



The physiological response to Trier Social Stress Test relates to subjective measures of stress during but not before or after the test

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Summary The Trier Social Stress Test (TSST) is an effective psychosocial laboratory protocol for inducing stress in humans and has been used in numerous research studies. The stressor leads to a physiological response of the hypothalamus–pituitary–adrenal axis (HPAA) and the autonomous nervous system (ANS). Common biomarkers are cortisol levels and heart rate. In addition to the physiological stress response, the TSST also triggers a psychological response such as an increase in perceived stress, anxiety and emotional insecurity. Whereas HPA and ANS measures can easily be obtained for the TSST period itself, psychological measures are usually determined prior to (baseline) and after the TSST. This may exclude information of the stressful event itself. In the present study, we assessed perceived stress, anxiety and emotional insecurity before, during and after the TSST using visual analogue scales. In addition, cortisol levels and heart rates were assessed. Data of 260 healthy non-smoking males aged 16–60 yrs were used for analyses. Our results show that stress perception, anxiety and emotional insecurity were significantly higher during the TSST as compared to post-TSST ratings. Furthermore, our results suggest a covariance of the psychological stress response during the TSST and the physiological stress responses (cortisol and heart rate) for stress perception though the explained variance was small. This observation was not found for pre- and post-TSST ratings suggesting that assessing psychological stress measures during the stressor itself present a more informative measure of the stress response.

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1. Introduction

Stress is an individual adaptive process to external and internal challenges that is regulated on the systemic and

cellular level (Selye, 1950; Mason, 1968). Acute stress responses can be induced experimentally by exposing individuals to uncontrollable situations that constitute social-evaluative threat (Dickerson and Kemeny, 2004), such as in the Trier Social Stress Test (TSST, Kirschbaum et al., 1993).

Response mechanisms to stress involve physiological stress responses of the autonomous nervous system (ANS) and the hypothalamus–pituitary–adrenal axis (HPAA). For instance, acute stress induces elevated cortisol levels via the release of corticotropin-releasing hormone from the hypothalamus and

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adrenocorticotrophic hormone from the pituitary. Cortisol has a multitude of complex actions, such as mediating effects on the metabolism and immune system that protect individuals from challenges to homeostasis (reviewed in Sapolsky et al., 2000).

In addition to the physiological stress response, stress also triggers a psychological response (Finan et al., 2011). Acute exposure to a stressor leads to adaptive processes including the regulation of emotions and the display of behavioural responses. These adaptations are essential for coping with stressors and may vary inter-individually mediating positive or negative emotional outcomes (Lazarus, 1993). Coping with stressful situations requires a persons' subjective appraisal and reappraisal (Lazarus, 1999; Gross, 2001). Therefore, emotions or their intensity can change within seconds which may ultimately result in the expression of a different psychological response by showing either other emotions or emotions with increased, respectively decreased intensity.

Some evidence for an association between the psychological and physiological stress response has been found for stressful events in daily life (van Eck et al., 1996; Schlotz et al., 2006) as well as under experimental conditions (Al'Absi et al., 1997; Cohen et al., 2000; Cohen and Hamrick, 2003; Hall et al., 2004; Schlotz et al., 2008; Oldehinkel et al., 2010; Waugh et al., 2010). This includes interrelations of the ANS and the HPA with subjectively experienced emotions and personality traits. For instance, Al'Absi et al. (1997) reported that increased negative mood was correlated with cardiovascular and endocrine stress responses during a public speaking task. Similar results were obtained by Schlotz et al. (2008) and Oldehinkel et al. (2010) who found an association between the psychological and the physiological stress response by exposing subjects to the TSST.

In contrast, other researchers failed to demonstrate a convergence between the psychological and physiological stress response (Semple et al., 1988; Schedlowski et al., 1992; Cohen et al., 2000; Hjortskov et al., 2004). The reason may be an imperfect coupling among these complex interacting systems (Lacey, 1967; Hellhammer et al., 2010), calling for a revision of stress concepts including multimodal approaches and assessments of the psychological and physiological stress response.

The psychological stress response of individuals is often assessed by using visual analogue scales (VAS, Aitken, 1969; Bond and Lader, 1974). The subjective perception of the stressfulness of a stressor can be determined by assessing several emotional states on VAS such as stress perception, anxiety, calmness, controllability and predictability of the stressor as well as the anticipation of negative consequences (Kirschbaum et al., 1999; Kudielka et al., 2004; Childs et al., 2006; Kelly et al., 2008; Oldehinkel et al., 2010). However, assessments of the psychological stress response with VAS often differ with regard to time of data collection. Some researchers determined self-reported ratings of the emotional state only after cessation of the TSST. For instance perceived stress was assessed in male and female individuals after TSST exposure (Kudielka et al., 2004). Other workgroups collected information prior to the TSST for identifying baseline levels as well as during several time points after the TSST. Kelly et al. (2008) assessed calmness, fear, happiness and irritability before, immediately after the TSST and 45 min later. Whereas calmness was decreased and irritabil-

ity slightly increased immediately after the TSST, almost no changes occurred in subjective ratings of fear and happiness in males. Furthermore, Childs et al. (2006) collected ratings of male and female subjects regarding anxiety, uneasiness, jitteriness and calmness before, immediately after cessation of the TSST as well as 5, 25 and 55 min later. As a result anxiety, uneasiness and jitteriness were increased and calmness was decreased immediately after the TSST. Moreover, both studies show that the emotional state of subjects improved again when comparing the results obtained immediately after the TSST with those collected some time later indicating a return to the homeostasis. However, one may ask whether ratings determined immediately after the TSST present already lowered values. In other words, the question is, if subjects would report higher ratings of a specific characteristic (e.g. stress perception) during the stressor than immediately after stress test cessation.

In the present study, we investigated the physiological and psychological stress response in healthy non-smoking males by measuring stress perception, anxiety and emotional insecurity before, during and immediately after the TSST. In addition, cortisol levels and heart rates were verified. The main aim of the analysis was to compare psychological measures with respect to time of assessment, i.e. baseline, during and after stressor exposure. In addition, we explored associations between the psychological and physiological stress response.

2. Methods

2.1. Subjects

Analyses were performed using data of healthy males from 9 different studies conducted by daacro, a contract research organisation, between June 2007 and June 2010. Studies were randomised, blinded and placebo controlled. Whereas 6 of these studies investigated emotional sweating, the effectiveness of a particular nutrient was determined in the remaining 3 studies; results of 2 studies were published (Schult et al., 2010; Martin et al., 2011). For the present analyses we included only data of subjects who received a placebo.

Study procedures were carried out with adequate understanding and written consent of all subjects. Only healthy non-smoking males were admitted for study participation. Health state, i.e. past and current health problems, was verified by a physician during a medical examination. Subjects suffering from psychiatric, endocrine, cardiovascular or other chronic diseases were excluded from study participation. Study protocols were all in accordance with the Declaration of Helsinki and approved by the Independent Ethics Committee (IEC) of the Medical Association Rhineland-Palatinate, Germany. Data of 260 healthy non-smoking males were used for the analyses. Demography is presented in Table 1.

2.2. Procedure

All subjects participated in the TSST between 2 and 6 pm. The TSST consists of an interview and an arithmetic task. For determining the subjective perception of the stressfulness of the TSST anxiety, emotional insecurity and stress perception were determined. Therefore, subjects were asked to rate

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