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BRIEF REPORTS

Emotional Expression Modulates Perceived Gaze Direction

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Gaze perception is an important social skill, as it portrays information about what another person is attending to. Gaze direction has been shown to affect interpretation of emotional expression. Here the authors investigate whether the emotional facial expression has a reciprocal influence on interpretation of gaze direction. In a forced-choice yes–no task, participants were asked to judge whether three faces expressing different emotions (anger, fear, happiness, and neutral) in different viewing angles were looking at them or not. Happy faces were more likely to be judged as looking at the observer than were angry, fearful, or neutral faces. Angry faces were more often judged as looking at the observer than were fearful and neutral expressions. These findings are discussed on the background of approach and avoidance orientation of emotions and of the self-referential positivity bias.

Keywords: face perception, emotional expression, eye gaze, social cognition, self-esteem

Faces attract the attention of most vertebrates. The information contained in faces, especially the eye region, is multifaceted and of high biological relevance. To know where another person is looking is an important cognitive and social skill. The attraction to the eye region may in fact be innately prepared (e.g., Baron-Cohen, 1995). Eye-gaze direction portrays information about what other people are attending to, a skill which is commonly referred to as *joint attention* (Argyle & Cook, 1976; Baron-Cohen, 1995). The emotional expression of the face, coupled with eyes looking at the observer, indicates whether a person is benevolent or means ill.

As warrants such an important skill, human beings are able to very accurately detect whether or not another person is making eye contact (e.g., Gibson & Pick, 1963), but are slightly less accurate in judging where a person is looking when gaze is directed somewhere in the environment (Lobmaier, Fischer, & Schwaninger, 2006; Schwaninger, Lobmaier, & Fischer, 2005; Symons, Lee, Cedrone, & Nishimura, 2004). Different sources of information are taken into account when interpreting eye-gaze direction. The unique morphology of the human eye with its dark iris surrounded by a widely exposed white sclera makes the iris:sclera ratio a fundamental cue for computing the direction of regard (Ando, 2002; Kobayashi & Kohshima, 1997). A second factor influencing gaze interpretation is the posture of the looker's head (Langton, 2000; Langton, Watt, & Bruce, 2000). Finally, the presence of objects in the attended space also influences the interpretation of gaze direction (Lobmaier et al., 2006).

Analysis of eye-gaze direction shares some underlying processing mechanism with other aspects of face perception. For example, Adams and Kleck (2003) showed that gaze direction influenced the perception of emotional expression. Specifically, direct gaze enhanced the perception of approach-oriented emotions, such as anger and joy, while averted gaze enhanced the perception of avoidance-oriented emotions such as sadness and fear. They found shorter response latencies when participants labeled angry and joyful emotions when faces showed direct gaze than when gaze was averted. Conversely, when labeling fearful and sad faces, response latencies were shorter when the gaze was averted than when the gaze was directed at the participants (Adams & Kleck, 2003). In a further study (Adams & Kleck, 2005), neutral faces with averted gaze were much more likely to be attributed to fear and sadness; the same faces were attributed more to anger and joy when gaze was directed at the observer. The authors concluded that gaze direction and facial expression interact meaningfully in the perceptual processing of emotionally relevant facial information. Thus, gaze direction affects the perceived emotional expression and emotional intensity of a face. This study aims to investigate whether emotional expression reciprocally modulates the perceived gaze direction. From the studies of Adams and Kleck (2003, 2005) one may predict that a face expressing an approach-oriented emotion is more likely to be perceived as looking at the observer than is a face with an avoidance-oriented expression, such as fear.

People typically judge the self more positively than they do others on certain dimensions (Alicke, Klotz, Breitenbecher, Yurak, & Vredenburg, 1995; Dunning, Meyerowitz, & Holzberg, 1989; Pahl & Eiser, 2005), a tendency that has been referred to as the *self-positivity bias* (e.g., Pahl & Eiser, 2005). This self-referential bias may suggest that a happy face is more likely to be judged as looking at an observer than is an angry, fearful, or neutral face.

