



Social cognition under stress: Differential effects of stress-induced cortisol elevations in healthy young men and women

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ABSTRACT

Humans as social beings often have to perform complex social cognitive tasks while under stress (e.g., during a social conflict). Previous research has established that the brain regions responsible for social cognitive tasks are target regions for stress hormones. However, little experimental research has been done testing the acute effects of stress on social cognition. Here, we investigated whether stress exposure and the ensuing glucocorticoid (i.e., cortisol) elevations affect social cognition. Thirty-two men and 32 women were exposed to either a psychosocial stress or a non-stressful control test before assessing their social cognition using the Reading the Mind in the Eyes Test (RMET) and the Movie for the Assessment of Social Cognition (MASC). Results showed differential effects of stress-induced cortisol responses among men and women for the MASC, but not the RMET. Among men, high cortisol responders displayed elevated MASC scores compared with low cortisol responders. Moreover, for stressed men a positive association between the magnitude of the cortisol responses to the stressor and MASC scores emerged. Among women, enhanced MASC scores were found for low cortisol responders relative to high cortisol responders and non-stressed controls. A strong negative association between cortisol reactivity and MASC scores was found among women. These results imply sex specific effects of glucocorticoids on social cognition and partially support the idea of sex differences in biobehavioral stress responses, with men engaging in fight-or-flight responses while women may react to stress with tending and befriending behavior.

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Introduction

The ability to form enduring social relationships permeates human society and in large part is dependent on individuals' social cognition. Social cognition refers to the mental operations that underlie social interactions and includes the ability to attribute mental states (e.g., emotions, thoughts, intentions) to oneself and others. A key brain structure implicated in successful social cognition is the prefrontal cortex (PFC) (for review, see Gallagher and Frith, 2003; Olsson and Ochsner, 2008; Singer, 2006). Aside from being implicated in social cognition, the PFC is also concerned with the feedback regulation of the stress responsive hypothalamic-pituitary-adrenal (HPA) axis (e.g., de Kloet et al., 1998). Of course, there is abundant evidence that the secretion of glucocorticoid (GC) stress hormones (e.g., cortisol; CORT) may modulate memory functioning (e.g., de Kloet et al., 1999; McGaugh and Roozendaal, 2002; Wolf, 2008). However, despite vigorous research of the past decades, only very few studies have focused on social aspects of information processing.

Meanwhile, there is considerable evidence suggesting that the effects of stress-induced CORT elevations on memory performance may be moderated by sex differences (e.g., Andreano and Cahill, 2006; Wolf et al., 2001). For example, Wolf et al. (2001) found that within a group of young adults exposed to the Trier Social Stress Test (TSST; Kirschbaum et al., 1993), CORT increases displayed a strong and negative correlation with memory retrieval performance in men, while no such correlation was found among women. Similarly, Andreano and Cahill (2006) demonstrated that low, but not high, CORT responses to stress enhanced memory consolidation and that this effect was restricted to male participants. In line with the results of Andreano and Cahill (2006), a number of studies (e.g., Buchanan and Tranel, 2008; Nater et al., 2007) have shown that memory modulation following stress exposure may depend on the magnitude of the CORT response.

In relation to this, it has been proposed that the biobehavioral response to stress differs between men and women (Taylor et al., 2000). Traditionally, the primary human stress response has been characterized as a "fight-or-flight" response. According to Taylor and colleagues, men and women share this fight-or-flight response on the physiological level, yet they differ in their behavioral stress response. Specifically, Taylor et al. (2000) suggest that, depending on the nature of the stressor, men either fight or flee. Women, on the other hand,

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engage in a so-called “tend-and-befriend” behavioral stress response. Here, tending refers to nurturing activities that are adaptive when the offspring is nearby, while befriending refers to the construction and maintenance of social relationships to alleviate stress. This latter issue points to the distinct possibility that in times of stress, women might show enhanced social cognition.

With this in mind, the current study was set out to determine whether stress-induced CORT elevations would yield sex-specific effects on one of the most important types of human social cognition, namely the ability to attribute internal states to oneself or others based on external cues (e.g., facial expressions, speech).

Materials and methods

Participants

Thirty-two male and 32 female undergraduates with a mean age of 25.89 years ($SD=4.33$) participated in the current study. Suffering from cardiovascular diseases, severe physical illnesses (e.g., fibromyalgia), hypertension, endocrine disorders, substance abuse, heavy smoking (>10 cigarettes/day) or being on any kind of medication served as exclusion criteria. Women using oral contraceptives were also excluded from participation. Test protocols were approved by the national ethic committee of the German Psychology Association (DGPs). All participants signed a written informed consent and were given a small financial compensation (20€; approximately 30\$) in return for their participation.

