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The effects of stress-induced cortisol responses on approach-avoidance behavior

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Summary High glucocorticoid stress-responses are associated with prolonged freezing reactions and decreased active approach and avoidance behavior in animals. The present study was designed to investigate the effects of cortisol responses and trait avoidance on approach-avoidance behavior in humans. Twenty individuals were administered a computerized approach-avoidance (AA)-task before and after stress-induction (Trier Social Stress Test). The AA-task involved a reaction time (RT) task, in which participants made affect congruent and affect incongruent arm movements towards positive and threatening social stimuli. Affect congruent responses involved arm extension (avoidance) in response to angry faces and arm flexion (approach) in response to happy faces. Reversed responses were made in affect incongruent instruction conditions. As expected, participants with high cortisol responses showed significantly decreased RT congruency-effects in a context of social stress. Low trait avoidance was also associated with diminished congruency-effects during stress. However, the latter effect disappeared after controlling for the effects of cortisol. In sum, in agreement with animal research, these data suggest that high cortisol responses are associated with a decrease in active approach-avoidance behavior during stress. These findings may have important implications for the study of freezing and avoidance reactions in patients with anxiety disorders, such as social phobia and post-traumatic stress disorder.

1. Introduction

Emotions and affective evaluations are assumed to play an important role in preparing the individual for appropriate actions (Darwin, 1872/1998; Lang et al., 1990). These actions are proposed to be organized by at least two different motivational systems that enable approach or avoidance behavior (Bargh, 1997; Cacioppo et al., 1993; Chen and Bargh, 1999; Davidson et al., 1990; Gray, 1994; Lang et al., 1990). In general, people tend to approach positively evaluated stimuli and to avoid negatively

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evaluated ones (Chen and Bargh, 1999; Rotteveel and Phaf, 2004; Solarz, 1960). Extensive animal studies have shown that approach and avoidance behavior is influenced by stress and stress-induced cortisol responses. However, in humans, the effects of these factors on approach–avoidance tendencies remain largely unexplored.

A relatively direct method to study approach-avoidance (AA) tendencies in humans is offered by reaction time (RT) paradigms, in which individuals evaluate the emotional valence of affective stimuli by making arm movements that are either congruent or incongruent with their action tendencies. For affect congruent arm movements participants are, for example, instructed to evaluate a stimulus as negative by pushing a response lever away (arm extension) and to evaluate a stimulus as positive by pulling the lever towards them (arm flexion). For affect incongruent actions, participants receive the opposite instruction. Using such an AA-task, Chen and Bargh (1999) and Solarz (1960) compared RTs for affect congruent and affect incongruent movements to positive and negative word stimuli and found faster responses for the affect congruent arm movements. Rotteveel and Phaf (2004) replicated these basic congruency-effects using pictures of happy and angry faces as positive and threatening stimuli, respectively.

In daily life, fast avoidance of a threatening stimulus is of particular importance when the stimulus information is relevant to its present context. Following this line of reasoning, one would predict faster avoidance responses towards angry facial expressions within a context of social stress than without such context. However, action tendencies such as those measured by the above-described AA-task have not been studied in relation to a task-relevant context yet. With the present study, we aim to examine AA-related action tendencies to happy and angry faces in the context of a social stressor. In the first place we will study the direct influence of stress on AA-action tendencies. Second, we will focus on the influence of individual differences in glucocorticoid stress-responses and trait avoidance on AA action tendencies.

Several studies have shown that the prefrontal cortex (PFC) plays an important role in the generation of approach and avoidance behavior. In general, affect related approach and avoidance reactions are associated with increased activity in the left and right prefrontal cortex (PFC), respectively (Davidson, 1992, 1995 for reviews). Although most hemispheric lateralization studies have been focused on the differentiation between approach and avoidance related affect (positive and negative affect, respectively) a few recent studies have more directly addressed the tendencies to generate approaching or avoiding actions towards external stimuli. Sutton and Davidson (1997), for example, found participants with greater resting activation of the right PFC to show higher scores on a self report scale measuring behavioral inhibition (avoidance) tendencies (BIS: Carver and White, 1994) and those with greater relative left PFC activation to score higher on measures of behavioral approach tendencies (BAS: Carver and White, 1994). Other support for the involvement of the PFC in the performance of approach and avoidance behavior in humans is offered by a study by D'Alfonso et al. (2000), showing low frequency repetitive transcranial magnetic stimulation (rTMS) over left PFC to result in increased avoidance of (i.e. selective attention away from) angry faces, whereas rTMS over right PFC resulted in increased approach of (i.e. selective attention towards) angry faces.

There is increasing evidence from animal studies that the relation between threat and PFC mediated approach and avoidance behavior may be influenced by activity of the Hypothalamic–Pituitary–Adrenal (HPA) axis, an important stress system resulting in the release of the stress-hormone cortisol. Primates with extreme asymmetric right-sided prefrontal activation have been found to show higher basal levels of cortisol (Kalin et al., 1998a) and higher cerebrospinal fluid levels of corticotrophin-releasing hormone (Kalin et al., 2000). In addition, high basal and reactive cortisol levels were found to be associated with increased freezing and diminished active approach and avoidance reactions to stress-stimuli in primates (Kalin et al., 1998b) and rats (Nunez et al., 1996). The PFC is indeed found to be a significant target for glucocorticoids involved in the stress response (e.g. Meaney and Aitken, 1985; Radley et al., 2004; Sanchez et al., 2000). Lyons et al. (2000), for example, found impairments in prefrontal inhibitory control of behavior in primates after prolonged exposure to stress-levels of cortisol. Also studies among healthy young men showed pharmacologically administered cortisol to impair prefrontal functions, such as working memory (Lupien et al., 1999; Wolf et al., 2001; Young et al., 1999). However, to our knowledge, only one human study directly addressed the relation between cortisol and prefrontal mediated approach and avoidance behavior. Buss et al. (2003) found that 6-months old infants, who showed relatively increased basal and reactive cortisol levels, demonstrated more avoidance behavior when faced with approaching strangers. The elevated cortisol levels and avoidance behavior were, moreover, associated with