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Interpreting happy expressions of others as self-directed promotes self-esteem and a positive view of the world, whereas interpretation of anger and hostility directed to oneself is likely to lower esteem and to promote a negative view of the world. In line with this notion, pioneering work of Martin and Rovira (1982) suggested a bias for eye-gaze responses for smiling faces. They compared two videotaped models either looking straight at the camera or looking away while speaking, smiling, or displaying a thinking gesture and found that observers reported more "looking at me" answers when the model was smiling. However, the authors did not control the angle of the averted face in the videos. Inspection of their results suggests that the angle of aversion may have differed between the different expressions. Furthermore, they did not test any negative emotions. In this study we test four different emotional expressions in 11 different views that were the same for each emotion. We hypothesize that (a) positive emotions (e.g., happiness) will bias interpretation of gaze toward the observer in comparison with the negative or neutral expressions; (b) approach-oriented emotions (happiness and anger) will bias interpretation toward the observer more than will fearful and neutral faces; and (c) fearful expressions will bias interpretation of gaze away from the observer, in comparison with neutral faces.

Method

Participants

Fifty-four observers gave informed consent to participate as part of a practical class on emotion. Five had to be excluded from the analyses because of technical errors, leaving the data of 49 participants (39 women and 10 men). They all reported normal or corrected-to-normal vision and gave informed consent to take part in this experiment.

Apparatus

The study was run on personal computers running on Windows XP using custom-made software. The stimuli were presented on a screen with a resolution of 1024 × 768 pixels and a color depth of 32 bits.

Stimuli

Three-dimensional (3-D) images were acquired with a 3dMD (www.3dMd.com) surface-capture system, which uses unstructured light (a speckle pattern) to perform stereo matching on two pairs of images (one for each side of the face). The system also collects a registered color texture map from each side of the face and combines the left and right sides into a single triangular mesh data structure. Faces of 4 actors (2 men and 2 women) were captured while expressing one of four emotions (neutral expression of happiness, fear, or anger) while simultaneously fixating their gazes on a predefined target point that was situated approximately 80 cm away, on a straight line in front of the actors. Nose, target point, and virtual camera lay on the same axis, resulting in aligned gaze and head direction. Using custom-made software, we rotated the 3-D models 10° to the left and 10° to the right of the veridical direct gaze. Eleven different viewing angles were computed from these rotations (2°, 4°, 6°, 8°, and 10° to the left and right, and 0°) and were converted to jpeg format. A series of example images for each emotional expression is shown in Figure 1.

The emotional expressions were classified by 24 independent observers in a four-alternative forced-choice task (options: happy, angry, neutral, and fearful). Specifically, the observers had to decide for each face which of the four emotions the face was most likely expressing. Each emotion of each stimulus face was correctly recognized by more than 65% of participants (chance = 25%), except for one angry face that appeared to be ambiguous. This face was rated as angry by 23% of the participants but as happy by 40% and neutral by 31%. Whether or not this particular face was included reveals the same results in the following tests. We report here only the results of the analyses in which all the expressions of this particular face were excluded.

Task and Procedure

Using a forced-choice yes-or-no task, we asked participants to decide whether a face was looking straight at them or not. They

