Journal of Gerontology: PSYCHOLOGICAL SCIENCES
2007, Vol. 62B, No. 1, P53–P60


# Age Differences in Emotion Recognition Skills and the Visual Scanning of Emotion Faces

Susan Sullivan,[1] Ted Ruffman,[2] and Sam B. Hutton[1]

[1]Department of Psychology, University of Sussex, England.
[2]Department of Psychology, University of Otago, New Zealand.

**Research suggests that a person's emotion recognition declines with advancing years. We examined whether or not this age-related decline was attributable to a tendency to overlook emotion information in the eyes. In Experiment 1, younger adults were significantly better than older adults at inferring emotions from full faces and eyes, though not from mouths. Using an eye tracker in Experiment 2, we found young adults, in comparison with older adults, to have superior emotion recognition performance and to look proportionately more to eyes than mouths. However, although better emotion recognition performance was significantly correlated with more eye looking in younger adults, the same was not true in older adults. We discuss these results in terms of brain changes with age.**

RESEARCH suggests that older adults do not identify emotions and cognitive states in the same way as younger adults do. For instance, subtle age differences have been found in emotion recognition skills, with older adults demonstrating relatively consistent deficits in identifying anger, fear, and sadness over a number of studies (see Sullivan & Ruffman, 2004 for a summary). Findings also indicate that older adults do not identify emotions and cognitive states in the same way as younger adults do when they are presented with just the eye region of faces in the Eyes Task (Phillips, MacLean, & Allen, 2002). However, the possible basis for these age-related changes in emotion reasoning skills is still unclear.

In the current experiments we explore one possible cause of age differences on emotion tasks. That is, we wondered whether age differences in emotion recognition skills might be related to differences in the way younger and older counterparts view emotion faces. Specifically, we were interested in the amount of time spent looking at the eye region of faces, as research suggests that the eyes are a particularly important source of emotional information for people during social encounters and when one is reading the mental states of others (see Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 2001 for a summary).

From as early as 2 months, neonates show a preference for looking at the eyes over other facial features (e.g., Maurer, 1985), and young infants spend significantly more time looking at a photograph of a person in which the eyes are open than at one in which the eyes are closed (Batki, Baron-Cohen, Wheelwright, Connellan, & Ahluwalia, 2000). By 3 months, infants look to targets more rapidly if an adult has gazed in that direction (Hood, Willen, & Driver, 1998), and 4-month-olds discriminate between direct and averted gaze (Vecera & Johnson, 1995). Such evidence suggests that a preference for looking at the eyes over other facial features develops early in infancy (Langton, Watt, & Bruce, 2000).

Findings also indicate that the preference for looking at the eyes extends into adulthood. Several studies show better discrimination and recognition of eyes than mouths in both children and adults (Joseph & Tanaka, 2002; Tanaka & Farah, 1993). In addition, when viewing a face stimulus, normal adults devote the vast majority of fixations to the eyes, nose, and mouth, with nearly 70% of these fixations directed to the eyes (Walker-Smith, Gale, & Findlay, 1977). Eye contact also appears to be important in social encounters. People who gaze at us are evaluated as more attentive (Kleinke, Bustos, Meeker, & Staneski, 1973), intelligent (Wheeler, Baron, Michell, & Ginsburg, 1979), and credible (Hemsley & Doob, 1978); furthermore, when complex emotions are judged, the eyes have been found to be just as informative as the whole face (Baron-Cohen, Wheelwright, & Jolliffe, 1997).

Research examining the visual scanpaths of clinical populations noted for qualitative differences in social behavior lends further weight to the notion that eye looking is important for social reasoning. The emotion recognition deficits often found in autistic spectrum disorders, for instance, may be attributable to the tendency of people with autism to ignore information from the eyes (see Baron-Cohen et al., 1997), and individuals with autism look less at eyes and more at mouths when viewing persons in social interactions (Klin, Jones, Schultz, Volkmar, & Cohen, 2002). Social phobics tend to avoid fixating the eye region, particularly for angry faces (Horley, Williams, Gonsalvez, & Gordon, 2004), and patients with schizophrenia have restricted scanpaths that do not focus on the most salient features of the face, that is, the eyes, nose, and mouth (e.g., Streit, Wolwer, & Gaebel, 1997; Williams, Loughland, Gordon, & Davidson, 1999).

Considering the importance of the eyes in social reasoning, we wondered whether age differences in emotion reasoning skills might be related to differences in the way younger and older counterparts look at the eyes in emotion faces. Because the emotions that older adults have the most consistent difficulty recognizing (i.e., anger, fear, and sadness) are those that are identified best from eye information than from other facial features (Bassili, 1979; Calder, Young, Keane, & Dean, 2000), we speculated that a preference for looking at the eyes over other facial features (Walker-Smith et al., 1977) may not extend into late adulthood. Likewise, as happiness and disgust are better identified from mouth information and surprise is equally recognizable from the eyes and the mouth (Bassili; Calder, et al.), and as older adults do not have as many difficulties recognizing these emotions, we predicted that the emotional information contained in the lower face region may be equally salient to young and older adults.

To examine these issues in Experiment 2, we compared the visual scanpaths of older and younger adults as they viewed and labeled emotion faces. If older adults are found to look less often at the eyes of emotion faces than are younger counterparts, especially when identifying the emotions of anger, fear, and sadness, then this would lend support to the notion that the age differences found on recognition tasks may be related to a tendency to overlook the emotion information portrayed by the eyes.

Hence, our main purpose in the current experiments was to examine the following issues. For Experiment 1, we asked this question: Are older adults less accurate than young adults when inferring emotion from the eyes? We employed previously used methods of comparing photos of the full face versus those of the eyes only versus those of the mouth only (Baron-Cohen et al., 1997; Bassili, 1979; Calder et al., 2000; Nummenmaa, 1964). For Experiment 2, we asked this question: Are young–old disparities in emotion recognition underpinned by differences in the way older versus younger adults visually scan emotion faces?

