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Interpretation of Emotionally Ambiguous Faces in Older Adults

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Research suggests that there is an age-related decline in the processing of negative emotional information, which may contribute to the reported decline in emotional problems in older people. We used a signal detection approach to investigate the effect of normal aging on the interpretation of ambiguous emotional facial expressions. High-functioning older and younger adults indicated which emotion they perceived when presented with morphed faces containing a 60% to 40% blend of two emotions (mixtures of happy, sad, or angry faces). They also completed measures of mood, perceptual ability, and cognitive functioning. Older and younger adults did not differ significantly in their ability to discriminate between positive and negative emotions. Response-bias measures indicated that older adults were significantly less likely than younger adults to report the presence of anger in angry-–happy face blends. Results are discussed in relation to other research into age-related effects on emotion processing.

Key Words: Emotion recognition—Aging—Facial emotion.

MANY studies have reported that depression, anxiety, and general distress are less likely to occur in later life (Jorm, 2000). These decreases may relate to differences between older and younger adults in the processing of emotional information. For example, older adults have different subjective experiences of emotion (Carstensen, Pasupathi, Mayr, & Nesselroade, 2000), exhibit different expressions of emotion (Malatesta, Izard, Culver, & Nicolich, 1987) and demonstrate different physical and psychological responses to emotion-evoking tasks (Levenson, Carstensen, Friesen, & Ekman, 1991). Older adults' memory for emotional information also appears to differ from that of younger adults (Thompson, Aidinejad, & Ponte, 2001). Overall, studies have found a reduction in the frequency of negative emotions and an increase in the frequency of positive emotions, both expressed and experienced, by healthy older adults (Calder et al., 2003).

Various theoretical views could explain these findings. For example, according to a motivational account, older adults shift their focus toward maintaining close interpersonal relationships in preference to achieving other life goals and, in so doing, learn to use strategic emotion-regulation and coping mechanisms in order to reduce the processing of negative information, which in turn reduces their susceptibility to negative affect (Carstensen, Isaacowitz, & Charles, 1999; Carstensen, Fung, & Charles, 2003; Lawton, 2001; Gross et al., 1997). Another view is that neurological, age-related decline may have an impact on emotion processing. For example, according to a hemispheric asymmetry view, the brain systems underlying the processing of negative information (i.e., right frontal regions) may be more impaired than those underlying the processing of positive information (i.e., left frontal regions; McDowell, Harrison, & Demaree, 1994). Another neurological account is that aging may dull the efficient functioning of an extensive neural network, including cortical and subcortical structures (including the amygdala), which is assumed to be of evolutionary significance and primarily responsible for the detection of negative information (LeDoux, 1996).

There is growing evidence that, when identifying emotions, older adults perform less well than younger adults. An early, naturalistic study used video footage to examine the recognition of anger, sadness, and fear, and it found that older adults were poorer than younger adults at recognizing emotions (Malatesta et al., 1987). Studies examining the identification of facial expressions have indicated impairments in older adults' ability to recognize sadness (Calder et al., 2003; MacPherson, Phillips, & Della Sala, 2002; McDowell et al., 1994; Phillips, MacLean, & Allen, 2002), anger (Calder et al.; McDowell et al.; Phillips et al.), and fear (Calder et al.; McDowell et al.). By contrast, the recognition of surprise and disgust appears to improve with age (Calder et al.).

Recent research has employed morphing techniques (i.e., computer-generated amalgamations of different facial expressions of emotion) to explore age differences in emotion processing (Calder et al., 2003; Sullivan & Ruffman, 2004a). Studies using morphed facial expressions may be more sensitive to age-related effects in emotional processing, compared with those using pure facial expressions as stimuli (such as prototypical happy, sad, or angry faces), because the latter may be easily identified and produce a ceiling effect in performance. Thus, the use of morphed faces allows the proportions of the emotional expressions to be manipulated (e.g., a dominant, angry component blended with a weak, happy component), which in turn allows the investigation of whether older adults show a bias in their identification of one emotion over another, within varying emotion combinations and intensities.

