Psychoneuroendocrinology xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Psychoneuroendocrinology

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

Ten years of research with the Socially Evaluated Cold Pressor Test: Data from the past and guidelines for the future

Lars Schwabe[a,*], Hartmut Schächinger[b]

[a] Department of Cognitive Psychology, University of Hamburg, Von-Melle-Park 5, 20146 Hamburg, Germany
[b] Department of Clinical Psychophysiology, Johanniterufer 15, 54290 Trier, Germany

ARTICLE INFO

Keywords:
Stress
Laboratory stressor
Socially Evaluated Cold Pressor Test
SECPT
Cortisol
Autonomic arousal

ABSTRACT

Ten years ago, the Socially Evaluated Cold Pressor Test (SECPT) was introduced as a standardized protocol for the efficient experimental stress induction in humans. In short, the 3 min SECPT, which can be conducted by only a single experimenter, combines a physiological challenge (hand immersion into ice water) with socio-evaluative elements. The purpose of this article is twofold. First, we aim to evaluate the subjective and physiological responses elicited by the SECPT. To this end, we pooled data from 21 studies from our lab and systematically analyzed the response profile to the SECPT. Our analyses show that the SECPT leads, both in men and women, to striking increases in subjective stress levels, autonomic arousal, and cortisol, albeit the cortisol response is typically somewhat less pronounced than in the Trier Social Stress Test. Second, we aim to provide guidelines for conducting the SECPT, in order to foster homogenization of the SECPT procedure across (and within) labs. In sum, we argue that the SECPT is a highly efficient tool to induce stress and activate major stress systems in a laboratory context, in particular if the guidelines that we outline here are followed.

1. Introduction

Stressful encounters, ranging from the many daily hassles to major life-events, are ubiquitous in our everyday life. In healthy humans, these stressors can induce changes in affective and cognitive processing (de Quervain et al., 2017; Joels et al., 2011; Roozendaal et al., 2009; Schwabe et al., 2012; van Stegeren et al., 2005; Vogel et al., 2016), with considerable implications, for instance, for educational contexts (Vanaelst et al., 2012; Vogel and Schwabe, 2016). In vulnerable individuals, stressful events may even contribute to the pathogenesis of mental disorders (Caspi et al., 2003) and, indeed, stress is thought to be a major factor in many psychopathologies, including major depression, schizophrenia, addiction, and posttraumatic stress disorder (de Kloet et al., 2005; Koob, 2008; Walker and Diforio, 1997; Yehuda, 2001). The effects of stress on emotion, cognition, and mental health are mediated by the multitude of hormones, neurotransmitters, and peptides that are released in response to a stressful encounter. Glucocorticoids (mainly cortisol in humans) and catecholamines have been in the spotlight of stress research, although it is well-known that many more substances are involved in the physiological stress response (Joels and Baram, 2009). In the face of the far-reaching consequences of stressful events, it is not surprising that stress is a subject of intense scientific inquiry, with thousands of publications on this topic every year. To investigate the phenomenon stress, its underpinnings and effects, systematically in a laboratory environment, it is essential that standardized protocols are available that reliably induce stress and activate major stress response systems in experimental contexts.

Ten years ago, we introduced in this journal the Socially Evaluated Cold Pressor Test (SECPT) as a highly efficient tool for experimental stress induction in humans (Schwabe et al., 2008). In short, the SECPT is an extension of the classical Cold Pressor Test (CPT; Hines and Brown, 1932), in which participants immerse their hand in ice water, by socio-evaluative elements. Based on meta-analytic evidence that identified social-evaluative elements as crucial for eliciting a robust cortisol response to a stressor (Dickerson and Kemeny, 2004), we reasoned that the addition of socio-evaluative aspects would boost the cortisol response to the cold pressor manipulation, which was often rather moderate in response to the classical CPT (al' Absi et al., 2002; Duncko et al., 2007; McRae et al., 2006). Indeed, we showed in our 2008 report that the cortisol response to the SECPT was significantly stronger than the cortisol response to the CPT (Schwabe et al., 2008), a finding that has subsequently been replicated by others (Smeets et al., 2012; see Fig. 1). Since 2008, the SECPT has been used in numerous studies around the world and it is by now an established standard protocol in human stress research that may represent an efficient alternative to other established protocols, such as the Trier Social Stress