## Experiment 1

### Methods

#### *Participants*

Participants consisted of 30 young adults (15 female, 15 male; *M* = 23 years; range = 18–32 years) and 30 healthy older adults (15 male, 15 female; *M* = 72 years; range = 60–87 years). All were right handed and spoke English as their first language; we had all of the older participants screened for signs of dementia by use of the Mini-Mental State Exam (Folstein, Folstein, & McHugh, 1975). We used a cutoff point of 26, because Folstein and colleagues demonstrated that the mean score for young adults is 27.6. We excluded no participants on this basis. None of the older adults had experienced strokes or right hemisphere damage, or had a history of psychological disorders such as depression as measured by the Geriatric Depression Scale (Brink et al., 1982). All of the older participants were university alumni or friends of alumni. The younger adults were undergraduate students or friends of such students. We had all older participants tested on Snellen's Three Metre Visual Acuity Chart, and all had vision falling within the normal range, which is 20/20 to 20/30.

We administered intelligence tasks to participants to ensure that they were not atypical in terms of their cognitive profile. A decline in fluid ability (i.e., those processes associated with greater mental effort, novelty, and information complexity) is one of the most robust findings in the aging literature, as is stable or improved crystallized ability (i.e., those processes dependent on learned skills or habitual adaptations; see Salthouse, 2000). Using the Culture Fair Intelligence Test (Cattell & Cattell, 1959) as a measure of fluid IQ, we examined whether our older adults were typical in terms of fluid decline; we expected better performance by younger adults. We measured crystallized ability by using the Vocabulary subtest of the Wechsler Adult Intelligence Scale—Revised (Wechsler, 1981). We administered both intelligence tasks at the end of the test session, with test order counterbalanced.

There was a significant advantage for younger adults on the fluid intelligence measure, $F(1, 59) = 62.53$, $p < .001$ (young adult, $M = 26.23$, $SD = 4.18$; older adult, $M = 17.33$, $SD = 4.53$), but not on the crystallized measure, $F(1, 59) < 1.00$, *ns* (young adult, $M = 43.90$, $SD = 7.44$; older adult, $M = 45.77$, $SD = 11.68$). Therefore, our participants showed the typical pattern of aging, with the younger adults better on only the fluid measure.

#### *Materials*

We randomly chose 12 pictures (6 female, 6 male) from Ekman and Friesen's Pictures of Facial Affect Series (1976), with two pictures (1 male, 1 female) for each of the six basic emotions (happiness, surprise, disgust, sadness, anger, and fear). For each image, we isolated and standardized the eye region and the mouth region to 15 × 10 cm, which is in keeping with the Eyes Task of Baron-Cohen and colleagues (1997, 2001). We placed the photographs of the eyes, the mouth, and the whole face (12 of each type) in three separate folders. We counterbalanced the order of presentation of the folders, and we randomized the order of each photograph within each folder.

#### *Procedure*

Participants were told that they were about to see a folder containing 12 photographs of a face region (e.g., the eyes), and they were asked to describe how the person in each photograph was feeling by using one of six "basic" emotion labels (happy, sad, fearful, disgusted, surprised, and angry), which were printed on a response sheet. They were told to take as long as necessary, but to go with their initial reaction as much as possible. There was a practice item prior to starting the test session.

### Results

There were no effects for emotion recognition for different orders of the eyes, mouth, and full face conditions. Table 1 depicts performance on the six emotion types in the three modalities. We log-transformed and analyzed data with a 2 (Age Group: young vs old) × 3 (Region: eyes only vs mouth only vs full face) × 6 (Emotion) analysis of variance, with number of correct responses (out of 36, with two trials for each emotion in each region) as the dependent variable. Because sphericity assumptions were violated, we report Greenhouse–Geisser corrected values of probability and mean square error. There was a main effect for age group, with young adults better at identifying emotions, $F(1, 58) = 4.25$, $p < .05$, $MSE = 1.74$, $\eta_p^2 = .07$; a main effect for emotion, $F(5, 290) = 23.39$, $p < .001$, $MSE = 5.05$, $\eta_p^2 = .29$; and a main effect for region, $F(2, 116) = 178.87$, $p < .001$, $MSE = 34.57$, $\eta_p^2 = .76$, with full faces better than eyes, $t(59) = 7.08$, $p < .001$, and the mouth, $t(59) = 7.40$, $p < .001$, and the eyes better than the mouth, $t(59) = 2.24$, $p < .05$. The other significant effects were the Emotion × Group interaction, $F(5, 290) = 5.97$, $p < .001$, $MSE = 1.29$, $\eta_p^2 = .09$; the Region × Emotion interaction, $F(10, 580) = 34.44$, $p < .001$, $MSE = 7.54$, $\eta_p^2 = .37$; and, most

Table 1. Mean Emotion Scores in Experiment 1

| Face Type | Happy | Sad | Disgust | Fear | Anger | Surprise | All Emotions |
|---|---|---|---|---|---|---|---|
| Full face | | | | | | | |
| Older | 2.00 (0.00) | 1.20 (0.71) | 1.60 (0.62) | 1.47 (0.68) | 1.16 (0.59) | 1.80 (0.41) | 9.23 (1.89) |
| Young | 2.00 (0.00) | 1.53 (0.51) | 1.57 (0.68) | 1.93 (0.25) | 1.50 (0.63) | 1.83 (0.38) | 10.40 (1.00) |
| Eyes | | | | | | | |
| Older | 1.60 (0.56) | 1.40 (0.77) | 1.10 (0.76) | 1.23 (0.82) | 0.93 (0.74) | 1.30 (0.70) | 7.53 (2.13) |
| Young | 1.93 (0.25) | 1.53 (0.63) | 0.47 (0.73) | 1.63 (0.56) | 1.47 (0.68) | 1.47 (0.57) | 8.50 (1.74) |
| Mouth | | | | | | | |
| Older | 1.93 (0.25) | 1.17 (0.70) | 1.17 (0.59) | 0.47 (0.63) | 0.63 (0.72) | 1.53 (0.63) | 6.87 (1.80) |
| Young | 1.93 (0.37) | 1.10 (0.55) | 1.33 (0.66) | 0.80 (0.81) | 0.73 (0.69) | 1.67 (1.53) | 7.57 (1.94) |

*Notes*: Standard deviations are shown in parentheses. The maximum score possible for each emotion type (in each region) is 2.0.

importantly, the Region × Emotion × Group interaction, $F(10, 580) = 3.82$, $p < .001$, $MSE = 0.84$, $\eta_p^2 = .06$. The Group × Region interaction was not significant, $F(2, 116) = 0.15$, *ns,* $MSE = 0.03$, $\eta_p^2 = 0$.