Sullivan and Ruffman (2004a) used three facial processing tasks to assess age effects on emotion identification. The first required participants to recognize a facial emotion as it morphed, over 12 s, from another facial emotion. The second task required participants to identify which of two morphed facial expressions demonstrated the greatest target emotion

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(e.g., which of two faces looked more angry). The third task required participants to identify which of six pictures of emotional facial expressions matched an emotional soundtrack. Results suggested that older adults were impaired when identifying angry and sad facial expressions, and when matching emotional sounds to angry, sad, and disgusted faces. In addition, an age-related decline in the identification of some negative emotions was not explained by general cognitive decline with age. Calder and colleagues (2003) also used normal and morphed faces to examine emotional face recognition across the adult life span. In one task, participants identified the emotional expressions in facial photographs showing six different pure emotions. In the second task, participants identified the emotion expressed in morphed facial images of varying blend proportions and expressions. The results suggested a reduction in older adults' ability to identify fear and a slight reduction in their ability to identify anger.

Overall, these findings suggest a decline in older adults' ability to identify negative emotional information, particularly sadness and anger, but a preservation of their ability to identify positive emotions such as happiness. However, the methodological features of previous studies using morphed faces may limit the interpretation of their findings. First, Sullivan and Ruffman (2004a) and Calder and colleagues (2003) used six emotions (happiness, sadness, anger, fear, surprise, and disgust), which were paired so that each emotion was contrasted with two other emotions. Although both studies balanced the number of times each emotion was a target, each emotion was not contrasted against every other emotion (it is likely that this would have made the task unacceptably long). For example, Sullivan and Ruffman contrasted anger with disgust and sadness; sadness with fear and surprise; and happiness with anger and disgust. Thus, in both studies, the extent to which the findings represent age-related deficits in recognition of the target emotion, or differential effects of the contrasting emotions, was unclear. In the present study we used only three emotions (anger, sadness, and happiness), with each emotion contrasted against each other. We chose these three primary emotions because research has previously shown that there are generally consistent age-related impairments for anger and sadness, and preservation for happiness (e.g., Sullivan & Ruffman). We also restricted the number of emotions in order to avoid a lengthy testing session, which might have fatigued older participants.

A second concern is that previous studies have mainly relied on analyses of correct identification performance, which means that it is difficult to disentangle an age-related deficit in discrimination performance from response-bias effects. For example, poorer identification performance for negative faces in older adults could reflect impaired perceptual discrimination of negative faces, or a bias against reporting the presence of negative expressions, or both.

In the current study we examined the effect of aging on emotion identification by using signal detection methodology in a morphed face-discrimination task (Garner, Mogg, & Bradley, 2007). We investigated age-related effects on emotion processing by quantifying performance in terms of discrimination accuracy (i.e., ability to identify the dominant emotion displayed in a morphed expression) and response bias (i.e., tendency to report a given emotion). Our main aim was to assess whether an age-related deficit in identifying negative faces is due to poor perceptual discrimination, response bias, or both. For example, the motivated, emotion-regulation account described earlier (e.g., Carstensen et al., 2003) would predict a general response bias in older adults against negative emotions and toward positive ones. Given previously reported findings, we hypothesized that, in comparison with younger adults, older participants would show reduced perceptual discrimination of negative (i.e., angry and sad) faces, relative to happy faces, and that they would also show a greater response bias against negative (i.e., angry and sad) faces, relative to happy faces.

Methods

Participants

We recruited 30 healthy, high-functioning older adults, aged 61 to 92 years, from a non-clinical, community population (e.g., local community and social clubs). We recruited 30 young adults, aged 18 to 30 years, from a non-clinical, student population. We lost the data from one younger adult as the result of a computer error, and we excluded the data from one older adult because the participant failed to select the happy response option throughout the face-classification task (i.e., an extreme outlier). Thus, for each group, $n = 29$.

Materials and Apparatus

Prototype angry, happy, and sad expressions were selected from the NimStim Face Stimulus Set (http://www.macbrain.org/resources.htm), which includes more than 600 facial stimuli depicting a wide range of emotions (including fearful, happy, sad, angry, surprised, calm, and disgusted). In the present study we used pictures of four female and four male models (1f, 3f, 7f, 8f, 21m, 23m, 27m, and 34m), each showing angry, sad, and happy facial expressions. There were seven European-American models and one Latino-American model. According to validation data, which are available at http://www.macbrain.org/validation.xls, there was overall agreement by 88% of the judges about the designated emotional expression of the 24 faces selected for use in the present study (also see Tottenham et al., in press).