* Corresponding author.
E-mail address: lars.schwabe@uni-hamburg.de (L. Schwabe).

https://doi.org/10.1016/j.psyneuen.2018.03.010
Received 13 December 2017; Received in revised form 12 February 2018; Accepted 17 March 2018

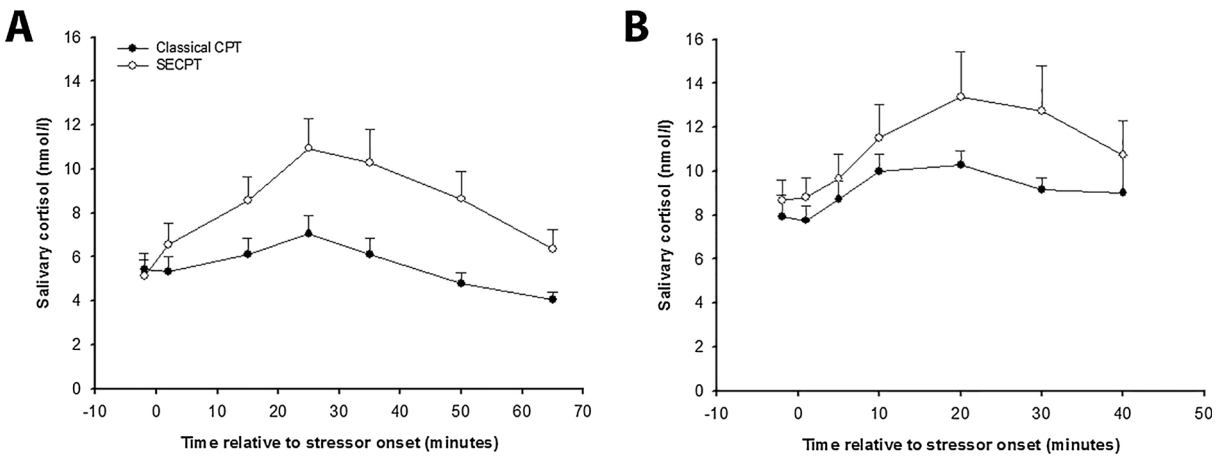

Fig. 1. Comparison of cortisol response to the classical Cold Pressor Test (CPT) and Socially Evaluated Cold Pressor Test (SECPT). The SECPT led both in (A) the study by Schwabe et al. (2008) and (B) the study by Smeets et al. (2012) to a more pronounced cortisol response than the classical CPT. Error bars represent standard error of the mean. The data shown in panel A were provided by courtesy of Dr. Tom Smeets, Maastricht.

Test (TSST; Kirschbaum et al., 1993), a 'gold standard' in the field.

The present article aims to provide a concise overview of the stress response elicited by the SECPT and some guidelines for conducting the SECPT in the lab. In the first part of this article, we will portray the typical subjective and physiological responses to the SECPT. We will focus in particular on the strength of the cortisol response because the SECPT was mainly developed as a tool that leads to a stronger cortisol increase than the classical CPT. In the second part of this review, we will describe in detail how to conduct the SECPT (and its control manipulation). We will clarify issues that have not been made explicit in our 2008 paper or have been further developed based on our experiences with the SECPT. Finally, we will address outstanding issues in the characterization of the stress response to the SECPT.

