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The socially evaluated cold-pressor test (SECPT) for groups: Effects of repeated administration of a combined physiological and psychological stressor

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Summary The combined administration of physiological (cold pressor) and psychological (social-evaluative threat) stressors, as in the socially evaluated cold pressor test (SECPT; Schwabe et al., 2008) activates the sympathetic nervous system (SNS) and the hypothalamic-pituitary-adrenal (HPA) axis. Thus far, the SECPT has been administered exclusively to individual participants, which requires substantial personal effort and time. Therefore, the aim of the present study was to investigate whether and to what extent cardiovascular parameters (SNS) and salivary cortisol concentrations (HPA axis) are affected over the course of repeated SECPT administration in a group design.

The SECPT was conducted in groups of seven or more persons and repeated twice with a 24-h interval between each administration. During the stress test, the participants ($n = 61$) were videotaped and observed continuously while they immersed their hands into ice-cold (1 °C, experimental group) or room-temperature (20 °C, control group) water. Blood pressure, heart rate, salivary cortisol concentration, and subjective stress perception were measured.

All of these parameters increased significantly during each of the three stress exposures; in contrast, they remained constant in the control group. Moreover, the heart rate response towards the stressor decreased significantly over the course of the repeated stress exposures and salivary cortisol concentration of the experimental group was elevated before the third SECPT administration.

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Our results indicate that the group SECPT activates the SNS and the HPA, leading to increased blood pressure, heart rate, and cortisol concentration. Moreover, the repeated administration leads to habituation exclusively of heart rate.

1. Introduction

Several protocols have been established to trigger psychological and physiological stress responses in a highly standardized and reliable manner (Hines, 1936; Kirschbaum et al., 1993; Schwabe et al., 2008). A commonly used technique to rapidly elicit a stress reaction is a cold-pressor test (CPT), in which the subject's hand is immersed in ice-cold water for a short period of time. This physiological stressor leads to stress responses such as elevations in blood pressure, heart rate, and adrenaline and noradrenaline concentrations (Robertson et al., 1979; Bolli et al., 1981; Al'Absi et al., 2002). Further, salivary cortisol concentrations rise moderately (Al'Absi et al., 2002; Gluck et al., 2004) or show no elevation at all (McRae et al., 2006; Duncko et al., 2007). In order to achieve more substantial hypothalamic-pituitary-adrenal (HPA) axis activation, the CPT was developed further to yield the socially evaluative cold-pressor test (SECPT), which contains two socio-evaluative components: videotaping and continuous observation by an investigator (Schwabe et al., 2008). The SECPT leads to the activation of both physiological stress pathways: the sympathetic nervous system (SNS) and the hypothalamic-pituitary-adrenal (HPA) axis, which is evidenced by increased blood pressure and cortisol. Furthermore, the subjective stress rating also rises (e.g. Schwabe et al., 2008; Smeets, 2011).

Despite these advantages, the SECPT is somewhat costly in terms of personal effort and time, particularly since it should be conducted at the same time of day because of the diurnal cortisol course; thus, it can be repeated in only a few individuals per day. Therefore, in order to improve the efficiency of the SECPT, a grouped design might be desirable for certain research questions. In addition, evidence suggests that stress responses may be enhanced in a group-design, despite the possible buffering effects of social support (Ditzen and Heinrichs, 2014). For instance, Dickerson and Kemeny (2004) and Het et al. (2009) have shown that the social evaluative threat, which is realized in the presence of others, triggers higher cortisol responses. Correspondingly, Childs et al. (2006) showed that the Trier Social Stress Test (TSST), a social evaluative stressor, elicits an increased stress reaction when it is conducted in groups. Yet, it remains unclear if these findings can be transferred to a test that combines social evaluative and physiological stressors, such as the SECPT. Thus, the aim of the present study was to investigate if the SECPT also elicits the HPA and SNS stress responses in a group design. For that purpose the SECPT was conducted with several participants at once and their blood pressure, heart rate, subjective feelings of stress and cortisol concentration before, during and after the test were measured.