We used these stimuli to create three emotion blends: angry–happy, sad–happy, and sad–angry. For each model and emotion blend, we combined two prototype images to create two morphed facial expressions that differed in emotional intensity (e.g., for the angry–happy blend, one morphed face was 60% angry and 40% happy, and the other morphed face was 40% angry and 60% happy); see Figure 1. The preparation of each morphed face used Gryphon Morph v2.5 software (Gryphon Software Corporation, 1994) and was similar to image-manipulation techniques used in studies investigating the categorical perception of emotional expression (e.g., Young et al., 1997); see Garner (2005) for details. In addition, we used prototype (unmorphed) angry, happy, sad, and neutral expressions from two additional male and female models in practice trials. Stimuli were 150 mm high and 115 mm wide, presented in color; we used Inquisit version 1.33 (2002) on a Sony Vaio Pentium III laptop. We collected the participants' responses by means of a labeled, external keyboard.

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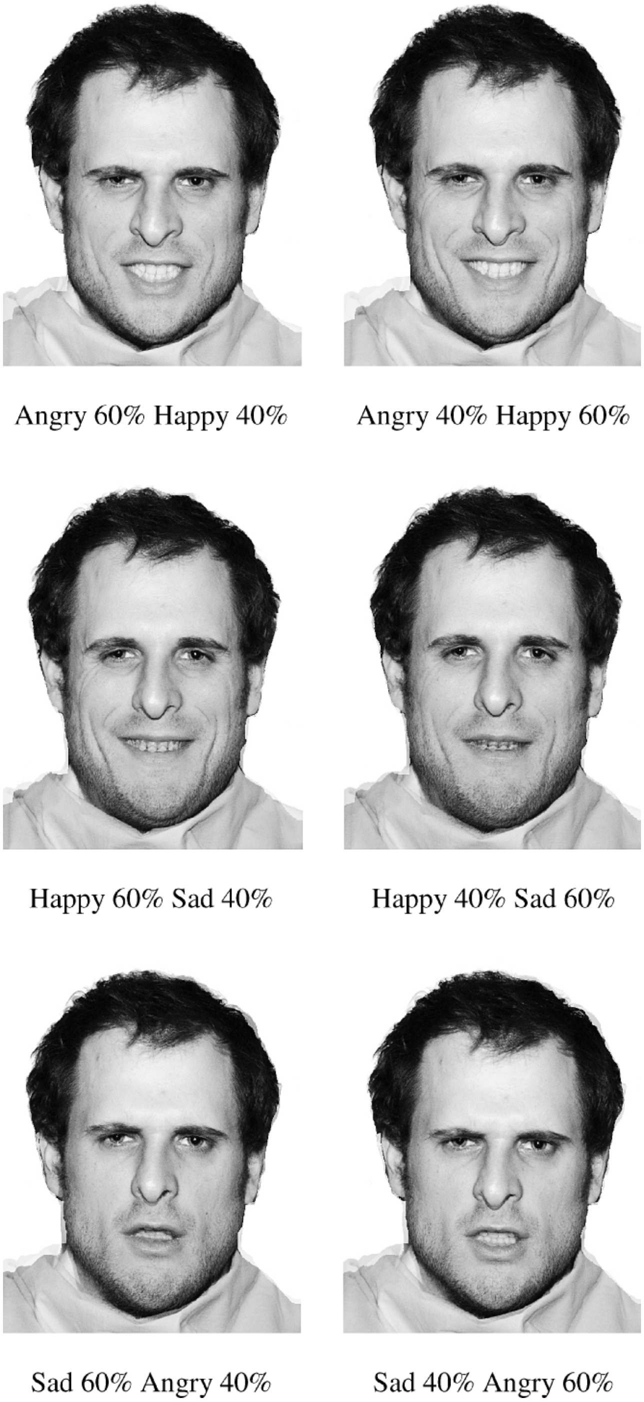

Figure 1. Example face blends: Angry-Happy (top row), Happy-Sad (middle row) and Sad-Angry (bottom row).