2. Subjective, autonomic, and cortisol responses to the SECPT

Whether an experimental stress induction was successful (or not) can be assessed at least at three levels: the manipulation should result in the subjective feeling of being stressed, it should lead to marked increases in parameters of sympathetic nervous system activity (such as blood pressure or heart rate), and, last but not least, the manipulation should activate the hypothalamus-pituitary-adrenal (HPA) axis and thus elicit elevated cortisol levels. In order to illustrate the subjective, autonomic, and (salivary) cortisol response to the SECPT, we pooled the data of 21 studies from our labs (see Table 1). In all of these studies, healthy, normal-weighted, medication-free non-smokers between 18 and 40 years of age (n = 1.619; 823 men, 796 women; all women without hormonal contraceptive intake) underwent either the warm water control condition or the SECPT. Both the SECPT protocol and the warm water control condition were conducted as described ten years ago (Schwabe et al., 2008), with only very few variations (e.g. whether there was a different experimenter for the SECPT and whether the gender of this experimenter was opposite to the gender of the participant) as shown in Table 1. Data from these 21 studies were merged and subjected to ANOVAs and *t*-tests in order to assess the average subjective, blood pressure, and salivary cortisol response to the SECPT. Moreover, we used this data set to test whether there are reliable sex differences in the responses to the SECPT and to what extent the outlined variations of the SECPT protocol affected the response to the stressor. As analyses of large data sets such as the present are often overpowered, we present effect sizes in addition to the two-tailed *p*-value to allow an assessment of the actual magnitude of an effect.

Our data confirm that the exposure to the SECPT leads to striking changes in subjective feeling. Fig. 2 shows that participants experience the SECPT typically as being significantly more stressful, painful, and unpleasant than the control manipulation (all $p < 0.001$; all $\eta^2 > 0.50$). In addition to these subjective changes, the SECPT triggers a sharp increase in systolic and diastolic blood pressure (Fig. 3; treatment × time point of measurement interactions: both $p < .001$; both $\eta^2 > 0.30$). This blood pressure increase is maximum during the SECPT and blood pressure returns to baseline quickly as the SECPT is over. Both the subjective and autonomic responses to the SECPT are very robust. We observed highly significant increases in blood pressure and subjective stress levels in each of our studies and we are not aware of any study that did not obtain these SECPT-induced changes. The autonomic changes, however, may not be equally well reflected in all parameters. Blood pressure increases in the SECPT represent at least partly a basic physiological response to cold (vasoconstriction) and this increase in blood pressure may hamper an increase in other autonomic parameters, such as heart rate, due to a baroreflex counterregulation that prevents overshooting of autonomic activity (see also Schwabe et al., 2008). While the increases in subjective stress and autonomic arousal are very robust, they are not at all specific to the SECPT. Significant elevations in subjective stress and autonomic activity are also induced by the classical CPT (Duncko et al., 2007; Hines and Brown, 1932; Schwabe et al., 2008; Smeets et al., 2012) and the CPT and SECPT (as well as the TSST) are comparable in their potency to evoke subjective and autonomic changes (Schwabe et al., 2008; Smeets et al., 2012).

However, previous data suggested that the SECPT results in a stronger cortisol response than the CPT (Fig. 1; Schwabe et al., 2008; Smeets et al., 2012), which is crucial as cortisol is thought to be a driving force in stress effects on emotion and cognition (Buchanan et al., 2006; de Quervain et al., 1998; Joels et al., 2011; Schwabe et al., 2013a,b; Sudheimer et al., 2013; Vogel et al., 2016). So how does the typical cortisol response to the SECPT look like? And how likely is it to occur? Fig. 4 shows that peak cortisol responses can be expected at about 25 min after SECPT onset and that cortisol levels are back at baseline after about 60 min after the beginning of the SECPT. In the pooled studies, the SECPT led on average to a cortisol increase of 4.37 nmol/l, corresponding to a baseline-to-peak increase of about 104 percent. Across studies, the average increase varied between 1.8 and 8.1 nmol/l (corresponding to an increase of 34–127 percent). The strength of the cortisol response was comparable between studies performed in the morning vs. afternoon (time of day × treatment interaction: $p = .76$, $\eta^2 < 0.001$). When participants were classified into cortisol responders and non-responders based on whether they showed a baseline-to-peak cortisol increase of at least 1.5 nmol/l, a cortisol response criterion that was established for the TSST (Miller et al., 2013), the average responder rate across studies was about 60 percent