

Interaction effects of perceived gaze direction and dynamic facial expression: Evidence for appraisal theories of emotion

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Appraisal theorists suggest that the face expresses cognitive processes involved both in the orienting of attention (primarily gaze direction) and in the evaluation of emotion-eliciting events. Contrary to the assumption of direct emotion recognition by basic emotions theorists, this implies an interaction effect between “perceived gaze direction” and “perceived facial expression” in inferring emotion from the face. These two theoretical perspectives were comparatively tested by requesting participants to decode dynamic synthetic facial expressions of emotion presented with either an averted or a direct gaze. Confirming the interaction predicted by appraisal theories, the perceived specificity and intensity of fear and anger depended on gaze direction (direct gaze for anger and averted gaze for fear).

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Based on the general assumption that expressions of emotion are produced by automatic mechanisms such as innate neuromotor affect programmes (see Ekman, 1972; Izard, 1971; Tomkins, 1963), influential studies by Ekman and his collaborators (Ekman, 1972; Ekman, Friesen, & Ellsworth, 1972) and Izard have encouraged an emphasis on a few prototypical emotion expression patterns, underlining the unitary nature of the emotion-specific patterns as organised sets. Tomkins (1963) described these affect programmes as resulting in unique expressive patterns characteristic of a given affect. Although the mechanism involved in decoding emotional expression has rarely been specified (see Goldman & Sripada, 2005), discrete emotions are typically being characterised in this tradition as innate, easy, categorical, and immediate (see Russel, Bachorowski, & Fernandez-Dols, 2003).

More recently, some investigators used predictions derived from appraisal theories of emotion (see Scherer, Schorr, & Johnstone, 2001) to develop an alternative approach to facial expression (e.g., Scherer, 1992; Smith, 1989; Smith & Scott, 1997). In general, appraisal theories adopt a multicomponential approach to emotion, according to which appraisal mechanisms primarily trigger changes in four interacting emotion components (i.e., action tendencies, autonomic processes, motor expression, and subjective feeling) in the process of generating and differentiating emotions (see Sander, Grandjean, & Scherer, 2005). With respect to facial expressions, the issue of mental activity driving particular muscle activity has been addressed in the past. Indeed, Darwin (1872/1965) interpreted the frown produced by the innervation of the corrugator supercilii as a sign of “something difficult or displeasing encountered in a train of thought or in action” (p. 222; see also Pope & Smith, 1994; Smith, 1989). Moreover, Duchenne (1876/1990) attributed a special role in thought-related expressions to the superior part of *musculus orbicularis oculi* (which he called the “muscle of reflection”; see also Scherer, 1992). Reviewing theoretical proposals and empirical evidence, Scherer suggested that mental operations elicit “expression of thought” in the face, and proposed that these mental operations can be dissociated into two classes: (1) operations involved in orienting the focus of attention and (2) operations concerned with evaluation of objects or events. This author proposed a model of expression according to which the facial expression of a given emotion expresses a differential sequential and cumulative response pattern based on a series of appraisal outcomes. If this proposal is correct, one might predict that by appropriate inferences from particular facial cues, decoders should be able to recognise a facial expression of emotion from the outcomes of the pattern of cognitive appraisals that have produced the emotion. A new theoretical hypothesis can be derived from this suggestion: The decoding of facial expression is performed by inferring the appraisal pattern from observable cues of cognitive processes in the face.

In the present experiment, we comparatively tested the alternative predictions emanating from these two competing theories of emotion.

The notion of innate neuromotor affect programmes of expression of basic emotion, as suggested by discrete emotion theorists, implies that the facial expression of emotion is constituted by a specific configuration of facial muscle actions and that the process of decoding should not be influenced by facial actions that are not elicited by emotion-specific neuromotor programmes (e.g., face orientation, gaze direction).

In contrast, the notion of cognitive evaluation, as suggested by appraisal theorists, implies that the facial expression of emotion is constituted by appraisal-driven facial actions. In particular, if one considers the two classes of mental operations identified by Scherer, appraisal theories would predict that these classes interact in the decoding of facial expression of emotion, whereas basic emotions theories would not predict such interaction.