We further explored the two interactions of primary interest. We used Holm's correction to ensure that the family-wise error rate was less than .05. To explore the Emotion × Group interaction (collapsing information across the three conditions), we compared young and older adults on each of the six emotions. We found that young adults were better than older adults at recognizing fear, $t(58) = 3.31$, $p < .001$, and anger, $t(58) = 2.65$, $p = .01$.

We explored the Region × Emotion × Group interaction by comparing eyes versus mouth performance in each group, again using Holm's correction. We found that young adults were better than older adults at identifying anger, $t(29) = -4.85$, $p < .001$, fear, $t(29) = -5.22$, $p < .001$, and sadness, $t(29) = -2.90$, $p < .01$, from the eyes than from the mouth, and they were better at identifying disgust from the mouth than the eyes, $t(29) = 5.52$, $p < .001$. However, they did not demonstrate an advantage for identifying happiness from the mouth $t(29) = 0$, $p = 1.00$. As we expected, surprise was recognized equally well from both eye and mouth information, $t(29) = 1.24$, $p = .23$. Older adults showed a similar advantage in recognizing fear from the eyes versus the mouth, $t(29) = -4.04$, $p < .001$. The advantage for eyes over mouth was not significant when the two groups were recognizing anger, $t(29) = -1.80$, $p = .08$, or sadness, $t(29) = -1.42$, $p = .17$. Older adults also showed an advantage for identifying happiness from the mouth over the eyes, $t(29) = 3.34$, $p < .01$, but this was not significant for disgust, $t(29) = 0.36$, $p = .72$. Once again, as we expected, surprise was recognized equally well from both eye and mouth information in this age group, $t(29) = 1.37$, $p = .18$. We double-checked all eyes versus mouth comparisons with a nonparametric test (Mann–Whitney U Test), yielding an identical pattern of results.

Finally, we split older adults into the young-old group ($n = 16$, $M = 66$ years; range = 60–70 years) and the old-older group ($n = 14$, $M = 79$; range = 72–87). Between the two groups, there were no differences in emotion recognition score as summed over the 36 emotion faces presented, $t = 0.22$, *ns*.

### Discussion

Experiment 1 produced four key findings. First, younger adults were more likely than older adults to accurately recognize emotions across modalities. Second, as in previous research, young adults were better at identifying anger, fear, and sadness from the eyes only versus the mouth only. These results are consistent with the idea that the eyes are important sources of information about mental and emotional states (e.g., Baron-Cohen et al., 1997, 2001). In contrast, older adults did not receive the same advantage from the eyes versus the mouth as young adults did. They were better at identifying fear from the eyes than from the mouth, but not anger and sadness. Third, younger adults were more likely to recognize fear and anger than were older adults. This is broadly consistent with the summary by Sullivan and Ruffman (2004) indicating older adults' differences in identifying fear, anger, and sadness. Fourth, young and older adults received a comparable advantage from mouth versus eyes information, in that each age group was better at identifying one of six emotions from the mouth versus the eyes.

Our results are interesting because previous research indicates that older adults tend to be less accurate than young adults when they are identifying fear, anger, and sadness (although, in the present study, older adults did not show their typical disadvantage for sadness recognition), and it is precisely these emotions that are better identified through eye information.

## Experiment 2

In Experiment 2 we examined the following question: Is less accurate emotion recognition in older adults a result of differences in the way they scan emotion faces? That is, when presented with a full face, do older adults spend less time than younger counterparts looking to the eyes, and are any differences in time spent looking at the eyes more pronounced for the emotions of anger, fear, and sadness? If the eyes are important when a person is making emotion attributions, then age-related declines in this skill may be a by-product of a tendency to overlook the vital information portrayed in the eyes. We also asked whether older adults look equally at negative and positive emotion faces. Mather and Carstensen (2003) found that, when presented with both images simultaneously, older adults attended more to a happy rather than a sad (or angry) face. Similarly, Isaacowitz, Wadlinger, Goren, and Wilson (2006) found that older adults demonstrate an attentional preference toward happy faces and away from angry ones. In contrast, Charles, Mather, and Carstensen (2003) presented positive and negative images (face and nonface) one at a time; they found that young and older adults showed similar scanning of the images, with both attending longer to negative images than to positive images. To further explore this issue, in Experiment 2 we examined adults' dwell times at sad, angry, and happy faces.

## Methods

### Participants

Participants consisted of 27 young adults (11 men, 16 women; $M = 23$ years; range = 20–37 years) and 27 healthy older adults (14 women, 13 men; $M = 73$ years; range = 61–95 years). All were right handed, spoke English as their first language, and had not participated in the previous experiment. None of the older participants had experienced strokes or right hemisphere damage, or had a history of psychological disorders such as depression as measured by the Geriatric Depression Scale (Brink et al., 1982). We had all participants screened for signs of dementia by use of the Mini-Mental State Exam (Folstein et al., 1975), with a cutoff point of 26. All of the older participants were university alumni or friends of alumni. The younger adults were undergraduates or their friends. We had all older participants tested on Snellen's chart (and they had vision falling within the normal range); they were administered the Culture Fair Intelligence Test (Cattell & Cattell, 1959) and the Vocabulary subtest of the Wechsler Adult Intelligence Scale—Revised (Wechsler, 1981). As a result of experimenter error, we did not have a fluid or crystallized IQ score for 9 of the younger participants.

We used a one-way analysis of variance to examine fluid and crystallized abilities in the two age groups. There was an advantage for the younger adults on the fluid intelligence measure, $F(1, 40) = 61.39$, $p < .001$ (young adult, $M = 26.95$, $SD = 4.49$; older adult, $M = 15.41$, $SD = 4.89$). There was an advantage for the older adults on the crystallized measure that approached significance, $F(1, 40) = 4.00$, $p = .05$ (young adult, $M = 48.52$, $SD = 8.19$; older adult, $M = 53.45$, $SD = 7.58$). Therefore, our participants were again typical in terms of their cognitive profiles.

