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Stress increases the feeling of being looked at

Ulrike Rimmele [a], Janek S. Lobmaier [b,*]

[a] New York University, Psychology Department, 6 Washington Place, New York, NY 10003, USA
[b] University of Bern, Institute for Psychology, Muesmattstrasse 45, CH-3012 Bern, Switzerland

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Summary Eye gaze direction and facial expression are important social cues. Recent studies have shown that emotional expression affects interpretation of gaze direction in such a way that positive emotions are more favorably interpreted as making eye contact than negative or neutral expressions. Here we examine whether stress affects this positivity bias in gaze perception. Stress was induced in 25 healthy young adults by means of the cold pressure stress test (CPS), 24 participants serving as controls. Stimuli were created from three-dimensional face models of 8 actors expressing happy, fearful, angry and neutral emotions. From each of these 3D models we extracted 9 different views (0°, 2°, 4°, 6° and 8° to the left and to the right). This resulted in 288 stimuli, which were randomly presented for 700 ms. Using a forced choice paradigm participants judged whether or not each face was looking at them. The results show that the CPS group falsely interpreted faces with averted gaze direction as making eye contact more often than did controls, independent of the expressed emotion. These results suggest that a stress-induced raise in cortisol level increases the sense of being looked at.

1. Introduction

The human face portrays numerous cues facilitating interpersonal communication. Of all these cues, the facial expression and eye gaze direction play a predominant role in social interactions. From the expression on somebody's face we can infer the emotional state or even the motivational intentions of this person. From the gaze direction we can infer what a person is looking at and where he or she is attending to, an important social skill that has commonly been referred to as joint attention (Argyle and Cook, 1976; Baron-Cohen, 1995a,b). 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 (Gibson and Pick, 1963), but are slightly less accurate in judging where a person is looking when gaze is directed somewhere in the environment (Symons et al., 2004; Schwaninger et al., 2005; Lobmaier et al., 2006). Different sources of information are taken into account when interpreting eye-gaze direction. One factor influencing the interpretation of eye gaze direction is emotional facial expression. In a series of recent experiments we found that people falsely interpret a happy face as directed towards them while angry, fearful or neutral faces were perceived as directed away from the observer (Lobmaier et al., 2008; Lobmaier and Perrett, 2011). In these experiments, participants were presented a series of faces showing either an

* Corresponding author. Tel.: +41 031 631 4024.
E-mail address: janek.lobmaier@psy.unibe.ch (J.S. Lobmaier).

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angry, happy, fearful or neutral expression. These faces were either looking directly at the observer, or they were rotated 2°, 4°, 6° or 8° away to the left or right. Participants were asked to decide for each face whether it was looking at them or not. Happy faces were more likely interpreted as having their gaze directed to the observer compared to angry, fearful, or neutral faces. Such a result can be interpreted in favor of a self-referential positivity bias, suggesting that healthy adults prefer to think they are the source of somebody else's happiness, in order to enhance self-esteem.

In the studies mentioned above, the observers who interpreted happy faces as more prone to be gazing at them were in an emotionally neutral state. Yet, it has been shown that participants who are in an emotional state, such as under acute stress, show altered brain activity during viewing of faces (van Marle et al., 2009; Mather et al., 2010). In addition, a study that increased stress hormone levels through pharmacological manipulation (exogeneous cortisol and reboxetine administration) found a negative response bias in the amygdala while viewing emotional faces, that is, an increase in amygdala activation in response to negative facial emotions (Kukolja et al., 2008). These findings are particularly striking given that patients with disorders associated with chronic stress and altered cortisol levels (both basally and as a response to stress) such as anxiety disorders or major depression (Gold and Chrousos, 2002; Burke et al., 2005; Southwick et al., 2005; Dedovic et al., 2010) exhibit a negative bias in their appraisal of other people and life events (Beck, 1967; Chamberlain and Sahakian, 2006). In the laboratory, a negative cognitive bias becomes evident when patients with major depression show more intense psychophysiological responses to emotionally negative stimuli and less intense responses to emotionally positive stimuli (Chamberlain and Sahakian, 2006). In addition, patients with post traumatic stress disorder, which has likewise been associated with altered cortisol levels (Yehuda, 2005), exhibit impaired recognition of negative facial expressions (Poljac et al., 2010).

