more positive in older adults is compatible with SST (Carstensen, 1993). Recent SST concepts of the age-associated positivity shift (e.g., Mather & Knight, 2005) would include a more liberal threshold for accepting positive information for older adults than for younger adults. Following this explanation, the absence, or weakness, of veridical memory representations in old adults gives way for pursuing emotional goals. Here, the inference of a "chronically active" desire to optimize affect is to be made. Further research should examine this point by including explicit or implicit measures of motivation and investigate whether they covary with both memory performance and judgments of valence.

It should be mentioned that the two approaches described above are not necessarily mutually exclusive. The hypothesis of Spaniol et al. (2008) is that positive items induce a greater feeling of familiarity, which enhances older participants' goal-directed propensity to count positive novel stimuli as previously encountered. This hypothesis might represent a starting point in the reconciliation of different types of age-specific processing. Fluency, or an age-related preference for the most "economic" way to solve memory tasks, might be well suited as a concept that links the impact of positivity-oriented emotional goals and the increased use of gist-based memory strategies in old age. A challenge for further research will be to move beyond the dichotomy of strategies that are either subserving emotion regulation or optimizing cognitive performance. A common underlying source may feed both age-related tendencies, and the specific impact of one of these strategies may be rather determined by individual differences.

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