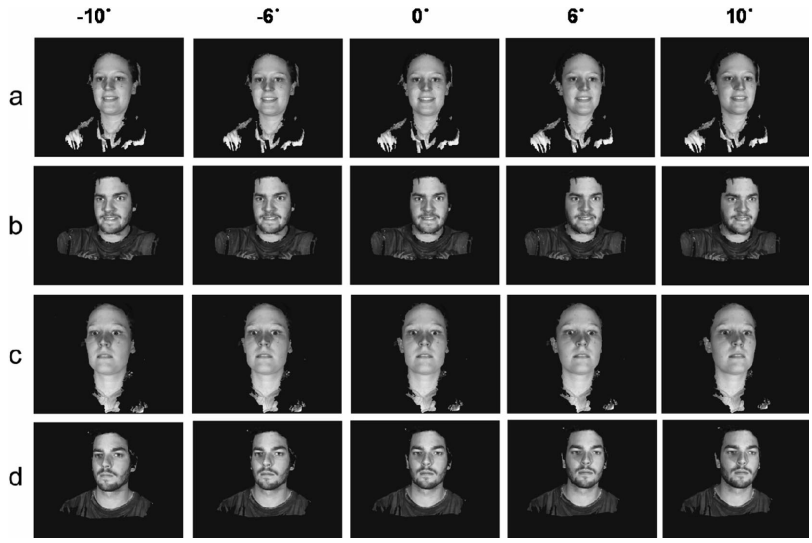

Figure 1. Example of stimuli: Five different viewing angles of (a) happy, (b) angry, (c) fearful, and (d) neutral expressions. The stimuli were presented in color.

were given oral and on-screen instructions and could start the experiment by pressing the space bar. Then a stimulus was presented for 1,000 ms, and participants answered by clicking a *yes* or a *no* button on the screen with the mouse cursor. All stimuli were shown once in random order (11 views, four expressions, and four identities). No feedback was given; participants initiated the next trial by pressing the space bar. The experiment encompassed 176 trials and lasted approximately 10 min.

Results

The proportion of answers for which gaze was reported as looking at the observer was calculated for each emotion and each view, separately for each participant. We pooled responses for views to the left with the corresponding view to the right, because preliminary analyses revealed the same effects for both sides and because there was no reason to expect a difference between gaze directions to the left and those to the right. This resulted in six different gaze angles (0°, 2°, 4°, 6°, 8°, and 10° deviations from straight at observer) that were entered into the analyses. The average proportions of answers for which gaze was reported as looking at the observer are shown in Figure 2, separately for the four emotions in each of the six gaze angles. A three-way repeated-measures analysis of variance (ANOVA) of the proportion trials reported looking at the observer with emotion (happiness, anger, fear, or neutral) and gaze angle (0°, 2°, 4°, 6°, 8°, or 10°) as within-participants factors, and sex as between participant factors was calculated, revealing clear effects of emotion, $F(3, 144) = 46.14$, $MSE = .033$, $p < .001$, $\eta^2 = .49$, and of gaze angle, $F(5, 240) = 523.93$, $MSE = .037$, $p < .001$, $\eta^2 = .92$. Participant sex was marginally significant, $F(1, 47) = 4.051$, $MSE = .181$, $p = .05$, $\eta^2 = .079$. Men tended to make more "looking at me" answers than did women ($M = 0.48$, $SE = 0.27$, vs. $M = .42$, $SE = .014$). Emotion interacted with gaze angle, $F(15, 720) = 4.19$, $MSE = .023$, $p < .001$, $\eta^2 = .08$, and participant sex interacted with gaze angle, $F(5, 235) = 2.45$, $MSE = .023$, $p < .05$, $\eta^2 = .05$, but there was no interaction of participant sex and emotion, $F(3, 141) = 1.47$, $MSE = .033$, $p = .931$, $\eta^2 = .003$. Pooled across gaze angles and participants, the mean proportion of answers for which gaze was reported as looking at the observer was highest for happy faces ($M = .53$, $SE = .016$), followed by angry faces ($M = .43$, $SE = .015$), neutral faces ($M = .38$, $SE = .015$), and fearful faces ($m = .38$, $SE = .017$). Post hoc pairwise comparisons (Bonferroni corrected) of the emotions revealed that happy faces evoked more eye-contact answers than did all other emotions (all $p < .001$). Angry faces evoked more eye-contact answers than did fearful ($p < .05$) and neutral faces ($p < .01$). Fearful and neutral faces did not differ ($p = 1.000$). To compare the two approach-oriented emotions, we carried out a 2 (anger, happiness) x 6 (views) ANOVA, revealing a significant effect of emotion, $F(1, 48) = 44.78$, $MSE = .034$, $p < .001$, $\eta^2 = .48$, and of view, $F(5, 240) = 379.59$, $MSE = .028$, $p < .001$, $\eta^2 = .89$. There was no interaction of emotion and view, suggesting a systematic bias toward interpreting gaze of happy faces toward the observer, in comparison with angry faces.