In the majority of cases, habituation occurs after repeated exposure to the same stressor (e.g. Grissom and Bhatnagar, 2009; Thompson and Spencer, 1966). Habituation to stress is characterized by a decreased physiological response caused by the diminished SNS and HPA axis activation that occurs to conserve energy and avoid exhaustion (e.g. Schommer et al., 2003; Kudielka et al., 2006). This process depends on the attenuation of individual and situation specific parameters such as novelty, unpredictability, or uncontrollability over the course of several repetitions (Mason, 1968; Wüst et al., 2004).

A well-documented example of habituation is the TSST: after repeated TSST exposure, cortisol and heart rate response diminishes, while norepinephrine/epinephrine release is rather unaffected (Schommer et al., 2003). This suggests that the HPA axis is more sensitive than the SNS to the process of habituation (Schommer et al., 2003).

Studies on habituation to cold-induced stress have been inconsistent. Some evidence suggests that initial blood pressure elevation, pain perception, shivering, and vasoconstriction diminish following repeated exposure to cold (Steward and Hardy, 1941; Krog et al., 1960; Shiraki et al., 1996; Young, 1996). However, the results of Windsheim et al. (1955) and Raven (2008) indicated that the responses to cold induced stress stay unaffected after a recovery period longer than ten minutes. This is evidence that the SNS may underlie habituation to cold. However, it remains unclear whether this habituation also occurs after repeated SECPT administration and whether the HPA axis also habituates towards cold.

Anticipation is another important factor in the stress response. Anticipation refers to the mental processing and presumption of a stressful event or stimuli before it actually happens. Even the anticipatory reflection upon a threatening event can initiate a stress response and activate both stress axes. For example, subjects' anticipation of the cold stress leads to increases in cardiovascular activity and blood pressure (Gregg et al., 1999; Kolk and van Well, 2007).

Additionally, psychosocial stress can lead to anticipatory reactions such as increased heart rate (Preston et al., 2007), blood pressure (Singh et al., 1999), or salivary cortisol concentration (Kirschbaum et al., 1995; Starcke et al., 2008). Furthermore, anticipation may also lead to stress-related feelings like anxiety or arousal (Preston et al., 2007).

Concerning the SECPT habituation and anticipation have not yet been investigated; however evidence suggests that the administration of cold pressor with added social-evaluative elements may elicit habituation and anticipation, as well as both stress elements alone. Further, it is of particular interest to determine whether the stress reactions can be generated in a group design. As the stressors remained the same in our group experiment and the presence of others can be an additional stressor (as mentioned above), we hypothesized that the extent of the stress responses are at least comparable to the ones in single tested individuals or even higher. Furthermore, we expected no differences between the stress responses of both sexes, as suggested by previous studies (e.g. Schwabe et al., 2008; Schwabe and Wolf, 2009).

2. Methods

2.1. Participants

Sixty-one students (27 Caucasian men and 34 women) were recruited by announcements at the University of Bochum. Because of possible confounding effects on cortisol concentrations, students with the following characteristics were excluded from this study: overweight or underweight (body mass index above 25 kg/m^2 or below 18.5 kg/m^2, respectively), frequent smoking, use of oral contraceptives or any long-term medication, or presence of a medical condition (Foley and Kirschbaum, 2010). The experiment was conducted in accordance with the Declaration of Helsinki, and was approved by the local ethics committee. All participants provided written informed consent.

2.2. Experimental procedure

In this study, the experiment was conducted between 1330 and 1530 h to control for the diurnal cortisol cycle. In order to eliminate possible contaminations of saliva, participants were instructed to refrain from food or drink for one hour prior to the experiment.