Procedure

Each participant provided informed consent to take part in the study in accordance with approval from the University of Southampton Psychology Research Ethics Committee. In the face-classification task, we presented stimuli from each emotion blend (i.e., sad-happy, angry-happy, and sad-angry) in separate blocks of trials (block order was counterbalanced across participants). At the beginning of each block, brief instructions were displayed on the screen in large print and clarified orally; participants had unlimited time to read these and ask questions. They were asked to classify each face, using one of six response options as accurately and as quickly as possible (e.g., for the sad–happy block, options were "very sad," "moderately sad," "slightly sad," "slightly happy," "moderately happy," and "very happy"). Each trial began with the presentation of a face that was displayed until response (for a maximum of 20 s for practice trials and 15 s for morphed face trials). The intertrial interval was 1,000 ms. We placed response labels on the keyboard at the beginning of each block to remind participants of the response scale. In addition, we presented the response scale at the base of the screen throughout the block. Following instructions, there were six practice trials at the start of each block in which the two prototype expressions for that block (e.g., happy, sad) and neutral faces were each presented once in random order. This format encouraged participants to use the full range of response options and to familiarize themselves with the new response choices for the block. Next, we presented all 16 morphed ambiguous expressions (for that block) three times across 48 randomly ordered trials. The task (three blocks) took approximately 20 min to complete.

Immediately before and after the face-classification task, participants rated their current mood state on three separate visual analog scales (VASs), that is, happiness, sadness, and anxiety, by marking a line on each VAS, which ranged from 0 (not at all) to 100 (extremely). Following the face-classification task, participants also completed neuropsychological assessments of crystallized and fluid intellectual ability (respectively, the Vocabulary and Matrix Reasoning subtests of the Wechsler Abbreviated Scale of Intelligence, WASI) (Wechsler, 1999); general, nonemotional, visual perception (The Incomplete Letters subtest of the Visual Object and Space Perception Battery, or VOSP; Warrington & James, 1991); and nonemotional facial perceptual ability (Benton, Sivan, Hamsher, Varney, & Spreen, 1994). In addition, participants completed the State–Trait Anxiety Inventory (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) and social items from the Fear Questionnaire (Marks & Mathews, 1979). We included the mood and anxiety measures because these variables may be associated with a bias to evaluate ambiguous information in a negative manner (e.g., Garner et al., 2007; Mogg & Bradley, 1998; Richards et al., 2002). Participants also completed a short form of the Social Desirability Scale (Strahan & Gerbasi, 1972) because defensiveness may be a confounding variable affecting measures of anxiety and emotion processing (Eysenck, 1997). Finally, participants completed questions related to demographic information and health (i.e., current medication, history of head injury, and physical and mental health problems).

Results

Data Preparation

Consistent with Donaldson (1996), we transformed raw data into nonparametric measures of discrimination accuracy and response bias, using the distribution-free nonparametric model, separately for each age group and for each emotion pair. A hit (H) denotes an accurate classification of the dominant emotion (e.g., a 60% sad, 40% happy face classified as "sad"). A false

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Table 1. Group Characteristics

Characteristics	Younger Adults $M \pm$ SD	Older Adults $M \pm$ SD
Age (years)	20.3 ± 2.8	72.8 ± 8.2
Years of education	14.9 ± 1.2	14.4 ± 3.0
WASI: Vocabulary Subtest (*t* score)	62.4 ± 4.2	67.3 ± 3.6
WASI: Matrix Reasoning Subtest (*t* score)	55.2 ± 5.7	60.9 ± 8.9
VOSP: Incomplete Letters Subtest (raw score, max 20)	19.7 ± 0.5	19.2 ± 1.1
Benton's Test of Facial Recognition (raw score, max 54)	48.1 ± 3.5	47.7 ± 3.8
STAI: State Anxiety (max 80)	36.3 ± 8.0	34.4 ± 10.1
Trait Anxiety (max 80)	37.9 ± 8.2	36.9 ± 9.9
Fear Questionnaire: Social scale (max 40)	11.6 ± 6.3	7.4 ± 5.9
Social Desirability Scale, short form (max 10)	4.4 ± 2.1	4.8 ± 2.1
VAS: Happiness (max 100)	63.6 ± 13.3	74.1 ± 12.6
VAS: Sadness (max 100)	13.4 ± 16.8	4.9 ± 7.5
VAS: Anxiety (max 100)	17.5 ± 16.0	10.8 ± 16.3

Note: WASI = Wechsler Abbreviated Scale of Intelligence; VOSP = Visual Object Space Perception Battery; STAI = State-Trait Anxiety Inventory; VAS = visual analog scale (mean of scores taken immediately before and after the emotion-discrimination task). N = 29 for younger and older adults; for younger adults, there were 10 men and 19 women; for older adults, there were 15 men and 14 women.

