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The effects of social stress and cortisol responses on the preconscious selective attention to social threat

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Abstract

The purpose of the present study was to investigate the effects of social stress and stress-induced cortisol on the preconscious selective attention to social threat. Twenty healthy participants were administered a masked emotional Stroop task (comparing color-naming latencies for angry, neutral and happy faces) in conditions of rest and social stress. Stress was induced by means of the Trier social stress test. Based on the stress-induced increase in cortisol levels, participants were allocated post hoc (median-split) to a high and low responders group. In contrast to low responders, high responders showed a negative or avoidant attentional bias to threat (i.e. shorter latencies for angry than neutral faces) in the rest condition. Most importantly, although low responders became avoidant, the high responders became vigilant to the angry faces after stress induction. There were no such effects for happy faces. Our findings are in line with previous studies in both animals and humans, that associate high glucocorticoid stress-responsiveness with diminished avoidance and prolonged freezing reactions during stress.

Keywords: Cortisol; Avoidance; Emotional Stroop task; Masked angry faces; Trier social stress test; Selective attention

1. Introduction

Social submissiveness and avoidance in social situations is associated with hypercortisolism and increased activity of the hypothalamic pituitary adrenal (HPA)-axis in primates (e.g. Golub et al., 1979; Sapolsky, 1990; Sassenrath, 1970). In humans the relation between social avoidance tendencies and HPA-axis activity has been studied less extensively and the findings are less unequivocal. Some recent studies found significant relations between self-reports of avoidance motivation, such as low self-esteem, negative affect and social submissiveness on the one hand and elevated cortisol responses to social stress on the other hand (e.g. Gruenewald et al., 2004; Pruessner et al., 1997). Also Hessl et al. (2006) found a significant relation between gaze avoidance and cortisol responses during a social stress test in healthy children. In contrast, a study among army recruits (Hellhammer et al., 1997) demonstrated socially dominant rather than socially submissive army recruits to exhibit elevated cortisol responses to social stress. Finally, Buss et al. (2003) studied avoidance reactions (observations of fear, sadness and withdrawal) in 6-month-old infants during a social challenge task and found no relation with cortisol responses during the task. In most of these studies social avoidance tendencies were indirectly measured using self-report questionnaires of withdrawal motivation (Gruenewald et al., 2004; Pruessner et al., 1997) or using observation scales of withdrawal related affect or behavior (Buss et al., 2003; Hellhammer et al., 1997; Hessl et al., 2006). Only a few studies have addressed the relation between HPA-axis activation and social avoidance tendencies directly by means of controlled reaction time paradigms. Using such paradigm, Van Honk et al. (1998) found that the tendency to avoid social threat stimuli was associated with high basal cortisol levels. The latter authors measured the preconscious emotional response to social threat using a masked Stroop task, in which pictures of angry and neutral facial expressions were presented backwardly masked and subjects were instructed to color name the masks. In emotional Stroop tasks, attentional bias scores are calculated by subtracting the reaction times (RT) for neutral faces from those

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for angry faces. In these tasks, positive attentional bias scores (i.e. RT for angry faces is larger than RT for neutral faces) are taken to indicate vigilance, while negative attentional bias scores (i.e. RT for angry faces are shorter than RT for neutral faces) are thought to indicate avoidance (e.g. Putman et al., 2004; Van Honk et al., 1998, 2000; Mathews and MacLeod, 1994). The notions of vigilance and avoidance in the emotional Stroop task with respect to both masked and unmasked angry faces not only find support in light of correlational studies using personality questionnaires and hormone levels but is also causally supported by human studies applying hormone administration and repetitive transcranial magnetic stimulation (for reviews see: Van Honk and De Haan, 2001; Van Honk and Schutter, 2005). This task, thus, seems to provide a research paradigm for the study of human avoidance reactions and the way they are influenced by individual differences, such as differences in basal cortisol levels. However, the masked emotional Stroop task has not yet been applied in stress challenge studies that allow studying the effects of reactive cortisol levels. In the present study we applied the masked emotional Stroop test before and after a social stressor and investigated the effects of social stress and glucocorticoid stress-responsiveness on preconscious attention processing of social threat stimuli.