Before the experiment began, the participants were randomly assigned to one of two treatment groups: the first (experimental; n = 21 women, 15 men) group was to immerse their hands into ice-cold water (CPT), while the second (control; n = 13 women, 12 men) group immersed their hands into room-temperature water. Apart from the water temperature, all parameters were the same in the experimental and control group.

The experimental procedure was comparable to Schwabe et al. (2008), except that our experiment was conducted in groups with an average group size of nine (9.16 ± 0.29 SEM; min. 7, max. 12). Additionally, in our experimental design both sexes were tested and cardiovascular and salivary cortisol values were recorded at different points in time during the SECPT. The variation of the group size was due to cancellations (e.g. illness), exclusion criteria like BMI and the complex time requirement (three consecutive days at 1330 h) so that some participants were excluded during the experiments. Each experimental and control group consisted of several men and women in comparable numbers in order to increase the social-evaluative threat (Dickerson and Kemeny, 2004) and to gain a high number of participants. Before each experimental session the participants had to wait outside the room to ensure that they all start simultaneously. At the first day, we gave the participants a short introduction to the experimental procedure and explained our objectives. In this context we told them that they will perform an ice water stress task and that they will be recorded in order to study their facial expressions. Furthermore, the collection of saliva and the measurement of the cardiovascular values and subjective stress rating were demonstrated. At the following days, only the presence of the cameras was mentioned again in order to maintain the social evaluative threat.

The participants were seated in opposite rows at two lines of tables in a seminar room (54.75 m^2). They could observe each other during the investigation but were not permitted to interact. In order to record the participants' faces, four cameras were positioned in each corner of the room. Each participant had a protocol sheet, a plastic box filled with ice water (experimental group) or room tempered water (control group), an upper-arm blood pressure monitor and three straws and micro tubes to collect the saliva at his table. This enabled the participants to collect saliva samples, protocol cardiovascular parameters and their feelings of stress independently.

During the stress test, the participants were videotaped while they immersed their non-dominant hand in the water.

Additionally, one experimenter observed all participants for the duration of the entire experiment. His task was to guarantee a smooth process and coordinated the measurements, especially the right timing. The experimenter was male, wearing a lab coat, and unknown to the participants. In order to ensure an identical process all trials were conducted by the same investigator.

The experimental procedure began with the collection of the first saliva sample and the first recordings of blood pressure, heart rate, and subjective stress perception (duration: 5 min) to determine baseline values. Then, the participants were asked to place their non-dominant hand (up to the wrist) into the water for as long as possible. Furthermore, they were informed that the maximum time of immersion would be 3 min, and that they could remove their hand if it became too painful. After 3 min, those who kept their hand in the water were instructed to remove it. Immediately after participants put their hand into the water, blood pressure, heart rate and subjective stress perception were recorded again. These parameters were measured again 1 min after hand immersion; directly after the CPT; and following a 15-min resting period, wherein participants watched a documentary film (Planet Earth, Fothergill, 2006). The second saliva sample was also collected after the resting period.

This experimental procedure was repeated on three consecutive days with each group and always at the same time interval (Fig. 1).

2.3. Cortisol assessment

Saliva was obtained by collecting the unstimulated passive drool of subjects using a shortened straw connected to polypropylene micro tubes (Sarstedt, Nürmbrecht, Germany). Immediately after collection, samples were stored at $-20\,^{\circ}C$ until analysis. The samples were thawed at room temperature, vortexed, and centrifuged at $2500 \times g$ for 15 min twice.

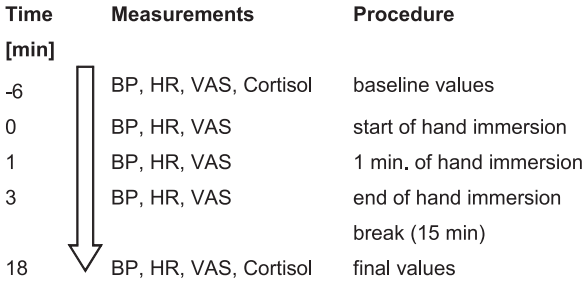

Figure 1 Experimental timeline (BP, blood pressure (systolic and diastolic); HR, heart rate; VAS, subjective stress perception).