We designed an experiment to test this interaction. Gaze direction was used as a facial feature that indexed the encoder's orienting of attention, with the decoder being inside or outside the focus of gaze shown in the stimulus face (direct vs. averted gaze; e.g., Mathews, Fox, Yiend, & Calder, 2003; Pelphrey, Viola, & McCarthy, 2004; Vuilleumier, George, Lister, Armony, & Driver, 2005; Wicker, Perrett, Baron-Cohen, & Decety, 2003). Thus, the direction of gaze should have different implications for different emotions: An angry face should be more relevant to an observer if the gaze is direct rather than averted, as this may imply the representation that the angry person will attack the observer. Thus, an angry face should be more accurately decoded in a direct than in an averted gaze condition, as it should have greater behavioural relevance. In the case of the facial expression of fear, one may hypothesise that a fearful face is more relevant for the observer if the gaze is averted than if it is direct because this might imply that there might be a source of danger next to the observer. Therefore, a fearful face should be more accurately decoded in an averted than in a direct gaze condition (see Sander, Grafman, & Zalla, 2003).

In contrast, from a basic emotions perspective, facial features that are not an integral part of the neuromotor programme of a given basic emotion should not systematically affect the decoding of the expression, and thus, no effect of gaze direction is predicted.

Recently, Adams and Kleck (2003, 2005) showed that the detection of expressions of emotion in still facial photographs was facilitated by motivationally congruent gaze direction (approach-related vs. avoidance-related). Adams and Kleck (2003) used a forced-choice procedure and compared response latencies for the categorisation of fear versus anger while these expressions were presented either with a direct or an averted gaze. Results showed that anger expressions were more quickly categorised when presented with a direct than with an averted gaze, whereas fear expressions

were more quickly categorised when presented with an averted than with a direct gaze. In a series of studies, Adams and Kleck (2005) used photographs to show consistently that direct gaze enhances the perception of anger and that averted eye gaze enhances the perception of fear. Although these experiments were motivated by a different theoretical rationale, the interaction results are consistent with our hypothesis. In their discussion, Adams and Kleck (2005) insisted on the importance of addressing what mechanism underlies the influence of gaze direction on emotion perception or interpretation. With respect to this, the hypothesis that we aim at testing is that this mechanism consists of inferring the appraisal pattern from observable cues of cognitive processes in the face. Rather than using morphed versions of standard still pictures in which gaze had been manipulated, we used dynamic facial expressions synthesised according to theoretical predictions with the help of a dedicated computer graphics tool (see Wehrle, Kaiser, Schmidt, & Scherer, 2000). As reaction time is less appropriate for use with dynamic stimuli, we measured the degree to which the target emotion was chosen over six alternatives and the perceived intensity of the underlying emotion. We hypothesised that anger would be identified with a higher degree of accuracy and rated as more intense when gaze is direct, whereas fear should be identified with a higher degree of accuracy and rated as more intense when gaze is averted.

METHOD

Participants

Thirty-four students (32 women and two men, 32 right-handed and two left-handed, mean age = 24 years) from the University of Geneva participated in the study.

Stimuli

Dynamic synthetic front-view facial expressions depicting fear (action units 1, 2, 4, 5, 20, and 26), anger (action units 4, 5, 7, and 23), and happiness (action units 6, 12, and 26) were created in a male face using the Facial Action Composing Environment (FACE). This tool allows one to synthesise in real time three-dimensional animated facial expressions, including eye movements, on the basis of the Facial Action Coding System (Ekman & Friesen, 1978). A first validation study using FACE showed that the synthetic images modelled after a series of photographs that are widely used in facial expression research yielded recognition rates and confusion patterns comparable to posed photos (see Wehrle et al., 2000). In the present

study, each FACE stimulus of fear, anger, and happiness was created in two versions with different intensities and with either a direct gaze or an averted gaze (30 degrees). Gaze was manipulated with the direction that the eyes were directed toward, and the heads were never turned (see Figure 1). Each dynamic facial expression started from a neutral expression with the eye direction fixed (direct or averted) from the start and took 1100 ms to reach apex. For both intensities, each face stimulus was presented twice with an averted gaze (either leftward or rightward) and twice with a direct gaze.

Procedure

Participants were seated in front of a computer screen in a quiet room. They were presented with 24 (3 emotions × 2 intensities × 2 gaze directions × 2 presentations) trials divided into two blocks separated by a short break. For each trial, the unfolding of the dynamic facial expression took 1100 ms, and the face disappeared and was replaced by a window composed of seven scales. Using this window, participants were requested first to rate the general intensity of the face on an “intensity scale”, and then to rate how strongly each of the six emotions was represented in the respective