### Materials

We again used pictures from Ekman and Friesen's Pictures of Facial Affect (1976). There were three pictures (two male and one female, or one male and two female) for each of the six basic emotions, and we selected only those pictures with the highest agreement rate from the normative data for each emotion. We had the slides presented in the same pseudorandom order to all participants.

### Procedure

We recorded each participant's eye movements by using an Eyelink II eye tracker, which uses two miniature video cameras mounted on a lightweight headset. A third camera simultaneously records the position of the participant's head, allowing the researcher to compute the gaze position without the need to restrain the participant's head movements. Participants were tested in a dimly lit, quiet room; they sat in a height-adjustable chair that had been modified to prevent any rotation about the vertical axis. They viewed a 21-in. (53.34-cm) ViewSonic monitor from a distance of 60 cm, which subtended at a visual angle of approximately 40° horizontally and 30° vertically. The face stimuli were high-resolution photos that were 23 cm high and 15 cm wide; they were presented in the center of the screen. The six basic emotion labels were printed at the bottom of each picture, and participants were instructed to decide in their own time how the person in each photograph was feeling.

Table 2. Number of Correctly Recognized Emotion Faces in Experiment 2

| Emotion | Group | *M* | *SD* |
|---|---|---|---|
| Happy | Young | 3.00 | 0.00 |
| | Older | 3.00 | 0.00 |
| Sad | Young | 2.48 | 0.75 |
| | Older | 2.43 | 0.59 |
| Angry | Young | 2.96* | 0.19 |
| | Older | 2.35* | 0.88 |
| Fear | Young | 2.33 | 0.78 |
| | Older | 2.22 | 0.67 |
| Disgust | Young | 2.96 | 0.19 |
| | Older | 2.74 | 0.62 |
| Surprise | Young | 2.78 | 0.42 |
| | Older | 2.87 | 0.34 |

*Notes*: The maximum score possible is 3.0. $SD$ = standard deviation.
*$p < .001$.

For the scanpath analysis, we defined regions by using the Data Viewer software supplied by SR Research (Osgoode, ON). Researchers individually positioned two rectangular areas of interest on each face. The rectangle defining the eye region included both the eyes and eyebrows. Researchers positioned the rectangle defining the mouth region so that it contained all of the mouth, including the lips. For each participant, we calculated the average dwell time (sum of fixation durations) for each region of interest across the 24 stimuli. The eye tracker automatically sampled the position of the eyes 500 times per second; we considered all samples that were not classed as occurring during a saccade to have occurred during a fixation. We used three thresholds to detect saccade onset: a change in eye position of greater than 0.1°, an eye velocity above 30° per second, and an eye acceleration above 8,000° per second squared. We classed a sustained gaze on a particular spot for 50 ms or more as a fixation. We summed dwell times from the left and right eye regions to provide a single figure for both eyes.

## Results

Preliminary analyses indicated there were no effects for gender for either emotion recognition or scanning, so we did not further consider gender in our analyses.

### Emotion Recognition

Emotion recognition scores are shown in Table 2; we analyzed them by using six $t$ tests with Holm's correction to ensure the family-wise error rate was less than $p = .05$. Older adults were significantly worse than young adults at identifying anger, $t = 3.27$, $p < .01$, but not other emotions. As a check, we compared young and older adults by using a nonparametric test (Mann–Whitney U test), again employing Holms correction. Once again, older adults were worse than young adults in recognizing anger, $z = -3.42$, $p < .001$, but no other emotions. Given the wide age range in the older group, we then examined whether individuals in the old-older group (74–95 years, $M =$

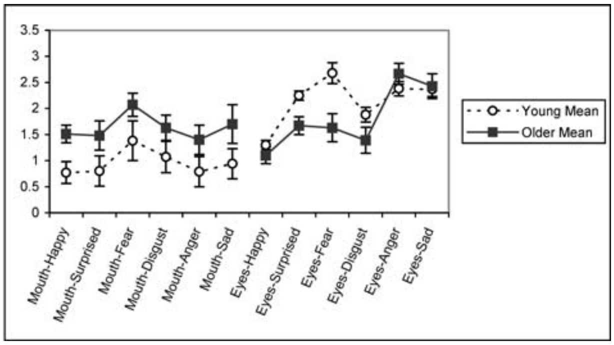


Figure 1. Dwell time at mouths and eyes for each emotion type in Experiment 2.

82 years) were worse recognizers than those in the young-old group (60–73 years, $M = 67$ years). Although the old-older individuals were slightly worse, the difference was not significant, $t = 1.37$, *ns*.

### Scanning

On average, young participants looked at the face for 1.79 seconds and older adults looked for 2.06 seconds. This difference approached significance, $t(52) = -1.84$, $p < .10$. However, we were primarily interested in the eyes and mouth because emotions are discernible from information in either area (see Experiment 1). When the amount of time spent looking at the eyes and mouth combined is expressed as a percentage of the total time spent looking at the face, there was no difference between the two groups: 43.1% for the young adults compared with 43.8% for the older adults, $t = -0.22$, $p = .83$.