Although glucocorticoid stress-responsiveness has never been studied in relation to the attentional processing of *masked* social threat stimuli, it has been studied in relation to the processing of *unmasked* social threat stimuli in two recent investigations. Roelofs et al. (2005) used a manual approach–avoidance task during which subjects were instructed to evaluate the emotional valence of pictures presenting happy or angry facial expressions, by making either approaching (arm-flexion) or avoidant (arm extension) arm-movements. The manual responses were made in affect-congruent (i.e. happy face-approach; angry face-avoid) and affect-incongruent (happy face-avoid; angry face-approach) instruction conditions. Subjects were tested in a rest and social stress condition and stress was induced by the Trier social stress test (TSST: Kirschbaum et al., 1993) that is known to elicit significant cortisol responses in the majority of the subjects (Dickerson and Kemeny, 2004). Comparison of high and low cortisol-responders revealed that high responders showed larger congruency effects, involving faster avoidance reactions to angry faces in the rest condition. Most significantly, in the social stress condition the initial avoidance reactions of the high responders disappeared. Thus, subjects characterized by a high stress-responsiveness of the HPA-axis displayed relatively high avoidance tendencies in neutral circumstances but seemed to fail in their active avoidance tendencies during stress (Roelofs et al., 2005). Although this manual avoidance task offers a direct and controlled operationalization of avoidance tendencies (Rotteveel and Phaf, 2004) it remains difficult to determine whether stress and cortisol reactivity primarily affected processes involved in the response initiation, such as movement planning and preparation or also earlier processes such as attentional processing of the threat stimuli. In an attempt to shed light on this question we added an unmasked Stroop color-word task, presenting social threat, general threat and neutral words in the same experimental setup (Roelofs and Elzinga, 2005). The results again showed that the initially increased avoidance reactions of high cortisol-responders disappeared during stress and, whereas high responders became vigilant, the low responders turned avoidant during stress. Apparently it is not the cortisol response or the test context per see, but the interaction between these two factors that affected the subjects' motivated attention to social threat stimuli. These findings are in agreement with the results from animal (De Kloet et al., 1999; Okuda et al., 2004) and human (Abercrombie et al., 2006; Elzinga and Roelofs, 2005) studies, showing that cognitive changes during stress depend on an interplay between cortisol responses and the context in which they are elicited. However, the findings from unmasked Stroop test have been criticized for the fact that subjects may be able to override emotional Stroop effects (e.g. MacLeod and Hagan, 1992; Putman et al., 2004; Van den Hout et al., 1995; Van Honk et al., 1998; Williams et al., 1996). In contrast, subliminal Stroop tests using masked threat stimuli seem to provide for a more reliable index of motivated attention (Putman et al., 2004) that is less vulnerable to uncontrollable subject and task factors.

The purpose of the present study was to investigate whether the previously found interaction between social stress and glucocorticoid stress-responsiveness on avoidance behavior (Roelofs and Elzinga, 2005; Roelofs et al., 2005) would hold for the preconscious selective attention to social threat. To this end, healthy subjects were administered the masked emotional Stroop task mentioned earlier, applying angry and neutral facial expressions for stimuli. During the task, backwardly masked pictures of angry, neutral and happy faces were briefly presented. The happy faces were added to check for a possible attentional bias for emotional stimuli per se. Stress was again induced using the TSST and high and low cortisol-responders were compared with respect to their avoidance reactions in both a resting and a social stress condition.

Based on the previous findings (Roelofs and Elzinga, 2005; Roelofs et al., 2005) we expected to find a significant interaction between the test condition (rest versus stress) and the subject group (high versus low cortisol-responders) in such a way that the initially increased avoidance tendencies of high cortisol-responders would diminish under conditions of social stress.

2. Methods

2.1. Participants

We tested these hypotheses in a sample of twenty volunteers (18 females, 2 males) with a mean age of 22.1 years (S.D. = 4.2) who were originally recruited as a control group for a larger patient study addressing a different research question. Nine subjects used oral contraceptives and all except one females had registered the first day of the last menstruation allowing to calculate the current week of the menstrual cycle (week 1 ($n = 7$); week 2 ($n = 2$); week 3 ($n = 4$); week 4 ($n = 4$)).[1] The participants were recruited via advertisements and participated in the experiment for financial credit reasons. Exclusion criteria were: any psychiatric disorder on AXIS-I (DSM-IV, APA, 1994), any clinical significant medical disease, use of medication, and age <18 or >40. Partici-

[1] On average, the first two weeks of the menstrual cycle include the follicular phase followed by the ovulation and the last two weeks involve the luteal phase.