alarm (FA) denotes the classification of the nondominant emotion and, therefore, an incorrect classification (e.g., a 60% sad, 40% happy face classified as "happy"). We collapsed H and FA data across the six response options into the two target emotions for each block (e.g., we collapsed "very," "moderately," and "slightly" sad into "sad," and we collapsed "very," "moderately," and "slightly" happy into "happy"). This ensured the maximum amount of data was entered into the main analyses, as not all the response options were used equally. We computed the discrimination index, A', by using the following formulae:

$$\text{for H} \geq \text{FA}: A' = 0.5 + [(\text{H}-\text{FA})(1+\text{H}-\text{FA})]/[4\text{H}(1-\text{FA})];$$
$$\text{for FA} > \text{H}: A' = 0.5 - [(\text{FA}-\text{H})(1+\text{FA}-\text{H})]/[4\text{FA}(1-\text{H})].$$

Discrimination scores range between 0 and 1. When H = FA (i.e., performance is at chance), then $A' = 0.5$. A score above 0.5 indicates above-chance discrimination between emotions.

We calculated the response-bias index, B''_D, by using the following formula:

$$B''_D = [(1-\text{H})(1-\text{FA}) - (\text{H})(\text{FA})]/[(1-\text{H})(1-\text{FA}) + (\text{H})(\text{FA})].$$

Two B''_D scores can be calculated for each emotion blend (e.g., data for the angry–happy blend yield one response-bias score for angry faces and one for happy faces, which have the same absolute value but opposite signs). For simplicity, we report only one bias score for each emotion blend: the angry response bias for the angry–happy blend, the sad response bias for the sad–happy blend, and the sad response bias for the sad–angry blend. Response-bias scores range between −1 and +1. Positive values indicate conservative response bias (a tendency *not* to report a specific emotion, irrespective of its dominance). For example, a positive response-bias score for angry faces in angry–happy blends would reflect a bias against reporting angry faces, irrespective of whether the blend is 40% angry or 60% angry. Negative values indicate liberal response bias (a

Table 2. Discrimination and Response Bias for Younger and Older Adults, for Each Emotion Blend

Blend	Younger Adults $M \pm SD$	Older Adults $M \pm SD$	Mean Difference and 95% CI of the Mean Difference: Mean	Lower	Upper
Discrimination					
Angry–Happy	.80 ± .08	.82 ± .07	−.02	−.06	+.02
Sad–Happy	.81 ± .08	.84 ± .06	−.03	−.07	+.01
Sad–Angry	.77 ± .11	.75 ± .07	.02	−.02	+.07
Response Bias					
Angry–Happy	−.42 ± .47	−.13 ± .58	−.29	−.57	−.01
Sad–Happy	−.04 ± .54	+.17 ± .52	−.22	−.50	+.06
Sad–Angry	+.15 ± .54	+.18 ± .52	−.03	−.31	+.25

Note: For younger and older adults, $N = 29$. CI = confidence interval.

tendency to report a specific emotion, irrespective of dominance). For example, a negative score for angry faces in angry–happy blends would reflect a response bias to report anger over happiness irrespective of whether anger was presented at 60% or 40% dominance. A zero value indicates neutral bias. Kolmogorov–Smirnov tests showed that the distributions of accuracy and response-bias scores for each emotion blend did not differ significantly from normality.

We set the alpha level at .05 unless otherwise stated. We used nonparametric tests for severely skewed data that could not be normalized by transformation (i.e., VOSP).

Group Characteristics

See Table 1 for means. Older and younger adult age groups did not differ significantly in gender, $\chi^2(1, N = 58) = 1.76$, $p = .29$; years of education, $t(56) = 0.87$, $p = .39$; state anxiety, $t(56) = 0.81$, $p = .42$; trait anxiety, $t(56) = 0.42$, $p = .68$; social desirability, $t(56) = 0.81$, $p = .42$; facial recognition performance (Benton's Test of Facial Recognition), $t(56) = 0.40$, $p = .69$; or visual perceptual performance (VOSP: Incomplete Letters subtest), $U(\text{N1} = 29, \text{N2} = 29) = 324$, $p = .08$. All participants scored in the normal range for visual perceptual performance (17 or more for younger adults; 16 or more for older adults). Older adults had higher scores than younger adults on vocabulary and nonverbal reasoning tests: WASI Vocabulary, $t(56) = 4.88$, $p < .01$; WASI Matrix Reasoning, $t(56) = 2.90$, $p < .01$. Older adults also reported lower levels of social anxiety than younger adults, $t(56) = 2.61$, $p = .02$. On the VAS mood measures (averaged across the two assessment times), older adults reported more happiness, $t(56) = 3.08$, $p < .01$, and less sadness, $t(56) = 2.49$, $p = .02$, than younger adults did, although the groups did not significantly differ in VAS anxiety, $t(56) = 1.58$, $p = .12$.