On the day of the assay, the supernatant of each probe was transferred in duplicate into a pre-coated micro-well plate. Cortisol concentrations were quantified using the cortisol saliva immunoassay kit from IBL (Hamburg, Germany). Analyses were conducted using a 96-well ELISA reader (Thermo Fisher, Vantaa, Finland). Intra-assay coefficients of variance were below 8%, and inter-assay coefficients were below 11%.

2.4. Cardiovascular data

Heart rate and blood pressure were measured using an upper-arm blood pressure monitor (Aponorm, Hillscheid, Germany). The cuff was adjusted 2 cm above the bend of the elbow. In order to obtain stable measurements, participants were instructed to refrain from speaking or moving during the measurement. The maximum time lag between the start and the end of the measurement was 30 s.

2.5. Subjective stress ratings

Subjective feelings of stress were measured through a Visual Analogue Scale (VAS; Folstein and Luria, 1973). The VAS consists of a 100-mm horizontal line that is entitled "stress perception"; the ends of the line are labelled "not at all" (0 mm, on the left) and "extremely" (100 mm, on the right). The participants were asked to rate the stressfulness of the experience by marking a cross on the appropriate part of the line.

2.6. Statistical analysis

Demographic and descriptive variables were analyzed using Pearson's Chi-square-tests and Student's *t*-tests.

Cardiovascular data, cortisol concentration, and subjective stress perception of the first day were initially analyzed using a repeated measure analysis of variance (ANOVA), with TIME (cardiovascular and VAS data: before, start, 1 min, end, after 15 min; cortisol concentrations: before and 15 min after the SECPT) as repeated measurement factor, and TREATMENT (SECPT vs. control) and SEX (men vs. women) as between-groups factors. In order to identify significant differences at specific measurement points between the two treatment groups, we used Bonferroni adjusted post hoc *t*-tests.

Data were log-transformed to approach normality, and Greenhouse–Geisser-adjusted *p* values are reported in case of sphericity assumption violations.

To reveal possible habituation effects, we calculated the difference between baseline and the first measurement of all three days and analyzed these values using a repeated measure ANOVA with DAY (Day 1, 2, 3) as a repeated measurement factor, and TREATMENT (SECPT vs. control) and SEX (men vs. women) as between-group factors. Possible anticipatory effects were also analyzed in this manner; however, the baseline values of all parameters were used in that analysis. Significant main effects were further analyzed by Hochberg's GT2 post hoc test, which controls for the type I error rate and is adapted for varying sample sizes (Field, 2009). The ANOVA analyses included partial η^2 as a measure of effect size. In accordance with the classification of Cohen (1973), a partial $\eta^2 = 0.01$ and 0.06 were considered small and medium effect sizes, respectively.

The overall significance level was $p < 0.05$. Statistical analyses were performed using SPSS 21 (IBM, Chicago, USA).

3. Results

3.1. Demographic data

The total sample consisted of 27 male and 34 naturally cycling female participants with a mean age of 22.86 years ($\pm$0.56 SEM), and a mean BMI of 22.87 kg/m^2 ($\pm$0.41 SEM). There was no significant intergroup difference in the distribution according to sex, age, or BMI ($p > 0.05$, χ^2 test, *t*-test). Furthermore, participants of the different groups did not exhibit significantly different baseline levels of heart rate, blood pressure, subjective stress rating, and salivary cortisol ($p > 0.05$, *U*-test).

