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Effects of two dominance manipulations on the stress response: Cognitive and embodied influences

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A B S T R A C T

In response to stress, physiological and mental resources are allocated towards those systems that are needed for rapid responding in terms of fight or flight. On the other hand, long term regenerative processes such as growth, digestion and reproduction are attenuated. Levels of the sex steroid testosterone are reduced in participants that suffer from chronic stress. However, beyond its role for reproductive functions, testosterone plays an important role in the regulation of social status and dominance, testosterone levels increase during competition or when the social status is challenged. The Trier Social Stress Test (TSST), a laboratory stressor with a substantial social-evaluative component, can provoke an increase in salivary testosterone levels. Still, so far the reported findings regarding acute stress effects on testosterone are equivocal, possibly due to moderating effects. In this study we experimentally manipulated social dominance in 56 healthy participants (28m) by two independent manipulations (body posture and cognitive role taking) and subjected them to the TSST. We analyzed salivary testosterone and cortisol levels as dependent measures for the endocrine stress response. The role taking manipulation interacted with the testosterone response: we found the strongest increase when participants had to put themselves in a dominant (vs. submissive) role. Our results suggest that transient changes in testosterone levels during stress reflect a response to status threat that is affected by social dominance.

1. Introduction

Acute stress provokes an immediate behavioral response to cope with a threatening situation; the need to confront the potential threat requires a shift in several processes that facilitate this response. Both, physiological and psychological resources are allocated towards those systems that are necessary to adaptively adjust behavior in terms of a quick flight-or-fight response (Hermans, Henckens, Joels, & Fernandez, 2014). On the other hand, rather long-term, regenerative functions such as growth, metabolism, immune function – but also reproduction are down-regulated (Chrousos, 2009). These coordinated processes, conceptualized as the stress response, are primarily regulated by the catecholamine system and the hypothalamic–pituitary–adrenal (HPA-) axis, with the downstream "stress hormone" cortisol being released into the bloodstream within a few minutes after the stressor (de Kloet, Joels, & Holsboer, 2005). Beyond these main stress regulation systems, the hypothalamic–pituitary–gonadal (HPG-) axis is involved in the stress response (Chichinadze & Chichinadze, 2008). Testosterone, as the primary androgen of the HPG-axis, is secreted by the gonads and, to a lesser degree, the adrenal gland. It acts as a sex hormone in the regulation of the reproductive function in men (Isidori et al., 2005) and women (van Anders, Hamilton, Schmidt, & Watson, 2007). In general, an antagonistic relationship is assumed between the HPA and the HPG. After chronic stress, the secretion of testosterone is reduced (Chichinadze & Chichinadze, 2008). This finding corresponds to the diminished sexual desire and appetence behavior often observed after stress and fits well to the attenuation of less urgent biological functions.

Transient testosterone changes also play a role in other social contexts, especially those involving competition for resources (such as sexual opportunities) and challenges to social rank or status (Gleason, Fuxjager, Oyegbile, & Marler, 2009; van Anders, 2013). From an evolutionary perspective, options for mating are a scarce resource under harsh competition. Social status grants access to potential mates; however, it is hard to obtain (von Rueden, Gurven, & Kaplan, 2011). Again, testosterone is associated with social status and dominance: threats to social status or competitive situations

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in which status can be gained or lost are accompanied by a rise in testosterone levels (Eisenegger, Haushofer, & Fehr, 2011), an effect that could be demonstrated in men and women (Jimenez, Aguilar, & Alvero-Cruz, 2012). This might explain why recent studies reported an increase in salivary testosterone levels following acute stress exposure: those studies employed a social stressor, i.e. the participant is put in a situation in which she/he is critically evaluated by others – allegedly high status – individuals (Lennartsson, Kushnir, Bergquist, Billig, & Jonsdottir, 2012). However, the findings regarding stress-induced testosterone effects remain ambiguous (Schoofs & Wolf, 2011). This might suggest a potential mediation of the effect by an intervening variable, with social dominance as a prime candidate. Stress can play a crucial role in the maintenance of social hierarchies(Timmer & Sandi, 2010), the response to stress is affected by social status (Massey, Byrd-Craven, Auer, & Swearingen, 2014). Cortisol responses after a status contest were associated with dominance disposition in humans: individuals with high power motivation had increased cortisol after losing the contest, while this relationship was reversed for success. This finding not only suggests the stressfulness of social defeat for those striving for dominance, but also that winning a status competition is stressful for subordinate individuals (Wirth, Welsh, & Schultheiss, 2006).