Given the evidence of the influence of stress and stress-related disorders on face processing, the emotional state of an observer might not only influence the interpretation of the emotional expression of a face, but also the interpretation of where another person is looking. Possibly an observer under stress may show an altered interpretation of others' gaze direction. To date, literature investigating the influence of stress on the interpretation of gaze direction and emotional expression is scarce, however recent laboratory evidence hints towards this possibility: Participants with pharmacologically increased cortisol levels, as they typically appear under stress, show a reduced gaze cueing effect in response to fearful cue faces (Putman et al., 2010). In their study, Putman et al. (2010) orally administered 40 mg cortisol or placebo in a double-blind crossover design and asked participants to detect a target which was presented peripherally, to the left or right of a happy or fearful face. This face either gazed at the target, or looked in the other direction. After placebo, the fearful faces caused stronger orienting of attention than happy faces. After cortisol, however, this typical response pattern towards fearful faces was abolished. The authors conclude that these findings provide evidence for acute influence of cortisol on spatial threat-selective attention. While Putman et al.'s (2010) study is only remotely comparable to the present study, it is to our best knowledge the closest approximate.

The aim of the present study was to investigate whether increased cortisol levels not only affect the interpretation of another person's gaze that is directed somewhere in the environment (Putman et al., 2010), but also the interpretation whether a face is directed to oneself. Gaze is but one body cue that provides information on the direction of attention. Head orientation provides further information about where someone is attending (Perrett et al., 1992). Such head cues will have greater importance when gaze is not clear either because the eyes lie in strong shadow or because the distance is too great to resolve the eyes. In this paper we refrain from differentiating between gaze and head direction and use the word "gaze" to describe the direction of the whole face and not just the eyes (following Lobmaier et al., 2008; Lobmaier and Perrett, 2011). Derived from the findings of clinical populations, we hypothesized that under heightened cortisol levels participants will be more prone to interpret the gaze of a face to be directed to themselves when the face is of negative nature (i.e. displays an angry or fearful expression). In addition, we expected that increased cortisol levels may also alter the interpretation of gaze direction of happy faces. That is, we expected to find a decrease in the magnitude of the previously found self-referential bias for happy faces. We induced stress by means of the cold pressure stress test, where participants are asked to immerse their hand in iced water. This procedure has proved to reliably increase cortisol levels (e.g., Pascualy et al., 2000; Cahill et al., 2003)

2. Methods

2.1. Participants

The study sample consisted of 52 healthy, medication-free, non-smoking undergraduate students (20—35 years). All participants reported to have normal or used eyeglasses or contact lenses for corrected-to normal vision. Participants were ineligible if they were using medication or reported any mental or medical illness. Additional exclusion criteria included regular strenuous exercise, smoking, alcohol and illicit drug abuse, allergies, oral contraceptives, current infectious diseases and insufficient knowledge of the English language. All exclusion criteria were obtained by participants' self-report. One male and one female participant in the stress condition were excluded because they had baseline cortisol values that were more than 3 SD above the mean of all other participants' data. Since we were interested in the effect of stress-induced cortisol on gaze perception, we also excluded cortisol non-responders (those whose cortisol levels did not increase from before the cold pressor test to after the stress test, i.e. whose cortisol difference between pre- and post stress was zero or below zero, $N = 9$; 5 men and 4 women). This left a total N of 40 with 16 participants in the stress group (5 women) and 24 in the control group (12 women). The groups in this final sample did not differ in age (control group: $M = 21.17$, SD = 3.18; CPS group: $M = 20.94$, SD 3.82; $p > .83$). Female participants were asked to take part during the mid-luteal phase of their menstrual cycle, as it has been shown that women react differently to stress in