3.2. Effects of single SECPT administration

Participants in the SECPT condition exhibited increases in all measured cardiovascular parameters (heart rate, systolic and diastolic blood pressure), while these parameters remained comparable to baseline in the control group. Correspondingly, the repeated measures ANOVA revealed a significant interaction effect for TIME $\times$ TREATMENT (all *F*'s (4,172) > 4.94, all *p*'s < 0.01). This interaction effect also applies for the subjective stress perception ($F(4,180) = 20.61$, $p < 0.001$) and cortisol concentrations ($F(1,32) = 4.05$, $p = 0.053$) which increased relative to baseline in the SECPT group, but not the control group. Moreover, Bonferroni adjusted post hoc *t*-tests revealed that the significant differences between the treatment groups are directly at the beginning (blood pressure, heart rate, VAS), during (blood pressure, VAS), at the end (blood pressure, VAS) or rather 15 min after the SECPT (cortisol) (Figs. 2–5).

The average time the participants kept their hand in the ice water was 176 s.

3.2.1. Cardiovascular parameters

The maximum increase in the cardiovascular parameters occurred directly at the beginning or one min after hand immersion. Following the test, these parameters decreased and returned to baseline levels after 15 min (Figs. 2 and 3). In the control group all cardiovascular parameters stayed rather unaffected. A repeated measures ANOVA with TIME (before, start, 1 min, end, after 15 min) as a repeated measurement factor, and TREATMENT (SECPT vs. control) and SEX (men vs. women) as between-group factors revealed a significant main effect of TIME (all $F(4,172) = >8.91$, all $p < 0.001$, all $\eta^2 > 0.17$). A significant interaction effect for TIME $\times$ TREATMENT was additionally observed (all *F*'s (4,172) > 4.94, all *p*'s < 0.01, all $\eta^2 > 0.10$).

No significant interaction was found between TIME $\times$ SEX. The between-group factor TREATMENT was significant only for diastolic blood pressure ($F(1,43) = 4.42$, $p < 0.05$, $\eta^2 = 0.09$).

The factor SEX influenced both systolic blood pressure and heart rate (both $F(1,43) > 8.85$, both $p < 0.01$, both $\eta^2 > 0.17$): women exhibited continuously higher heart rates, while men showed higher systolic blood pressure particularly