Classification of Emotionally Ambiguous Facial Expressions

Discrimination.—We entered A' scores into a 3 × 2 mixed-design analysis of variance with emotion blend (angry–happy, sad–happy, sad–angry) and group (younger, older adults) as independent variables (see Table 2 for means, standard deviations, and confidence intervals of the mean difference).

Results revealed no significant main effect of age group $F < 1$. There was a significant main effect of emotion blend,

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$F(2, 112) = 13.93$, $p < .01$, $\eta_p^2 = .20$, as, across the whole sample, participants were poorer in discriminating between two negative faces (i.e., sad–angry) relative to their ability to discriminate between faces that blended negative with happy expressions ($M = 0.81$, 0.83, and 0.76 for angry–happy, sad–happy, and sad–angry blends, respectively). There was a nonsignificant trend toward an interaction between group and blend, $F(2, 112) = 2.62$, $p = .08$, $\eta_p^2 = .05$. However, independent *t* tests showed no significant differences between older and younger adults in discrimination scores for any specific blend: angry–happy, $t(56) = 1.01$, $p = .32$; sad–happy, $t(56) = 1.51$, $p = .14$; and sad–angry, $t(56) = 1.01$, $p = .32$.

We also conducted an analysis of covariance (ANCOVA), which included social anxiety, VAS sadness, VAS happiness, and WASI Matrix Reasoning and Vocabulary subtest scores as covariates (the groups differed on these variables). There were no significant results; for example, for the Age Group × Emotion blend, $F(2, 102) = 1.75$, $p = .18$, $\eta_p^2 = .03$.

Response bias.—Given that two B''_D scores can be calculated for each emotion blend, we could not analyze the B''_D scores in a single 3 (emotion blend) × 2 (age group) analysis of variance because the results would vary according to which of the two B''_D scores was used for each blend. Thus, for simplicity and to minimize the number of statistical tests, we compared the groups on their B''_D scores for each blend by using independent *t* tests (see Table 2 for means). Younger adults had a significantly greater tendency than older adults to report angry–happy morphed faces as angry, rather than happy (–.42 vs –.13), $t(56) = 2.09$, $p = .04$, $d = 0.55$. One-sample *t* tests revealed that the mean response-bias score for angry faces (in angry–happy blends) differed significantly from zero (no bias) for younger adults, $t(28) = 4.78$, $p < .01$, $d = 0.89$, but not for older adults, $t(28) = 1.20$, $p = .24$, $d = 0.22$. The groups did not differ significantly in response-bias scores for sad faces, relative to happy faces, in the sad–happy blend (–.04 vs .17), $t(56) = 1.54$, $p = .13$, nor for sad faces relative to angry faces in the sad–angry blend (.15 vs .18), $t(56) = 0.20$, $p = .84$.

We repeated the group comparisons by using an ANCOVA that included social anxiety, VAS sadness, VAS happiness, and WASI Matrix Reasoning and Vocabulary subtest scores as covariates. Results confirmed that younger adults were more likely than older adults to report anger in angry–happy blends (adjusted means, –.50 vs –.06), $F(1, 51) = 5.71$, $p = .02$, $\eta_p^2 = .10$. ANCOVA results also indicated that younger adults were relatively more likely than older adults to report sad faces in sad–happy blends (adjusted means, –.14 vs .17), $F(1, 51) = 4.80$, $p = .03$, $\eta_p^2 = .09$. One-sample *t* tests using adjusted means revealed that the mean response-bias score for sad faces (in sad–happy blends) did not differ significantly from zero (no bias) for younger adults, $t(28) = 1.18$, $p = .25$, $d = 0.22$, but it was significantly different for older adults, $t(28) = 2.31$, $p = .03$, $d = 0.43$. A further ANCOVA showed no group difference in response bias for the sad–angry blend (adjusted means, .16 vs .16), $F < 1$.