Materials

Autism Spectrum Quotient (AQ)

The Autism Spectrum Quotient (Baron-Cohen et al., 2001a) is a self-report questionnaire measuring the degree to which an adult of normal IQ possesses traits related to the autistic spectrum. Scores range from 0 to 50, with higher scores indicating more autistic traits. In the present study, the AQ served to evaluate potential group differences in subclinical autistic symptomatology that may affect social cognition.

Negative affect

Negative affective experiences following the stress or control task were measured using the Positive and Negative Affect Schedule state version (PANAS; Watson et al., 1988). The PANAS is a sound psychometric tool (Watson et al., 1988; see also Crawford and Henry, 2004) consisting of two subscales that quantify positive affect (PA) and negative affect (NA). The NA subscale comprises 10 items for which respondents indicate on a 5-point scale (anchors: 1=very slightly or not at all; 5=extremely) the extent to which certain feelings and emotions apply to them. Higher scores are indicative of higher levels of experienced negative affect. In the current study, the NA subscale was administered at baseline and immediately after the TSST or control task.

Reading the Mind in the Eyes Test – Revised (RMET-R)

The Reading the Mind in the Eyes Test – Revised version (Baron-Cohen et al., 2001b) measures the performance of inferring mental states of individuals using only the information conveyed in those individuals' eyes. For each of the 36 sets of eyes that were shown, participants were instructed to choose one out of four mental state descriptors. To control for general deficits in face recognition, participants were also asked to indicate the sex of the individual in the picture.

Movie for the Assessment of Social Cognition – Multiple Choice version (MASC-MC)

To assess social cognitive competence the Movie for the Assessment of Social Cognition (MASC; Dziobek et al., 2006a) was used. The

MASC is a computerized test for the assessment of mindreading abilities that approximates the demands of everyday life. It involves watching a 15 min film about four characters getting together for a dinner party and it requires subjects to make inferences about the featured characters' mental states. The film is stopped at 45 points during the plot and questions referring to the characters' feelings, thoughts, and intentions are asked (e.g., “What is Betty feeling?”, “What is Cliff thinking?”). Participants' correct responses are scored as one point and added to an overall score. In addition, the MASC allows separate quantification of the extent to which emotional mental states (EMS; e.g., anger, disappointment) and non-emotional mental states (non-EMS; e.g., thoughts, action plans) are inferred correctly (Dziobek et al., 2006b). Moreover, it allows separate quantification of individuals' tendency (i) to make overly complex inferences based on social cues that result in errors (OCI_{error}), i.e., to over-interpret social signs, (ii) to make overly simplistic inferences (OSI_{error}), i.e., to under-interpret social signals, and (iii) to not make any inferences at all from social cues (NI_{error}). We used the multiple-choice version of the MASC that offers four options for each query (MASC-MC; Fleck et al., 2006). The MASC is a reliable instrument that has proven sensitive in detecting even subtle mindreading difficulties in individuals of normal IQ (Dziobek et al., 2006a).

Stress manipulation

The Trier Social Stress Test (Kirschbaum et al., 1993) is a psychosocial challenge test consisting of a preparation period, a free speech, and a mental arithmetic task in front of an audience while being videotaped. The TSST is a valid and reliable procedure to induce physiological stress responses in children and young as well as elderly adults (e.g., Kirschbaum et al., 1992; Kudielka et al., 2004a,b). The TSST was found to provoke the most robust CORT stress responses relative to various other laboratory stress tasks (Dickerson and Kemeny, 2004).

Design and procedure

A 2 (Group: stress vs. control) \times 2 (Sex: men vs. women) between-subject design was employed. Specifically, the 32 male and 32 female participants were randomly assigned to a psychosocial stress or a no-stress control group. Participants were tested in sessions run between 09 h and 11 h. To allow for controlled saliva collection participants were asked not to brush their teeth and were deprived of food, drinks, and heavy exercise at least 1 h prior to the test phase. During the first 35 min after arrival in the laboratory, participants were informed about the TSST and social cognition tests, gave written informed consent, and completed the AQ and PANAS NA. The stress group was subsequently exposed to the TSST (cf. supra) while the no-stress control group completed a non-stressful control task of equal duration (i.e., delivering a speech and performing an undemanding counting task by themselves in an otherwise empty room; see Kuhlmann et al., 2005; Schoofs et al., 2008). Immediately following TSST or control task, participants completed the PANAS NA a second time and were subsequently exposed to the RMET-R and MASC-MC. Finally, participants were debriefed, paid, and thanked for their participation. Fig. 1 summarizes the timeline of the experimental protocol.

Saliva sampling and biochemical analyses

CORT was measured in response to the TSST as a measure of activity of the stress-responsive HPA-axis. CORT data were obtained with cotton Salivette (Sarstedt®, Etten-Leur, the Netherlands) devices over a 65 min period at four assessment points: $t-5$ (baseline), $t+20$, $t+30$ and $t+60$ min with reference to the start of the stressor. The saliva samples were stored at -20 °C immediately on collection. Free CORT levels were determined by a commercially available

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