Dwell times for scanning the eyes and mouth are included in Figure 1. In order to determine whether there were differences in the gaze strategies used by young and older adults when they are making judgments of emotion, we performed a 2 (Age Group) × 2 (Region: eyes vs mouth) × 6 (Emotion) analysis of variance by using dwell time as the dependent variable. We omitted two outliers (± 3 *SD*): one young adult with very long dwell times on the eyes, and one older adult with very long dwell times on the mouth. There was no main effect of group, $F(1,52) = 1.33$, *ns*, $MSE = 4{,}753{,}815$, $\eta_p^2 = .03$, indicating that overall the young adults and old adults did not differ in the amount of time they looked at the faces. There was a significant main effect of region, $F(1, 52) = 12.03$, $p < .01$, $MSE = 76{,}358{,}709$, $\eta_p^2 = .19$, but this main effect was qualified by a significant Region × Group interaction, $F(1, 52) = 46.46$, $p < .001$, $MSE = 41{,}026{,}701$, $\eta_p^2 = .11$ (see Figure 1). This interaction occurs because younger adults spend a longer time looking at eyes than mouths, $t(26) = 4.40$, $p < .001$, whereas this difference was not significant in older adults, $t(26) = 0.66$, *ns*. Another way to consider this interaction is to compare young and older adults' dwell times within each region. Older adults looked at the mouth for a significantly longer time than younger adults did, $t(62) = -2.90$, $p < .01$, but although older adults tended to look less at the eyes, this effect was not significant, $t(62) = 1.07$, *ns*. It is important to remember that overall dwell times to eyes and mouth combined did not differ between the young and older participants, so the interaction reflects a difference in the strategic allocation of gaze to the eyes and mouth between the two groups. Young participants directed 67% of their total dwell time (looking at eyes and mouth combined) to the eyes, compared with only 52% in older adults; this is a significant difference, $t(45) = 2.10$, $p < .05$.

The analysis of variance also revealed a main effect of emotion, $F(5, 48) = 21.40$, $p < .001$, $MSE = 9{,}041{,}060$, $\eta_p^2 = .18$. The Emotion × Group interaction approached significance, $F(5, 48) = 1.60$, $p = .09$, $MSE = 1{,}625{,}729$, $\eta_p^2 = .04$, as did the three-way Emotion × Group × Region interaction, $F(5, 41) = 2.32$, $p < .06$, $MSE = 1{,}583{,}572$, $\eta_p^2 = .11$. From Figure 1, it is clear that older adults looked at the mouths in each type of emotion picture for roughly 700 ms longer than young adults did, although the pattern of looking at the mouth across different emotion types was remarkably similar for the two groups. The three-way interaction that approached significance occurs because, for some emotions (mainly fear, surprise, and disgust) but not others, older adults look less at the eyes than younger adults do.

To examine dwell times at positive or happy versus negative or sad or angry faces (as in Charles et al., 2003 and Mather & Carstensen, 2003), we examined dwell times at "eyes and mouth combined" for happy, sad, and angry faces by using a 3 (Emotion) × 2 (Age Group) analysis of variance. The main effect for emotion was significant, $F(2, 52) = 19.25$, $p < .001$, $MSE = 32{,}048{,}713$, $\eta_p^2 = .27$, as was the effect for age group, $F(1, 52) = 15.61$, $p < .05$, $MSE = 22{,}898{,}400$, $\eta_p^2 = .10$ (with older adults looking more). The interaction did not approach significance, $F(2, 52) = 0.28$, *ns*, $MSE = 465{,}056$, $\eta_p^2 = .01$. Planned comparisons indicated that older adults looked longer at sad than at happy faces, $t(26) = -3.92$, $p < .001$, and at angry than at happy faces, $t(26) = -4.49$, $p < .001$, but there was no difference in looking at sad and at angry faces, $t(26) = -0.12$, *ns*. Likewise, younger adults looked longer at sad than at happy faces, $t(26) = -4.44$, $p < .001$, and at angry than at happy faces, $t(26) = -4.61$, $p < .001$, but there was no difference in looking at sad and at angry faces, $t(26) = -0.42$, *ns*.

Finally, to examine whether eye and mouth looking correlated with emotion recognition performance, we grouped together those emotions that are best recognized from the eyes (i.e., anger, sadness, and fear) and those emotions that are best recognized from the mouth (i.e., disgust and happiness). For younger adults and for those emotions best recognized from the eyes, more eye looking was associated with better performance, $r = .35$, $p < .05$, whereas more mouth looking was associated with worse emotion recognition, $r = -.41$, $p < .05$.. However, for older adults, more eye looking was *not* associated with better emotion recognition, $r = .02$, *ns*, but like young adults, more mouth looking was associated with worse emotion recognition, $r = -.50$, $p < .01$.

There were no significant correlations for either age group for the amount of time spent looking at the mouth and emotion recognition performance on those emotions best identified by the mouth (happiness and disgust), although younger adults' performance was in the expected direction for both eye looking, $r = -.18$, and mouth looking, $r = .23$. In comparison, for older adults, the amount of time spent looking at the mouth was negatively (although not significantly) correlated with performance on these emotions, $r = -.20$ (thereby suggesting that, even when older adults look at the mouth, they fail to use that information effectively in order to correctly identify an emotion), and eye looking was completely unrelated to performance, $r = 0$.

## Discussion

First, when we consider whether or not older adults look equally at negative and positive emotion faces, the findings from Experiment 2 demonstrate that both age groups looked significantly more at negative emotion faces than at positive emotion faces (i.e., they looked significantly more at angry vs happy faces, and sad vs happy faces). Hence, these findings are more in keeping with those of Charles and colleagues (2003) rather than those of Isaacowitz and colleagues (2006; note, however, that these latter authors used considerably more trials than the current experiment did).

Second, in Experiment 2 we presented participants with pictures of full faces and simultaneously recorded the participants' eye movements as they made emotion attributions. We found that older adults made more errors in emotion recognition than young adults did. The analysis of gaze revealed some interesting similarities and differences between the age groups. On average, both groups looked at the eyes and mouth of each face for just over 1,000 ms, but older adults generally spent more time looking at mouths and less time looking at eyes than younger adults did. Nevertheless, older adults' pattern of mouth looking across the different emotion types was identical to that of younger adults, thereby suggesting that mouth information is equally salient to both younger and older adults. In contrast, young and older participants' pattern of looking at eyes across different emotions varied, with younger adults generally looking longer at eyes than older adults, but not so for all emotions. The notion that older adults' consistent difficulties compared with younger counterparts in recognizing anger, fear, and sadness may be related to an age-related tendency to look less at the eyes for these emotions was not supported by the current findings. In this experiment, older adults were worse than younger adults at identifying anger, yet older adults tended to look at angry eyes for a longer time period than did young adults, whereas their eye looking time for other emotions for which they were not worse was less than that of young adults. Furthermore, in contrast to young adults, older adults' eye looking did not correlate with their overall success in recognizing emotions.