Discussion

When evaluating ambiguous emotional facial expressions, older and younger adults differed significantly in task performance. In comparison with younger adults, older adults showed a reduced tendency to report ambiguous faces as being angry rather than happy, whereas the groups did not differ significantly in their ability to discriminate between emotional facial expressions. Across the whole sample, participants were less able to discriminate between emotion blends containing two negative emotions (sad–angry) than between emotion blends combining a negative and a positive emotion (sad–happy, or angry–happy). This may reflect an effect of task difficulty (rather than an emotion-specific effect), as it may be harder to discriminate between two negative emotions (sad–angry) than between contrasting negative and positive emotions (sad–happy), given that the latter may have more distinctive perceptual features. There was a weak suggestion that this effect may have been greater in older adults (i.e., a nonsignificant trend for an Age Group × Emotion Blend interaction). However, there was no evidence of a specific deficit in the discrimination of emotional faces in older adults, given that post hoc comparisons of the groups on their discrimination scores for each emotion blend were nonsignificant.

In interpreting the results it is important to note that the groups were matched on gender, years of education, state and trait anxiety, social desirability, and facial recognition performance. However, older adults had significantly higher levels of vocabulary and nonverbal reasoning than younger adults. Younger adults also reported significantly higher levels of social anxiety than older adults, and increased social anxiety has been associated with a tendency to classify ambiguous faces in a negative fashion (Joormann & Gotlib, 2006; Richards et al., 2002). Younger adults also rated their current mood as sadder and less happy, compared with older adults. When these five variables (i.e., vocabulary, nonverbal reasoning, social anxiety, sad mood, happy mood) were included as covariates in the analyses, there was still no evidence of age-related effects on discrimination accuracy. The finding of higher fluid intelligence (nonverbal reasoning scores) in older participants is unusual, and this is likely to be a consequence of selective recruitment of older participants so as to be comparable with university-educated younger adults and also to reduce the risk of inadvertently including someone with incipient dementia. However, as we already noted, controlling for age group differences in fluid intelligence did not produce an age group difference in discrimination. Moreover, four previous studies (Phillips & Allen, 2004; Phillips et al. 2002; Sullivan & Ruffman, 2004a, 2004b) have shown that age-related differences in emotion identification are independent of age differences in fluid intelligence.

The present discrimination results fail to confirm findings from previous studies using morphed faces. Both Calder and colleagues (2003) and Sullivan and Ruffman (2004a) found that older adults were poorer at recognizing anger than were younger adults, with no differences in happiness. The former study also revealed age group differences in recognizing fear, and the latter study revealed such differences for sadness. It is important to reflect on what may account for the different findings across studies. We have considered some possibilities in the introduction, such as the lack of consistency in the emotion combinations used across studies. In the present study, each block of trials presented stimuli blended from just two emotions, with participants asked to discriminate between the two emotions (i.e., two -alternative forced choice). Previous studies reporting

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emotion-discrimination deficits in older adults have commonly used more emotion pairings (presented in mixed order within blocks of trials), used fewer trials of any one type of emotion blend, or have given participants multiple emotion labels from which to choose. Evidence suggests that switching between decision types rapidly, or within blocks of trials, may produce age differences that partly reflect goal-maintenance difficulties (Braver, Satpute, Keys, Racine, & Barch, 2005). Thus, previous studies may have used more difficult emotion-discrimination tasks than the one used here, which could contribute to differential sensitivity to emotion-discrimination deficits. However, it is advisable to be cautious when interpreting null results, such as the present discrimination findings; further research with larger sample sizes would be informative.

By contrast to the discrimination results, a significant difference was found between younger and older adults' response bias for angry faces, relative to happy faces. Older adults showed a reduced tendency to report anger in these emotionally ambiguous faces, compared with younger adults. These significant findings indicate that the present study had sufficient power to detect age-related effects in response bias, which is an important determinant of performance on emotion-identification tasks. As with the discrimination analyses, a supplementary ANCOVA controlling for vocabulary, nonverbal reasoning, sad and happy mood, and social anxiety confirmed significant age-related effects on response bias; that is, older adults were less likely than younger adults to report angry (rather than happy) faces, with the older adults being more neutral than younger adults in their response style. ANCOVA results further suggested that older adults were somewhat more likely than younger adults to report that faces were happy (in sad–happy blends), compared with younger adults who showed bias toward reporting sadness. There was no evidence of an association between age and response bias for angry versus sad faces.

