Psychoneuroendocrinology 63 (2016) 119–127

Contents lists available at ScienceDirect

Psychoneuroendocrinology

journal homepage: www.elsevier.com/locate/psyneuen

Stress responses to repeated exposure to a combined physical and social evaluative laboratory stressor in young healthy males

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ARTICLE INFO

Article history:
Received 9 July 2015
Received in revised form
22 September 2015
Accepted 22 September 2015

Keywords:
Cortisol
Habituation
Social evaluative threat
Stress induction
Laboratory stress

ABSTRACT

Repeated exposure to homotypic laboratory psychosocial stressors typically instigates rapid habituation in hypothalamic–pituitary–adrenal (HPA) axis-mediated stress responses in humans. However, emerging evidence suggests the combination of physical stress and social evaluative threat may be sufficient to attenuate this response habituation. Neuroendocrine, cardiovascular and subjective stress responses following repeated exposure to a combined physical and social evaluative stress protocol were assessed to examine the habituation response dynamic in this context.

The speech task of the Trier social stress test (TSST; Kirschbaum et al., 1993) and the socially evaluated cold pressor task (SECPT; Schwabe et al., 2008) were administered in a combined stressor protocol. Salivary cortisol, cardiovascular and subjective stress responses to a non-stress control and repeat stressor exposure separated by six weeks were examined in males ($N = 24$) in a crossover manner.

Stressor exposure resulted in significant elevations in all stress parameters. In contrast to the commonly reported habituation in cortisol response, a comparable post-stress response was demonstrated. Cortisol, heart rate and subjective stress responses were also characterised by a heightened response in anticipation to repeated stress exposure. Blood pressure responses were comparatively uniform across repeated exposures. Findings suggest a combined physical and social evaluative stressor is a potentially useful method for study designs that require repeated presentation of a homotypic stressor.

1. Introduction

Rapid habituation of response to stress is a frequently reported characteristic of the HPA axis. The cortisol response in humans has been shown to rapidly habituate in a number of stress contexts including repeated parachute jumps (Deinzer et al., 1997) and following repeated exposure to psychosocial stress protocols (Federenko et al., 2004; Gerra et al., 2001; Jonsson et al., 2010; Kirschbaum et al., 1995; Schommer et al., 2003). Response habituation to psychosocial stress is often specific to the HPA axis. Biomarkers of sympathetic activation (e.g., epinephrine [EPI], norepinephrine [NE], blood pressure [BP]) tend to show comparatively uniform activation patterns across repeated stress exposures (Gerra et al., 2001; Mischler et al., 2005; Schommer et al., 2003; von Kanel et al., 2006; von Kanel et al., 2004).

Rodent models suggest the HPA axis predominantly habituates to processive (psychological) stressors. Comparatively less habituation to physiological stressors comprising a proximate physical threat is demonstrated (Grissom and Bhatnagar, 2009). Indeed, different neural pathways may underpin the HPA axis response to processive and physiological stressors. Processive stressors primarily activate the paraventricular nucleus (PVN) of the hypothalamus via limbic pathways. Conversely, rapid activation of the PVN via the brainstem nuclei, without significant activation of limbic circuitry, has been demonstrated to underpin responses to physical stressors (Emmert and Herman, 1999).

A combined physical (cold pressor task) and social evaluative (speech task) stressor has been employed without significant habituation in cortisol response (Prof. Sheila West; personal communication). A lack of significant habituation in cortisol response following repeated exposure to a physical stressor combined with elements of social evaluative threat (the socially evaluated cold pressor test [SECPT]) has also recently been reported (Minkley et al., 2014). Thus the combination of social evaluation and a physical

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http://dx.doi.org/10.1016/j.psyneuen.2015.09.025
0306-4530/

stressor may be a promising method for reducing habituation to repeated stress induction. A stress protocol suitable for repeated application without significant habituation in HPA axis activation would be a useful methodological tool. Significant habituation results in difficulties separating the effect of stress from response habituation when interventions are assessed under repeated exposures.

Whilst Minkley et al. (2014) have demonstrated no cortisol habituation to the SECPT, a more complete measurement of the habituation response is required since Minkley et al. collected only two salivary cortisol samples. Further, the short and variable duration of the SECPT, determined by the length of time the hand is retained in an ice bath (0–3 min), results in cardiovascular and subjective stress responses that are limited to the duration of stressor (Giles et al., 2014), and are fully extinguished by the cortisol response peak (21–40 min post-stress onset; Dickerson and Kemeny, 2002). In comparison to the SECPT, more prolonged stress responses are elicited by social-evaluative speech tasks (TSST; Giles et al., 2014). Therefore, the addition of a speech task to the SECPT may ensure a more sustained cardiovascular and subjective stress response. A stressor capable of sustaining concurrent responses post-stress exposure has greater utility for studies examining the impact of stress on dependent variables. For example, the effects of stress on cognitive performance are often only observed during synergistic cortisol and sympathetic activation (Elzinga and Roelofs, 2005; Kuhlmann and Wolf, 2006); a relationship that would be difficult to examine using the SECPT. This paper reports the neuroendocrine, cardiovascular and subjective responses following repeated exposure to a combined physical and social evaluative laboratory stressor. The combination of a social-evaluative speech task and the SECPT was expected to elicit robust and enduring cortisol stress response over repeated exposures.