## General Discussion

A number of researchers have reported age-related differences in the way older adults make emotion and social attributions. The current experiments add to this growing body of research in that older adults did not recognize emotions in the same way as did younger adults. At the same time, young and old adults were similar in that, in Experiment 1, both groups identified emotions more accurately when given pictures of full faces, were second best when given pictures of the eyes, and were third best when given pictures of the mouth. Given that the eyes are important in identifying anger, fear, and sadness, and that previous research suggests that older adults are generally less accurate at identifying these emotions (although an age-related decline in recognizing sadness was not found in the current experiments), in Experiment 2 we examined whether older adults were less likely than younger adults to look at the eyes when presented with pictures of full faces. The pattern of mouth looking across different types of emotions was nearly identical in both age groups, whereas the pattern for eye looking differed somewhat for young and old adults. The critical difference was that for each emotion type, older adults spent about 700 ms longer looking at the mouth, whereas they tended to spend less (but not significantly less) time looking at the eyes. As there was no difference between the two groups in the overall amount of time spent looking at the eyes and mouth combined, the end result is that older participants spent a disproportionately large amount of time looking at the mouth (about one third of the time for young adults vs one half of the time for older adults).

One interpretation of our results is that older adults need more time to process face stimuli because of an age-related decline in processing speed (Salthouse, 1992). That is, older adults may need to look at particular facial regions for a longer period of time to achieve an emotion recognition level that is equal to that of younger counterparts. Consistent with this idea, in Experiment 1 older adults were not worse at recognizing emotions from mouths, and in Experiment 2 they spent a longer time looking at mouths than young adults did. In contrast, in Experiment 1 older adults were worse at recognizing emotions from the eyes, and although in Experiment 2 they did not look at the eyes for significantly less time than young adults did, their dwell time on the eyes was significantly reduced when expressed as a proportion of the total amount of time spent looking at the eyes and mouth combined. In other words, in order to be able to make effective use of eye information, older adults might have to look at the eyes for a longer period of time than do young adults, as older adults do with mouths.

A number of other explanations can also be given to account for the findings. For instance, one might argue that older adults look less to the eyes because eye looking is not a culturally accepted practice within this age group and, indeed, at present we cannot rule out this explanation. An alternative explanation, based on age-related changes in certain brain regions, could also be speculated upon, as although the current experiments did not give rise to brain imaging data, they could be used as indirect evidence of such changes. For instance, the amygdala, along with the superior temporal sulcus and orbitofrontal cortex (OFC), is involved in coding eye gaze information (e.g., Adolphs, Tranel, & Damasio, 1998; Young, Aggleton, Hellawell, & Johnson, 1995) and in giving meaning to emotion displays (Adolphs & Tranel, 2003). Both the amygdala and the OFC are also thought to mediate recognition of anger, fear, and sadness (Adolphs & Tranel, 2004; Blair & Cipolotti, 2000; Blair, Morris, Frith, Perrett, & Dolan, 1999; Calder, Lawrence, & Young, 2001; Fine & Blair, 2000; Iidaka et al., 2001; Whalen, Shin, McInerney, & Häkan, 2002). Our finding that older adults do not show a preference for looking at the eyes over other facial features, combined with their general difficulties recognizing anger, fear, and sadness, could be suggestive of age-related changes in these brain regions.

Research that found age differences on the Eyes Task (i.e., Phillips et al., 2002) and research that found age differences in perceiving danger in faces (Ruffman, Sullivan, & Edge, in press) both add further indirect weight to the notion of changes in the amygdala, OFC, superior temporal sulcus, and related brain regions thought to mediate performance on these tasks (Adolphs et al., 1998; Baron-Cohen et al., 1999; Winston, Strange, O'Doherty, & Dolan, 2002).

However, direct evidence of age-related changes in these brain regions is at present inconclusive. For instance, some studies suggest minimal or no age differences in amygdala volume (Good et al., 2001; Grieve, Clark, Williams, Peduto, & Gordon, 2005), whereas others report age-related reductions in amygdala volume (Jack et al., 1997; Mu, Xie, Wen, Weng, & Shuyun, 1999) and activation (Cerf & Murphy, 2003). Still others suggest an age-related shift in the type of emotional stimuli to which the amygdala responds, with older adults demonstrating less activation than younger counterparts when the adults are viewing negatively valenced stimuli (Gunning-Dixon et al., 2003; Iidaka et al., 2001; Mather et al., 2004; Tessitore et al., 2005). The effect of aging on the OFC is also a matter of debate. Some researchers postulate that this region is less affected by aging than other regions (Salat, Kaye, & Janowsky, 2001), whereas others report age-related neuronal loss (Rajkowska, Miguel-Hidalgo, Dubey, Stockmeier, & Krishnan, 2005) and reductions in volume (Convit et al., 2001) and activation (Suzuki et al., 2001). In summary, as the emotions that older adults have general difficulties in recognizing (i.e., anger, sadness, and fear) are best identified from the eyes, we speculated that older adults may look less at the eyes of emotion faces than do younger counterparts.

In support of this notion, Adolphs and colleagues (2005) recently found that the impairment of their participant, SM, in recognizing fear stemmed from an inability to make normal use of information from the eye region of faces, a defect that they traced to a lack of spontaneous fixations on the eyes. However, when SM was directed to look specifically at the eyes of other faces, her impairment in fear recognition was negated. Nevertheless, in this study at least the correlation between eye looking and improved emotion recognition was significant for younger but not older adults (although it was in the expected direction). Thus, it remains unclear whether less eye looking might cause worse emotion recognition in older adults. Future research that examines whether or not training older adults to look at the eyes has a positive impact on older adults' emotion recognition skills would be a means of resolving this issue.

To conclude, the current experiments indicate both similarities and differences between young and older adults in their ability to determine facial expressions of emotions. However, compared with young adults, older adults show subtly worse emotion recognition, and a pattern of relatively more mouth looking and less eye looking. How subtle differences in emotion recognition and scanning might affect real-life adaptation in older adults remain's to be addressed.

## Acknowledgments

Address correspondence to Susan Sullivan, School of Life Sciences, JMS Building 3d7, University of Sussex, Falmer, Brighton, BN1 9RH, United Kingdom. E-mail: susansu@biols.susx.ac.uk.