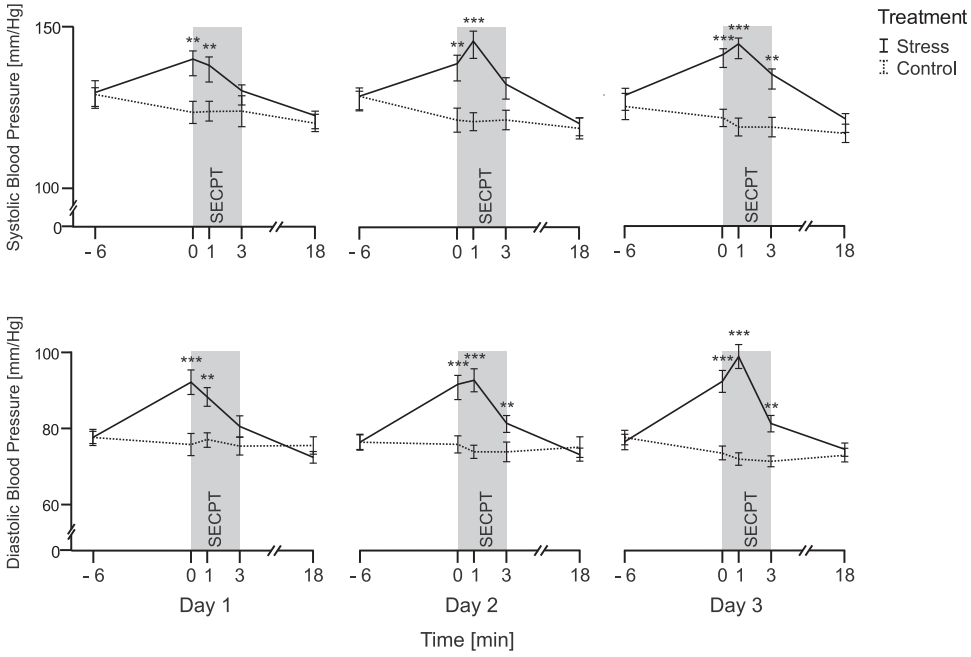

Figure 2 Blood pressure (systolic and diastolic) in response to the SECPT and control condition. The grey bar denotes the timing and duration of the treatment (stress vs. control). Data represent means ± SEM. $^{**}p < 0.01$, $^{***}p < 0.001$ significant group difference.

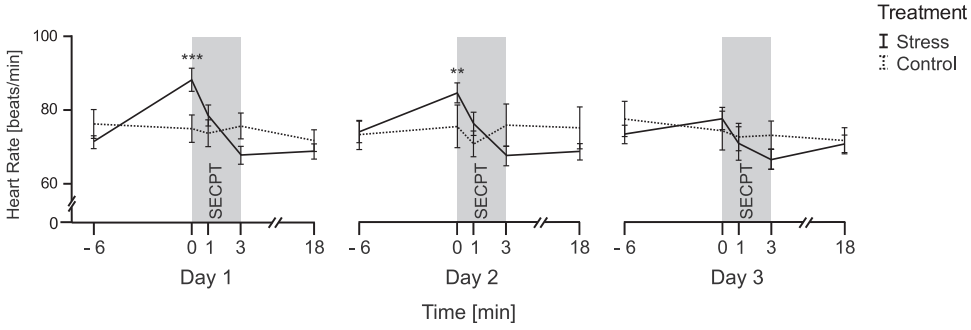

Figure 3 Heart rate response to the SECPT and control condition. The grey bar denotes the timing and duration of the treatment (stress vs. control). Data represent means ± SEM. $^{**}p < 0.01$, $^{***}p < 0.001$ significant group difference.

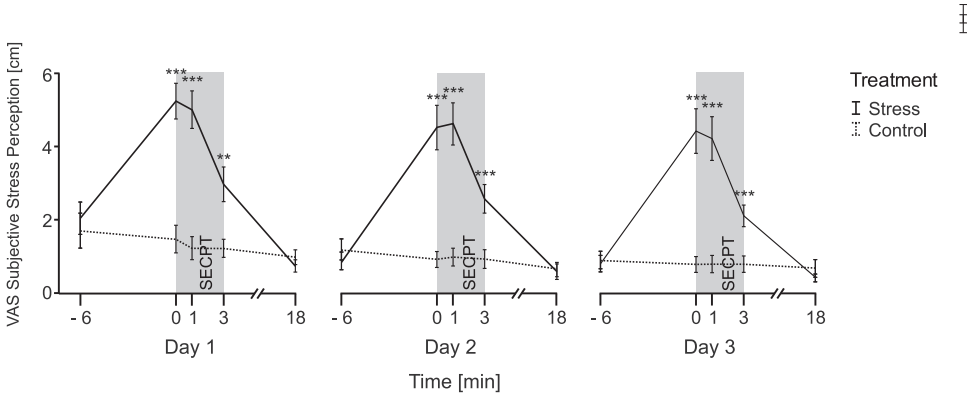

Figure 4 Subjective stress perception (VAS) in response to the SECPT and control condition. The grey bar denotes the timing and duration of the treatment (stress vs. control). Data represent means ± SEM. $^{**}p < 0.01$, $^{***}p < 0.001$ significant group difference.