2. Methods

2.1. Sample

Twenty-five medication-free, non-smoking males aged 19–32 years ($\bar{x}$ = 21.83, SD = 3.55) with a normal body mass index ($\bar{x}$ = 22.36, SD = 1.79 kg/m^2) were recruited via email and poster advertisements around the University campus and local community. Exclusion criteria included endocrine, cardiovascular, or other chronic diseases (ascertained using a health screening questionnaire), smokers, BMI >30 kg/m^2, current psychological affective/mood disorders (assessed by the Hospital Anxiety and Depression Scale [HADS]; Zigmond and Snaith (1983); score on either scale >8 excluded as potential 'caseness'; Bjelland et al., 2002), and night shift work. Previous experience of a stress induction protocol was also an exclusion criterion.

2.2. Design

The study conformed to a repeated measures, crossover design comprising an initial counterbalanced control and stress visit in week one (separated by no more than three days), and a repeat stress visit after a six weeks delay. Stress visit 1 and the non-stress control day were counterbalanced to account for potential practise and order effects influencing performance on cognitive tasks. Participants completed three short, low demand cognitive tasks (2 back, Ospan, and an attention-switching task) post-stress in between measurement collection time points +20 and +40 min (not reported here). Stress visit 2 was completed six weeks (±2 days) after completion of stress visit 1. The study was approved by the University of Leeds' School of Psychology Research Ethics Committee and undertaken in accordance with the principles expressed in the Declaration of Helsinki (World Medical, 2013). An honorarium of £40 was paid upon completion of the study. All participants provided written informed consent prior to participation.

2.3. Procedure

All participants were exposed to the protocol between 1200 h and 1600 h to account for diurnal variation in endogenous cortisol levels. A procedural timeline is shown in Fig. 1. Participants were asked to refrain from exhaustive exercise, consuming large meals or caffeinated/low pH drinks, and brushing their teeth at least 1 h prior to testing. Upon arrival a standardised meal and glass of water were consumed. Following a 1 h relaxation period, cardiovascular, endocrine and subjective measures were taken at regular intervals pre-, mid- and post-stress exposure (see Fig. 1 for measurement timings). Measures collected during the control visit were time-matched to those collected during stress visits. For the control visit, participants were instructed to walk to the stress induction room and back to match the physical exertion of stress sessions and relaxed in the test cubicle for thereafter.

A partial debrief was given to participants following the completion of stress visit 1 explaining that none of the 'recorded' data would be analysed until completion of stress visit 2. A full debrief was provided at study completion. All visits were matched within 1 h within participants to control for time of day effects.

2.4. Stress protocol

The combined physical and social evaluative threat stress induction protocol comprised the public speech task from the TSST (Kirschbaum et al., 1993) and a SECPT (Schwabe et al., 2008). Speech tasks have been previously demonstrated to elicit larger and more consistent endocrine (ACTH and cortisol) and cardiovascular responses than mental arithmetic tasks (AlAbsi et al., 1997). Hence, the TSST speech task was retained rather than the maths task.

Following a 5 min anticipation period, participants were required to give an extemporaneous 5 min speech (standing) presenting themselves as a job candidate to two non-responsive, evaluative female confederates. Upon completion of the speech participants completed a CPT in front of the social-evaluative panel. The SECPT required the submersion of the hand above the wrist in ice cold water (0–4 °C) for as long as possible (a maximum of three minutes) whilst maintaining eye contact with the panel (seated). Participants were falsely informed that performance on both tasks would be video and audio recorded for further analysis. An opposite sex (female) evaluative panel was selected to increase the level of social-evaluative threat. Opposite sex panels have been demonstrated to be more efficacious in the elicitation of cortisol stress responses compared to single sex panels (Duchesne et al., 2012). The stress protocol, including stress response measures taken mid-stress induction, lasted approximately 15 min dependent upon the time taken to complete the SECPT.

Novelty, lack of control, unpredictability, and social-evaluative threat have been identified as primary psychological determinants of cortisol responsivity to acute psychosocial stress (Dickerson and Kemeny, 2002; Mason, 1968; Rose, 1984). Repeated exposure to a homotypic stressor reduces the moderating influence of these psychological characteristics on the engendered response as the contextual and psychological elements of the stressor are perceived as more familiar, predictable and controllable (Harl et al., 2006; Schommer et al., 2003; Voigt et al., 1990). Increased familiarity, control and predictability may also reduce the impact of perceived social evaluation experienced during exposure to a social evaluative threat. Therefore, a number of contextual changes were made to the stress induction protocol across stress visits 1 and 2. The