## References

Adolphs, R., Tranel, D., & Damasio, A. R. (1998). The human amygdala in social judgment. *Nature, 393*, 470–474.

Adolphs, R., & Tranel, D. (2003). Amygdala damage impairs emotion recognition from scenes only when they contain facial expressions. *Neuropsychologia, 41*, 1281–1289.

Adolphs, R., & Tranel, D. (2004). Impaired judgements of sadness but not happiness following bilateral amygdala damage. *Journal of Cognitive Neuroscience, 16*, 453–462.

Adolphs, R., Gosselin, F., Buchanan, T. W., Tranel, D., Schyns, P., & Damasio, A. R. (2005) A mechanism for impaired fear recognition after amygdala damage. *Nature, 433*, 68–72.

Baron-Cohen, S., Ring, H., Wheelwright, E., Bullmore, M., Brammer, A., Simmons, A., et al. (1999). Social intelligence in the normal and autistic brain: An fMRI study. *European Journal of Neuroscience, 11*, 1891–1898.

Baron-Cohen, S., Wheelwright, S., Hill, J., Raste, Y., & Plumb, I. (2001). The ''Reading the Mind in the Eyes Task'' Test, revised version: A study with normal adults, and adults with Asperger Syndrome or high-functioning Autism. *Journal of Child Psychology and Psychiatry, 42*, 241–251.

Baron-Cohen, S., Wheelwright, S., & Jolliffe, T. (1997). Is there a language of the eyes? Evidence from normal adults, and adults with autism or Asperger Syndrome. *Visual Cognition, 4*, 311–331.

Bassili, J. N. (1979). Emotion recognition: The role of facial movement and the relative importance of upper and lower areas of the face. *Journal of Personality and Social Psychology, 37*, 2049–2058.

Batki, A., Baron-Cohen, S., Wheelwright, S., Connellan, J., & Ahluwalia, J. (2000). Is there an innate gaze module? Evidence from human neonates. *Infant Behaviour & Development, 23*, 223–229.

Blair, R. J. R., & Cipolotti, L. (2000). Impaired social response reversal. A case of 'acquired sociopathy'. *Brain, 123*, 1122–1141.

Blair, R. J. R., Morris, J. S., Frith, C. C., Perrett, D. I., & Dolan, R. J. (1999). Dissociable neural responses to facial expressions of sadness and anger. *Brain, 122*, 883–893.

Brink, T. L., Yesavage, J. A., Lum, O., Heersema, P. H., Adey, M., & Rose, T. L. (1982). Screening tests for geriatric depression. *Clinical Gerontologist, 1*, 37–43.

Calder, A. J., Lawrence, A. D., & Young, A. W. (2001). Neuropsychology of fear and loathing. *Nature Reviews Neuroscience, 2*, 352–363.

Calder, A. J., Young, A. W., Keane, J., & Dean, M. (2000). Configural information in facial expression perception. *Journal of Experimental Psychology: Human Perception and Performance, 26*, 527–551.

Cattell, R., & Cattell, A. K. (1959). *The Culture Fair Intelligence Test.* City: The Institute for Personality and Ability Testing.

Cerf, D., & Murphy, C. (2003). FMRI brain activation in response to odors is reduced in primary olfactory areas in elderly subjects. *Brain Research, 986* (1–2), 39–53.

Charles, S. T., Mather, M., & Carstensen, L. L. (2003). Aging and emotional memory: The forgettable nature of negative images for older adults. *Journal of Experimental Psychology – General, 132* (2), 310–324.

Convit, A., Wolf, O. T., de Leon, M. J., Patalinjug, M., Kandil, E., Caraos, C., et al. (2001) Volumetric analysis of the pre-frontal regions: Findings in aging and schizophrenia. *Psychiatry Research: Neuroimaging, 107*, 61–73.

Ekman, P., & Friesen, W. V. (1976). *Pictures of facial affect.* Palo Alto, CA: Consulting Psychologists Press.

Fine, C., & Blair, R. J. R. (2000). Mini review: The cognitive and emotional effects of amygdala damage. *Neurocase, 6*, 435–450.

Folstein, M. F., Folstein, S. E., & McHugh, P. R. (1975) Mini-mental state: A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research, 12*, 189–198.

Good, C. D., Johnsrude, I. S., Ashburner, J., Henson, R. N. A., Friston, J., & Frackowiak, S. J. (2001). A voxel-based morphometric study of ageing in 465 normal adult human brains. *NeuroImage, 14*, 21–36.

Grieve, S. M., Clark, C., Williams, L., Peduto, A., & Gordon, E. (2005). Preservation of limbic and paralimbic structures in aging. *Human Brain Mapping, 25*, 391–401.

Gunning-Dixon, F. M., Gur, R. C., Perkins, A. C., Schroeder, L., Turner, T., Turetsky, B., et al. (2003). Age-related differences in brain activation during emotional face processing. *Neurobiology of Aging, 24*, 285–295.

Hemsley, G. D., & Doob, A. N. (1978). The effect of looking behavior on perceptions of a communicator's credibility. *Journal of Applied Social Psychology, 8*, 136–144.

Hood, B. M., Willen, J. D., & Driver, J. (1998). Adult's eyes trigger shifts of visual attention in human infants. *Psychological Science, 9*, 131–134.

Horley, K., Williams, L. M., Gonsalvez, C., & Gordon, E. (2004). Face to face: Visual scanpath evidence for abnormal processing of facial expressions in social phobia. *Psychiatry Research, 127*, 43–53.

Iidaka, T., Omori, M., Murata, T., Kosaka, H., Yonekura, Y., Tomohisa, O., et al. (2001). Neural interaction of the amygdala with the prefrontal and temporal cortices in the processing of facial expressions as revealed by fMRI. *Journal of Cognitive Neuroscience, 13*, 1035–1047.

Isaacowitz, D. M., Wadlinger, H. A., Goren, D., & Wilson, H. R. (2006) Selective preference in visual fixation away from negative images in old age? An eye-tracking study. *Psychology & Aging, 21*, 40–48.