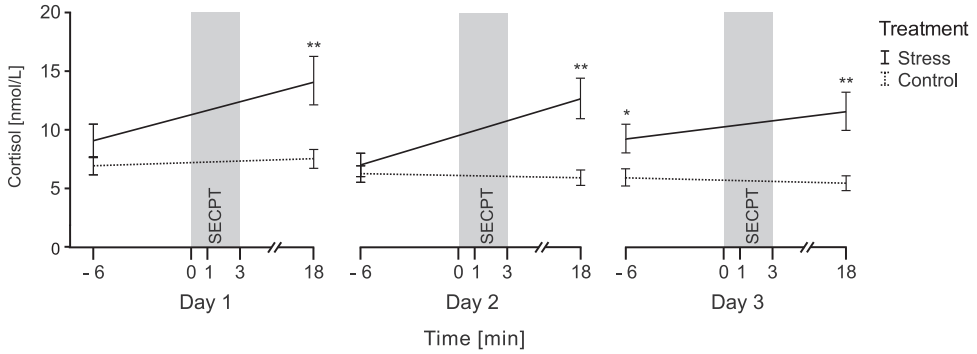

Figure 5 Salivary cortisol concentration in response to the SECPT and control condition. The grey bar denotes the timing and duration of the treatment (stress vs. control). Data represent means ± SEM. *$p < 0.05$, **$p < 0.01$ significant group difference.

before and after the SECPT. However, no interaction effect between TREATMENT × SEX was observed.

Furthermore, there was no interaction effect between TREATMENT × TIME × SEX.

3.2.2. Subjective stress perception

Similar to the cardiovascular parameters, subjective stress perception reached maximal intensity after 1 min of hand immersion, decreased immediately thereafter, and reached the baseline value 15 min after the end of the SECPT (Fig. 4), whereas they remained nearly constant in the control group.

The ANOVA showed a significant main effect of TIME. ($F(4,180) = 24.17$, $p < 0.001$, $\eta^2 = 0.35$) and TREATMENT ($F(1,45) = 16.25$, $p < 0.001$, $\eta^2 = 0.26$). Furthermore, a significant interaction effect between TIME × TREATMENT was observed ($F(4,180) = 20.62$, $p < 0.001$, $\eta^2 = 0.32$). No significant interaction was found for SEX. Furthermore, there was no interaction effect between TREATMENT × TIME × SEX.

3.2.3. Salivary cortisol

Salivary cortisol concentrations significantly increased 15 min after the test. They stayed unaffected in the control group (Fig. 5). A repeated measures ANOVA revealed a significant main effect of TIME ($F(1,32) = 8.75$, $p < 0.01$, $\eta^2 = 0.22$) and TREATMENT ($F(1,32) = 4.62$, $p < 0.05$, $\eta^2 = 0.13$). Furthermore, a significant interaction effect of TIME × TREATMENT was observed ($F(1,32) = 4.05$, $p < 0.05$, $\eta^2 = 0.11$). However, the factor SEX did not significantly influence cortisol concentration. Also, there was no interaction effect between TREATMENT × TIME × SEX.

3.3. Habituation

Potential habituation of stress responses following repeated SECPT administration was assessed by calculating the changes in all parameters (Δ baseline, hand immersion) and analyzing these values using a repeated measures ANOVA (repeated measurement factor DAY (Day 1, 2, 3)) including TREATMENT (SECPT vs. control) and SEX (men vs. women) as between-group factors. The SECPT-induced increase in all parameters except for heart rate was comparable across the three days; the heart rate response decreased over the course of the repetitions (Fig. 3). Correspondingly, the ANOVA showed a significant interaction effect of DAY × TREATMENT for only heart rate (heart rate: $F(2,80) = 6.88$, $p < 0.05$, $\eta^2 = 0.15$). Further, a main effect of DAY was observed for heart rate ($F(2,80) = 8.72$, $p < 0.01$, $\eta^2 = 0.18$). A trend towards an effect of DAY on cortisol concentration was additionally observed ($F(2,64) = 2.83$, $p = 0.066$, $\eta^2 = 0.08$). Furthermore, the interaction DAY × SEX was not significant.