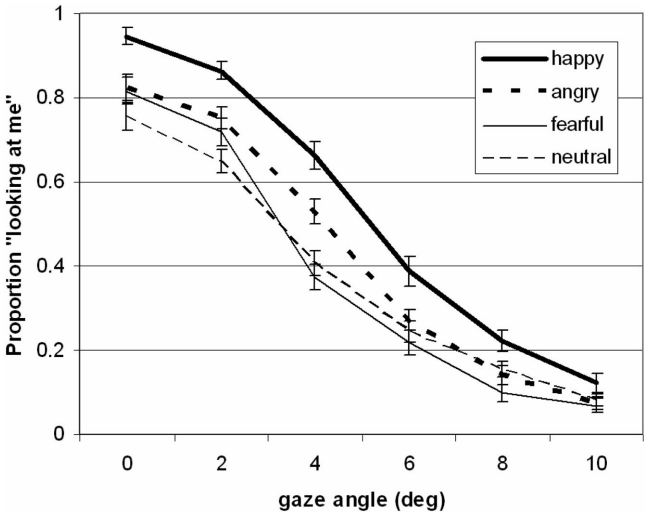

Figure 2. Mean proportion of answers for which gaze was reported to be looking at the observer, given separately for the four different emotions as a function of the six different viewing angles, pooled across participants. Error bars depict standard errors.

Discussion

These results reveal that the emotional expression of a face influences perceived gaze direction. The expressed emotion therefore is a further cue taken into account when judging the gaze direction of others, alongside the iris:sclera ratio (e.g., Kobayashi & Kohshima, 1997), the head direction (e.g., Langton, 2000; Langton et al., 2000) and objects in the proximity of the gaze direction (Lobmaier et al., 2006). More important, this study revealed that different emotional expressions differentially modulate perception of eye-gaze direction. Expressed happiness increased the probability that a face is perceived as looking at the observer, in comparison with neutral faces and faces expressing other emotions, such as anger or fear. Faces with a neutral or fearful expression were less likely to be perceived as looking at observers than were faces expressing happiness or anger. These findings correspond with the studies of Adams and Kleck (2003, 2005), who reported that gaze direction influenced the processing of expressed emotions. Specifically, they found that neutral faces were judged as happier, or angrier, when their gaze was directed toward the observer, in comparison with when the same faces displayed averted gaze direction. They interpreted this finding by arguing that happiness and anger communicate approach-oriented behavior, whereas fear and sadness were associated with avoidance-oriented behavior. Accordingly, direct gaze is associated with approach, while averted gaze is associated with avoidance. In line with the approach–avoidance hypothesis, we found that both happy and angry faces were more likely to be perceived as looking straight at the observer than were fearful and neutral faces. However, fearful faces did not evoke fewer "looking at me" answers than did neutral faces, which would be expected according to the approach–avoidance hypothesis. Furthermore, happy faces were disproportionately more likely to be perceived as looking at an observer than were angry faces, which can also not be explained by the approach–avoidance interpretation.

The framework of the self-referential positivity bias better describes our findings in the way that it predicts that other people's positive emotions are associated with their own person, while

negative expressions are not. While this indeed reflects an egocentric demeanor, such an attitude may be healthy for self-esteem. Interpreting others' happiness as being directed at oneself will mean that one does not miss out on positive reinforcement and social reward. Conversely, interpreting negative emotions as directed away from oneself protects one from undue disapproval and can enhance the ability to detect sources of danger. Because people tend to see themselves in a more positive light than do others (cf. Alicke et al., 1995; Dunning et al., 1989; Pahl & Eiser, 2005), it is conceivable that they expect to be the reason for the happiness of others. These results therefore suggest an egocentric bias for positive emotions being directed to the observer.

