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Intra-individual psychological and physiological responses to acute laboratory stressors of different intensity

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Cold pressor test;
Stroop test

Summary
Objectives: The phenomenon of stress is understood as a multidimensional concept which can be captured by psychological and physiological measures. There are various laboratory stress protocols which enable stress to be investigated under controlled conditions. However, little is known about whether these protocols differ with regard to the induced psycho-physiological stress response pattern.
Methods: In a within-subjects design, 20 healthy young men underwent four of the most common stress protocols (Stroop test [Stroop], cold pressor test [CPT], Trier Social Stress Test [TSST], and bicycle ergometer test [Ergometer]) and a no-stress control condition (rest) in a randomized order. For the multidimensional assessment of the stress response, perceived stress, endocrine and autonomic biomarkers (salivary cortisol, salivary alpha-amylase, and heart rate) were obtained during the experiments.
Results: All stress protocols evoked increases in perceived stress levels, with the highest levels in the TSST, followed by Ergometer, Stroop, and CPT. The highest HPA axis response was found in the TSST, followed by Ergometer, CPT, and Stroop, whilst the highest autonomic response was found in the Ergometer, followed by TSST, Stroop, and CPT.

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Conclusions: These findings suggest that different stress protocols differentially stimulate various aspects of the stress response. Physically demanding stress protocols such as the Ergometer test appear to be particularly suitable for evoking autonomic stress responses, whereas uncontrollable and social-evaluative threatening stressors (such as the TSST) are most likely to elicit HPA axis stress responses. The results of this study may help researchers in deciding which stress protocol to use, depending on the individual research question.

1. Introduction

When studying the phenomenon of stress under controlled conditions, researchers need standardized laboratory stress protocols which induce stress in a reliable and valid manner. Such protocols will enable the researcher to investigate (a) the psychological and physiological mechanisms of the stress process itself, and (b) the emotional, cognitive, and behavioral consequences of induced stress. There are various approaches to describe the domains of stress responses, the physiological domain, the subjective experiences domain (including emotional states), the cognitive domain, and the behavioral domain. In the following, we focus on a bi-modal approach, according to which the stress response comprises both psychological and physiological processes.

The 'Transactional Model of Stress' (Lazarus and Folkman, 1984) focuses on psychological mechanisms and proposes that an imbalance of primary appraisal (i.e., evaluation of the current situation as threatening and potentially harmful) and secondary appraisal (i.e., evaluation of an individual's resources to cope with threat) results in a stress response. The central nervous system (CNS) plays a key role in these psychological processes and also orchestrates the body's response to a stressor. Stress-induced CNS activation drives the two most prominent physiological stress-response systems, namely the hypothalamus—pituitary—adrenal (HPA) axis and the autonomic nervous system (ANS), particularly the sympatho—adrenal—medullary (SAM) system (Chrousos, 2009). Due to its quick and uncomplicated assessment, the most commonly used marker of HPA axis responses is salivary cortisol. Autonomic stress responses are frequently obtained by non-invasive measurement such as heart rate (HR) or salivary alpha-amylase (sAA) activity. Altered psycho-physiological stress responses to different laboratory stressors are related to various psychiatric and somatic disorders (Gerra et al., 2001; Hamer and Steptoe, 2012; Kelly and Cooper, 1998). Laboratory stressors may thus be used as a tool for predicting and/or diagnosing negative health outcomes.

Variability in stress responses can be attributed to the factors originating from the person or the environment. The concept of stimulus response specificity reflects the observation that variability in stress response patterns is to some degree attributable to situational characteristics or the type of stressor a person is exposed to (Schlotz, 2013). For example, it has been suggested that HPA axis responses are specifically triggered by social evaluative threat (Dickerson and Kemeny, 2004), whereas stressors characterized by effort might specifically trigger SAM responses (Lundberg and Frankenhaeuser, 1980). Alternatively, it has been suggested that variability in response pattern among stressors might essentially be attributable to differences in response *intensity* elicited by different stressors (Bosch et al., 2009). Regardless of the specific mechanisms underlying response differences associated with stressor types, it is obvious that detailed information about such patterns is useful for decisions on which stressor to employ in a stress study. The primary aim of this study therefore was to compare psycho-physiological stress response patterns of various stressors and a non-stress resting condition in a within-subjects design. The specific stressors studied here were chosen on the basis of their popularity in stress research as well as their potency to elicit stress responses (Biondi and Picardi, 1999).

We searched the literature and reviewed previous peer-reviewed studies which (a) used at least two different laboratory stress protocols, and (b) reported a measure of psychological stress response (perceived stress) or reported findings on measures of the physiological stress response (cortisol, sAA, or HR), or both (see supplementary material I). The review revealed that the majority of stressors indeed successfully induced psycho-physiological stress responses indicated by various stress measures. However, the pattern of stress responses associated with a specific stressor was rather inconsistent across studies. This inconsistency might be explained by methodological limitations within and differences between the reviewed studies. In most of the studies, participants were exposed to multiple stressors during the same session, which does not allow for a direct comparison between single stressors due to potential carry-over effects. This selection resulted in only a small number of remaining studies. A list of these studies with details on methods, design, and outcome measures is provided as a supplement (see supplementary material I). It becomes evident from this list that the available studies allow only limited conclusions about the comparability of stressors, as most suffered from various methodological limitations, such as between-subjects designs (different participants were exposed to different stressors), comparison of no more than two stressors in a within-subjects design, or a lack of control condition (no comparison between stress and no-stress condition). Furthermore, the majority of studies focused on a single stress measure, thus ignoring the multidimensional nature of stress. In summary, there is a lack of studies using a within-subjects design which systemically compare psycho-physiological stress responses between various stress protocols, and provide a comparison with a no-stress control condition. The current study was designed to overcome these methodological limitations and one-dimensional assessment of stress responses.