With our study we planned to assess the role of experimentally induced variations in social dominance on the stress-induced testosterone response. Social dominance can be influenced by cognitive appraisal and by embodied processes. Research on social power and dominance has traditionally relied on cognitive methods such as the assignment to powerful roles: imagining or recalling a situation in which they had power over others alters the participants subsequent behavior (Galinsky, Gruenfeld, & Magee, 2003). However, recent studies could demonstrate effects of embodiment manipulations such as arm movements (Deuter, Best, Kuehl, Neumann, & Schachinger, 2014) and body posture (Harmon-Jones & Peterson, 2009) on emotional and motivational processes, potentially via somatosensory feedback (Price, Peterson, & Harmon-Jones, 2012). For instance, increased testosterone levels were reported after participants had to assume dominant and assertive vs. submissive postures (Carney, Cuddy, & Yap, 2010).

However, few studies so far have integrated both approaches to dominance in one design. Huang, Galinsky, Gruenfeld, & Guillory (2011) addressed the question of their relative contribution by combining a cognitive as well as an "embodied", physical task. With both factors usually combined in real live, their aim was to independently assess the impact of both, "role power" and "embodied power": was there an effect of consistency between both or do they independently act on separate pathways? Interestingly, the authors reported stronger effects of the cognitive manipulation on self-report while behavioral measures were stronger affected by a posture manipulation, with no interaction between both. Still, this study did not assess any physiological parameters. Therefore, we implemented a combined approach of a cognitive and an embodiment intervention to investigate the effects of dominance on the human stress response, with a focus on the "social" hormone testosterone. Whether there would be independent or interactive contributions of cognitive and embodied influences on testosterone is interesting from different research perspectives on stress that investigate each influence in isolation.

In this study, we experimentally manipulated social dominance as a state variable in a healthy, mixed-gender sample and assessed the salivary testosterone and cortisol response after the TSST, a well-established, standardized protocol for the induction of social stress (Kirschbaum, Pirke, & Hellhammer, 1993). Each participant was subjected to a role-taking task derived from Galinsky et al. (2003) and a body posture manipulation adapted from Carney et al. (2010), in both the participant was independently assigned to either a dominant or submissive condition.

We hypothesized that participants in dominant conditions have increased testosterone responses after the TSST, compared to submissive conditions. Since previous studies reported rather quick and short-lived effects of psychological interventions on the HPG-axis, we specifically expected effects immediately after the stress exposure, at an interval of 15 min after TSST-onset (Hellhammer, Hubert, & Schurmeyer, 1985; Lennartsson et al., 2012). Furthermore, we hypothesized that embodied and cognitive influences on social dominance to be partially independent (Huang et al., 2011), the strongest increase of the testosterone response should be obtained when participants had to put themselves in a dominant (vs. submissive) role and adopted a dominant posture during stress exposure. In addition, we included 'sex' as a factor in our analysis to control for sex effects. However, we had no directed hypothesis for any modulating role of this factor in regard to our dominance manipulation.

2. Methods

2.1. Participants

Fifty-six (28f/28m, age between 18 and 40 years) undergraduate students, recruited at the University of Trier, participated in the study. The gender ratio was balanced for each condition.

All participants were free from any neurological, psychiatric or psychological disorders, acute or persistent medical disease and current medication. Female participants were in the luteal cycle phase and/or took oral contraception (without chlormadinone, drospirenone or others with anti-mineralocorticoid properties). All participants were non-smokers, and of normal body weight (body mass index ranging from 18.5 to 25) (see Table 1).

Participants received a monetary compensation. Study procedures were approved by the institutional review board, and the participants signed a written informed consent.

2.2. Procedure

Experiments were conducted in the afternoon between 2 and 6 p.m. Participants were told beforehand to refrain from alcohol, caffeine and sports on the day of the experiment.

Upon arrival, the participant was given an information sheet which she/he had to sign for consent. Immediately thereafter, the first baseline saliva sample was obtained. The experimenter interviewed the participant for personal data and potential medical problems. Afterwards, the participant had to complete the role taking task (see below), for which she/he was randomly assigned to either the high or low dominance condition. This task required the participant to write down an autobiographical story on a provided sheet of paper. After five minutes, the participant had to quit the task and was instructed by the experimenter with a cover story for the upcoming posture manipulation (adopted from Carney et al., 2010): "In the following experiment we measure your body signals. We will ask you to assume a posture that will be demonstrated to you. Please hold this posture until further notice and refrain from any movements since this would compromise our recording." In accordance with Carney et al. (2010), we attached a mobile ECG device to increase the credibility of the cover story.

The participant was guided to another room to perform the TSST according to the protocol. Following the TSST, the experimenter picked the participant up and brought him back to the adjoining room. He obtained another saliva sample (which was followed by three more samples at intervals of 15 min). After receiving his