To the best of our knowledge, the finding of an age-related effect in response bias for emotionally ambiguous morphed faces is novel. In a study that was published after the completion of the present investigation, Isaacowitz and colleagues (2007) examined identification of anger, disgust, fear, happiness, sadness, surprise, and neutral stimuli in a large sample of adults aged 18 to 85 years. Their results indicated that older adults were more likely to label facial expressions incorrectly as disgust and fear. After these biases were controlled, findings suggested that older adults were less accurate at identifying emotions, such as faces displaying anger, disgust, fear, and happiness, than were younger adults. However, a direct comparison of results across studies is complicated by methodological differences as, for example, Isaacowitz and colleagues could not calculate signal detection measures of response bias because their data were not in a binary format, and this may explain the differences observed.

The present findings may also be considered in the light of previous research reporting age-related differences in attention to negative and positive faces. For example, a visual-probe study indicated that older adults had an attentional bias away from negative faces (angry and sad), relative to neutral faces, whereas younger adults did not demonstrate such attentional bias (Mather & Carstensen, 2003). A recent eye-tracking study (Knight et al., 2007) revealed that older adults allocated less attention to a negative face when it was paired with a neutral face than younger adults did. However, when placed under conditions of divided attention, such that their attentional resources were depleted, older adults showed the same bias toward negative stimuli as younger adults. These results seem consistent with older adults' directing their attention away from negative stimuli in a motivated way. Thus, the present findings of a relatively greater reporting bias against negative faces in older than younger adults appear to fit well with such evidence of an attentional bias away from negative faces in older adults, as well as with the finding that younger adults show a greater tendency to interpret neutral faces as showing anger (Phillips & Allen, 2004).

In sum, the present study provided evidence of an age-related effect on response bias for emotional faces, as older adults were less likely than younger adults to report anger when presented with an ambiguous facial expression that contained both angry and happy features. The ANCOVA results also showed effects of age on response bias for sad-happy emotion blends. Taken together, this may suggest that normal aging is associated with a reduced tendency to report negative emotion in general, relative to positive emotion. This raises the possibility that previous studies of aging effects on emotion-recognition performance may similarly reflect response-bias differences, rather than a deficit in perceptual discrimination of emotional information.

The reduced tendency of older adults (relative to younger adults) to report the presence of anger in ambiguous facial expressions, which combine negative and positive features, may be compatible with either an emotion-regulation view of normal aging or with neurocognitive accounts, noted earlier. For example, Carstensen and colleagues (2003) suggested that older adults engage in response-focused emotion-regulation strategies aimed at minimizing negative affect. This proposal seems consistent with the finding that older adults were less likely than younger adults to endorse negative than positive response options, possibly as a result of a desire to avoid acknowledging the presence of negative emotion. However, further research using a wider selection of emotions would be required to confirm this. It would also be informative to include fear in the emotional blends, as research suggests that identification of fear may be a problem in older age (Calder et al., 2003; Isaacowitz et al., 2007; Sullivan & Ruffman, 2004a). We did not include additional emotions, such as fear, in the present study in order to avoid a lengthy testing session, as older participants may be more prone to fatigue. Future research should also vary the blend proportions in order to clarify the emotion intensities that distinguish older and younger adults' discrimination accuracy and response bias.

The present findings may also be accommodated within a neurocognitive account of emotion processing (e.g., LeDoux, 1996). That is, a neural system (involving cortical and subcortical regions), which is responsible for evaluating the presence of negative information in the environment, may be more reactive to ambiguous information in younger adults than in older adults. If so, this may lead to a bias for relatively greater reporting of the presence of negative information in younger adults. It would seem informative to investigate this further, for example, by using neuroimaging methods to assess activity in this neural system while older and younger adults engage in emotion-discrimination tasks, such as the one used here.

The present findings also have potential clinical implications. It would be useful in clinical settings to have a better understanding of response biases, which may reflect the use of

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emotion-regulation and coping strategies among older adults. For example, older adults may perceive negative emotional information (e.g., hostile component of an ambiguous emotional expression) but be reluctant to report its presence. Thus, older individuals may underreport their identification of negative emotions when confronted with emotionally ambiguous situations, and it should not be assumed that this reflects a deficit in their perception of negative emotion. If the present findings are confirmed, it would seem helpful to increase the awareness of health professionals of potential difficulties of older adults in reporting negative emotional information in an unbiased way.

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