Given that interpretation of eye gaze and emotional expression serve an adaptive function, it could be expected that threatening expressions such as anger or fear would evoke more accurate interpretations of threatening faces. In this article we found a bias toward interpreting the direction of positive expressions toward the observer; our data say nothing about accuracy. In fact, the strong bias toward positive expressions suggests that participants were not very accurate in attributing the focus of attention of happy faces. It will have to be the aim of future studies to determine accuracy of gaze interpretation in emotional faces.

Men interpret gaze as directed at them more often than do women. This finding is interesting in the context of recent work by Bayliss, di Pellegrino, and Tipper (2005), who found that women show greater sensitivity to gaze direction than do men. However, women and men showed the same response pattern for all expressions, suggesting that the positivity bias in gaze perception works for both women and men. Future studies will have to further explore the sex differences for gaze interpretation in faces.

Our findings indicate that analysis of gaze direction and of emotions might share some underlying processing mechanisms. Indeed, neurophysiological and neuroimaging findings suggest shared anatomical structures for processing facial expression and gaze direction. Specifically, the superior temporal sulcus (STS) has been reported to be involved in processing changeable features of a face, including expression and gaze direction (e.g., Hoffman & Haxby, 2000; Perrett et al., 1985). Furthermore, the amygdala seems to play a critical role in processing negative emotions (e.g., Adolphs, Tranel, Damasio, & Damasio, 1994) and monitoring gaze direction (e.g., Adams, Gordon, Baird, Ambady, & Kleck, 2003; George, Driver, & Dolan, 2001).

Although other authors have reported an interrelationship between gaze and emotion processing (e.g., Adams & Kleck, 2003, 2005; Bayliss, Frischen, Fenske, & Tipper, 2007; Fox, Mathews, Calder, & Yiend, 2007; Ganel, Goshen-Gottstein, & Goodale, 2005; Hietanen & Leppanen, 2003; Holmes, Richards, & Green, 2006; Martin & Rovira, 1982), our study is the first to vary viewing angle and hence gaze direction in a parametrically controlled manner. While approach-oriented emotions were interpreted as directed toward the observer more than were avoidance-oriented and neutral expressions, happy faces were perceived as looking toward the observer more often than were angry faces. Finally, in comparison with neutral expressions, fearful faces did not evoke more responses that gaze was perceived as looking at the observer, challenging the view that avoidance-oriented emotions bias the interpretation of other people's gaze away from observers. Hence, both the approach-avoidance hypothesis and the self-referential positivity bias contribute in explaining the interrelation between emotion and gaze interpretation.

Recent findings suggest that smiling faces are more likely to be judged as familiar (e.g., Baudouin, Gilibert, Sansone, & Tiberghien, 2000). Therefore it could be argued that what we interpret as a positivity bias is confounded with a familiarity effect. It will have to be the aim of future studies to test whether familiar faces, more than unfamiliar faces, are perceived as looking at an observer. Furthermore, it has to be noted that our conclusions are drawn from experiments investigating mutual gaze awareness, not full gaze awareness. Mutual gaze awareness denotes the awareness of being looked at, while full gaze awareness is described as knowing precisely what someone else is looking at in the environment. Although it would indeed be interesting to investigate how emotional expression influences full gaze awareness, it is not relevant in the present context.

Emotional expressions are very relevant in social cognition, and they are especially relevant when these expressions are addressed toward oneself. It seems that happiness is especially often perceived as directed toward oneself. In conclusion, this study provides strong evidence that emotional expressions meaningfully modulate perceived gaze direction. Positive faces are interpreted as directed toward an observer more than are angry, fearful, or neutral faces, consistent with the preservation of self-esteem.

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