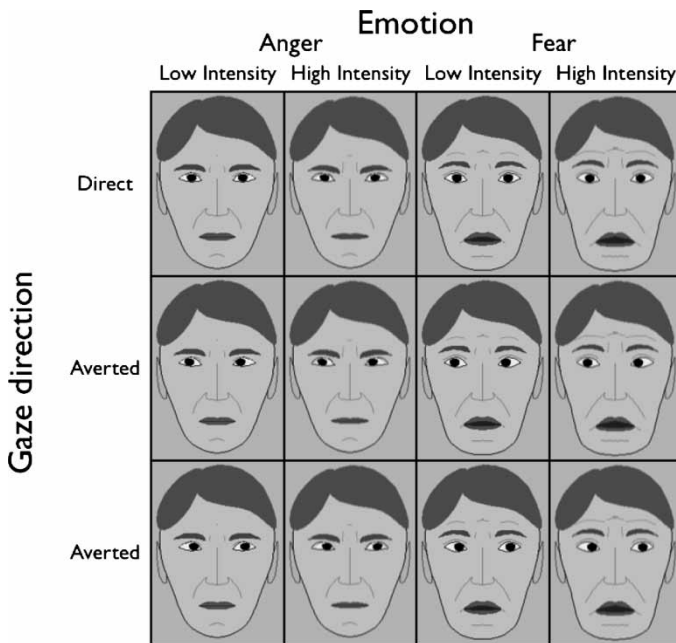


Figure 1. Stimuli consisted of dynamic facial expressions of emotion (anger and fear are depicted) created with two possible intensity levels (low vs. high) and with either a direct or an averted gaze.

expression by using six “emotion scales”. Therefore, in our judgement study, participants were requested to use continuous emotion scales, which allowed them not only to discriminate a given emotion in the context of multiple possible labels, but also to decide what emotions are present in the face (see Rosenthal, 1987). This multiple measure is thought to indicate the recognition of the expressed emotion (see Wehrle et al., 2000). The aim of the intensity scale was to index the decoding of the intensity of the underlying emotion rather than the type of emotion, allowing us to verify, in particular, that the intensity manipulation was efficient and to measure the effect of gaze direction not only on the recognition per se, but also on the decoded intensity. The emotion labels used for the ratings were the French labels for fear, anger, disgust, happiness, surprise, and sadness. The order of the blocks and the order of the scales were counterbalanced across participants. Slider coordinates were recorded for each scale on a continuum (0 to 5).

RESULTS

For each trial, ratings on (1) the emotional scales and on (2) the intensity scale were used as dependent variables for measuring, respectively, (1) how accurately the emotion was recognised and (2) how intense the underlying emotion was judged to be. An analysis of variance was performed on each dependent variable, with target emotion (anger, fear, happiness), expressed intensity (low, high), and gaze direction (direct, averted) as within-subjects factors.

Emotion ratings

The planned contrast analysis revealed that expressions were accurately recognised: For each specific emotion, the score on the corresponding scale was significantly higher than the scores on all the other five emotion scales: $F(1, 33) = 125.3, p < .001$ for anger; $F(1, 33) = 38.6, p < .001$ for fear; $F(1, 33) = 112.83, p < .001$ for happiness.

As shown in Figure 2, planned contrast analysis revealed the predicted two-way interaction between emotion (anger vs. fear) and gaze direction (direct vs. averted), $F(1, 33) = 13.06, p < .001, \eta = .53$. Angry faces were recognised as expressing more anger with a direct than with an averted gaze, $F(1, 33) = 6, p < .02, \eta = .40$, whereas fearful faces were recognised as expressing more fear with an averted than with a direct gaze, $F(1, 33) = 11.7, p < .002, \eta = .51$. No significant difference in the recognition of happy faces was observed according to gaze direction ($F < 1$). Results also revealed an effect of the expressed intensity of the face (low vs. high), with

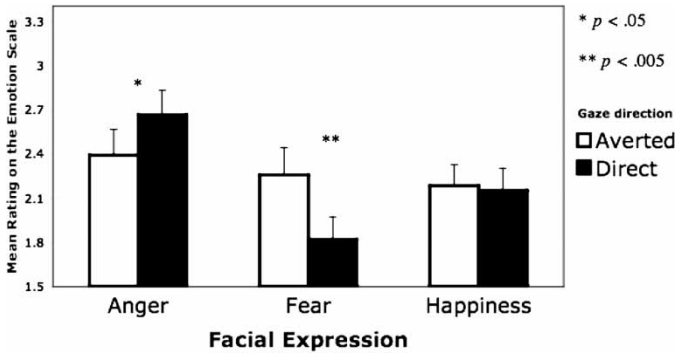


Figure 2. Mean emotional ratings of emotion in the face as a function of expression and gaze (+SE).

high-intensity expressions being rated as expressing more of a specific emotion than low-intensity expressions: $F(1, 33) = 86.4, p < .001$ for anger; $F(1, 33) = 23.6, p < .001$ for fear; $F(1, 33) = 87.0, p < .001$ for happiness.