Jack, C. R., Petersen, R. C., Xu, Y. C., Waring, S. C., Obrien, P. C., Tangalos, E. G., et al. (1997). Medial temporal atrophy on MRI in normal aging and very mild Alzheimer's disease. *Neurology, 49*, 786–794.

Joseph, R. M., & Tanaka, J. (2002). Holistic and part-based face recognition in children with autism. *Journal of Child Psychology and Psychiatry, 43*, 1–14.

Kleinke, C. L., Bustos, A. A., Meeker, F. B., & Staneski, R. A. (1973). Effects of self-attributed and other-attributed gaze on interpersonal evaluations between male and females. *Journal of Experimental Social Psychology, 9*, 154–163.

Klin, A., Jones, W., Schultz, R., Volkmar, F., & Cohen, D. (2002). Visual fixation patterns during viewing of naturalistic social situations as predictors of social competence in individuals with autism. *Archives of General Psychiatry, 59*, 809–816.

Langton, S. R. H., Watt, R., & Bruce, V. (2000). Do the eyes have it? Cues to the direction of social attention. *Trends in Cognitive Sciences, 4*, 50–59.

Mather, M., Canli, T., English, T., Whitfield, S., Wais, P., Oschner, K., et al. (2004). Amygdala responses to emotionally valenced stimuli in older and younger adults. *Psychological Science, 15*, 259–263.

Mather, M., & Carstensen, L. L. (2003) Aging and attentional biases for emotional faces. *Psychological Science, 14*, 409–415.

Maurer, D. (1985). Infants' perception of facedness. In T. Field & N. Fox (Eds.), *Social perception in infants* (pp. 73–100). New Jersey: Ablex.

Mu, Q. W., Xie, J. X., Wen, Z. Y., Weng, Y. Q., & Shuyun, Z. (1999) A quantitative MR study of the hippocampal formation, the amygdala, and the temporal horn of the lateral ventricle in healthy subjects 40 to 90 years of age. *American Journal of Neuroradiology, 20*, 207–211.

Nummenmaa, T. (1964). *The language of the face*. Jyvaskyla Studies in Education, Psychology, and Social Research. Jyvaskyla, Finland.

Phillips, L. H., MacLean, R. D. J., & Allen, R. (2002). Age and the understanding of emotions: Neuropsychological and sociocognitive perspectives. *Journal of Gerontology: Psychological Sciences, 57B*, P526–P530.

Rajkowska, G., Miguel-Hidalgo, J. J., Dubey, P., Stockmeier, C. A., & Krishnan, K. R. R. (2005). Prominent reduction in pyramidal neuron density in the orbitofrontal cortex of elderly depressed patients. *Biological Psychiatry, 58*, 297–306.

Ruffman, T., Sullivan, S., & Edge, N. (in press). Differences in the way older and younger adults rate threat in faces but not situations. *Journal of Gerontology: Psychological Sciences and Social Sciences.*

Salat, D. H., Kaye, J. A., & Janowsky, J. S. (2001). Selective preservation and degeneration within the prefrontal cortex in aging and Alzheimer disease. *Archives of Neurology, 58*, 1403–1408.

Salthouse, T. A. (1992). *Mechanisms of age-cognition relations in adulthood.* J. M. MacEachran Memorial Lecture Series. Hillsdale, NJ: Erlbaum.

Salthouse, T. A. (2000). *Steps towards the explanation of adult age differences in cognition.* In T. J. Perfect & E. A. Maylor (Eds.), *Models of cognitive aging* (pp. 19–49). Oxford: Open University Press.

Streit, M., Wolwer, W., & Gaebel, W. (1997). Facial-affect recognition and visual scanning behaviour in the course of schizophrenia. *Schizophrenia Research, 24*, 311–317.

Sullivan, S., & Ruffman, T. (2004) Emotion recognition deficits in the elderly. *International Journal of Neuroscience, 114*, 403–432.

Suzuki, Y., Critchley, H. D., Suckling, J., Fukuda, R., Williams, S. C. R., Andrew, C., et al. (2001). Functional magnetic resonance imaging of odor identification: The effect of aging. *Journal of Gerontology: Medical Sciences, 56A*, M756–M760.

Tanaka, J. W., & Farah, M. J. (1993). Parts and wholes in face recognition. *Quarterly Journal of Experimental Psychology, 46A*, 225–245.

Tessitore, A., Hariri, A. R., Fera, F., Smith, W. G., Das, S., Weinberger, D. R., et al. (2005). Functional changes in the activity of brain regions underlying emotion processing in the elderly. *Psychiatry Research: Neuroimaging, 139*, 9–18.

Vecera, S. P., & Johnson, M. H. (1995). Gaze detection and the cortical processing of faces: Evidence from infants and adults. *Visual Cognition, 2*, 59–87.

Walker-Smith, G. J., Gale, A. G., & Findlay, J. M. (1977). Eye movement strategies involved in face perception. *Perception, 6*, 313–326.

Weschler, D. (1981). *Manual for the Weschler Adult Intelligence Scale—Revised.* New York: Psychological Corporation.

Whalen, P. J., Shin, L. M., McInerney, S. C., & Häken, F. (2001). A functional MRI study of human amygdala responses to facial expressions of fear versus anger. *Emotion, 1*, 70–83.

Wheeler, R. W., Baron, J. C., Michell, S., & Ginsburg, H. J. (1979). Eye contact and the perception of intelligence. *Bulletin of the Psychonomic Society, 13*, 101–102.

Williams, L. M., Loughland, C. M., Gordon, E., & Davidson, D. (1999). Visual scanpaths in schizophrenia: Is there a deficit in face recognition? *Schizophrenia Research, 40*, 189–199.

Winston, J. S., Strange, B. A., O'Doherty, J., & Dolan, R. J. (2002). Automatic and intentional brain responses during evaluation of trustworthiness of faces. *Nature Neuroscience, 5*, 277–283.

Young, A. W., Aggleton, J. P., Hellawell, D. J., & Johnson, M. (1995). Face processing impairments after amygdalotomy. *Brain, 118*, 15–24.

*Received September 21, 2004*
*Accepted July 25, 2006*
*Decision Editor: Thomas M. Hess, PhD*