Intensity ratings

As shown in Figure 3, the predicted two-way interaction was again observed between emotion (anger vs. fear) and gaze direction (direct vs. averted), $F(1, 33) = 7.9, p < .01, \eta = .44$. Anger was judged as more intense with a direct than with an averted gaze, $F(1, 33) = 4.8, p < .04, \eta = .36$, whereas fear was judged as more intense with an averted than with a direct gaze, $F(1, 33) = 4.9, p < .04, \eta = .36$. No significant difference in the judgement of the intensity of happy faces was observed according to gaze direction,



Figure 3. Mean intensity ratings of emotion in the face as a function of expression and gaze (+SE).

$F(1, 33) = 2.4, p > .1$. Results also revealed an effect of the expressed intensity of the face (low vs. high), with high-intensity expressions being rated as expressing more intense emotions than low-intensity expressions: $F(1, 33) = 174.6, p < .001$ for anger; $F(1, 33) = 23.6, p < .001$ for fear; $F(1, 33) = 127.9, p < .001$ for happiness.

DISCUSSION

Using synthetic dynamic facial expressions, we showed that angry faces are recognised as expressing more anger and that the underlying emotion is judged as being more intense with a direct than with an averted gaze, whereas fearful faces are recognised as expressing more fear and that the underlying emotion is judged as being more intense with an averted than with a direct gaze. These results are consistent with the findings of Adams and Kleck (2003, 2005) for fear and anger, and the fact that the mechanisms involved in the explicit decoding of emotional facial expression can be modulated by the processing of gaze direction raises the critical issue of the level of processing at which these two facial features interact in the decoding mechanism. This issue concerns (1) models of emotional processing and (2) models of face processing. For models of emotional processing, it is acknowledged that facial actions can be produced to express domains of information other than emotions (Ekman, 1997; Fridlund, 1994; Frijda, 1986; Scherer, 1992). However, to our knowledge, basic emotions theorists did not predict that such information interacts with the expressed emotion in the decoding of this expression, and the notion of prototypical universal expression patterns based on innate neuromotor programmes seems to explain why such an interaction was never predicted. On the other hand, our results are consistent with the proposal that the decoding of a facial expression of emotion involves inferences regarding the cognitive processes in the encoder that elicited specific facial actions. In particular, we interpret our results as suggesting that, during the decoding process, facial features reflecting attention shifts (but which do not belong to the prototypical facial display of emotion) can interact with facial features reflecting appraisal processes in the encoder. Therefore, appraisal predictions provide a more complex account of what is involved in the inference of emotion and other information, such as attention, in the face.

For models of face processing, the question of how different facial dimensions of faces are segregated and/or integrated is of critical importance (Bruce & Young, 1986; Haxby, Hoffman, & Gobbini, 2002). Cognitive neuroscience results suggest that the right somatosensory cortex is particularly concerned with the processing of emotional expression (see Adolphs, Damasio, Tranel, Cooper, & Damasio, 2000), whereas the right lateral

temporal cortex is particularly concerned with the processing of gaze shifts (see Puce, Allison, Bentin, Gore, & McCarthy, 1998), suggesting that these two facial features are differentially computed at an early stage of processing (Pourtois et al., 2004; see also Klucharev & Sams, 2004, for timing issues). However, results showing an interaction between gaze direction and expressed emotion suggest that these two dimensions become integrated at a later stage during emotional decoding. It can be proposed that, taken together, gaze direction and facial expression of emotion increase the relevance of the face, and if one considers that (1) both these facial dimensions involve the amygdala (Adolphs et al., 2005; Kawashima et al., 1999; Whalen et al., 2005; Winston, O'Doherty, & Dolan, 2003) and (2) the amygdala was proposed to be critical for relevance detection (Sander et al., 2003), then it can be suggested that the amygdala is essential for establishing the emotional significance elicited by the integration of gaze and emotion in the face. Supporting this view, Adams, Gordon, Baird, Ambady, and Kleck (2003) recently showed that the amygdala's sensitivity to displays of anger and fear differentially varied as a function of gaze direction. Generalising such interaction to another expression of the focus of attention, Sato, Yoshikawa, Kochiyama, and Matsumura (2004) observed that the amygdala showed an interaction between emotional expression and face direction, indicating higher activity for angry expressions facing the observer than for angry expressions in a face directed away from the observer. Therefore, our results suggest that two critical facial features of social communication, gaze direction and expression of emotion, interact to produce a relevance effect in the evaluation of emotion in the face.

In conclusion, we interpret our results as evidence for appraisal theories of emotion rather than for basic emotions theories, with the decoding of facial expression being performed by inferring the unfolding of cognitive processes in the encoder from observable facial cues and deducing the emotion presumably elicited by the appraisal process.

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