3.4. Anticipation

Baseline levels of the cardiovascular stress parameters remained relatively unaffected over the course of the investigation (Figs. 2 and 3), and were comparable between both groups. Consistent with this, the repeated measures ANOVA, with DAY (Day 1, 2, 3) as the repeated measurement factor, and TREATMENT (SECPT vs. control) and SEX (men vs. women) as between group factors showed no interaction effects of DAY × TREATMENT or DAY × SEX.

4. Discussion

The SECPT is an established stress test that can activate the HPA axis and the SNS (Schwabe et al., 2008); however, it requires substantial time and personal resources since each participant must be tested sequentially. Thus, the present study assessed whether the SECPT elicits the stress responses of the HPA axis and the SNS when it is performed in groups. Further, we determined whether habituation and/or anticipation effects occur when the test is administered repeatedly on three consecutive days.

Results demonstrated that the grouped SECPT activated the HPA axis and the SNS, as indicated by a significant increase in cortisol concentration and cardiovascular parameters (systolic and diastolic blood pressure, heart rate). Furthermore, the subjective perceived stress increased. The increase of the cardiovascular parameters could be primarily explained by the physiological cold pressor and the cortisol increase by the social evaluative components (permanent investigator observation, video documentation, and the presence of other participants; Dickerson and Kemeny, 2004; Schwabe et al., 2008).

Further, the rapid increase of cardiovascular parameters and the delayed increase of cortisol was comparable to that observed in previous studies wherein participants were tested individually (Schwabe et al., 2008; Schwabe and Wolf, 2009). Moreover, blood pressure and heart rate increases

occurred rapidly (the peak reaction was at least 1 min after hand immersion) and returned to baseline levels 15 min after the SECPT, which is consistent with previous experiments (Greene et al., 1965; Palmer et al., 1987; Llabre et al., 2001; Mourot et al., 2009). In addition, subjective stress perception was maximal at the beginning of the hand immersion.

In contrast to cardiovascular parameters and subjective stress perception, the cortisol reaction was delayed, which is additionally consistent with many previous studies (e.g. Dickerson and Kemeny, 2004; Schwabe et al., 2008). As a result of this time lag, we measured a cortisol response 15 min after the end of the SECPT.

Thus, our results, as well as the results of von Dawans et al. (2011), show that stress can be significantly elicited in a grouped experimental design. Moreover, the increases in stress parameters observed in the present study are comparable to those found when participants are tested individually (as mentioned before). Additionally, the average time the participants kept their hand in the water was also similar to single tested individuals (Schwabe et al., 2008). Furthermore, the stress responses induced by the SECPT were comparable between male and female participants. These results are consistent with previous studies using the SECPT (e.g. Schwabe et al., 2008; Schwabe and Wolf, 2009); however, many earlier studies reported a larger salivary cortisol response in men during psychological laboratory stress tasks (Kudielka et al., 2009). In contrast, subjective stress perception is typically higher in women (Edwards et al., 2004; Thorn et al., 2004); this might result from a higher motivation in men to endure pain, respectively stress (Jackson et al., 2002). Moreover, procedural variables such as the sex and professional status of the investigator (Kállai et al., 2004; Gijsbers and Nicholson, 2005), or beliefs concerning the maximal amount of pain (Robinson et al., 2003) may influence stress perception. Some of these factors may have played a role in our experimental design; however, as these effects reciprocally influence each other, their potential overlap may have rendered them immeasurable.

Over the course of the three experimental days, SECPT-induced blood pressure increases remained at a similar level. However, a significant effect of habituation was exclusively observed in heart rate, which decreased with the number of SECPT repetitions. The cortisol stress reaction also decreased, but without significance. This finding contrasts the clear habituation of the cortisol response to the TSST, observed by Pruessner et al. (1997) and Schommer et al. (2003). Therefore, it is conceivable that the cold pressor is responsible for the reduced cortisol habituation during the SECPT.

The absence of blood pressure habituation could have resulted from the relatively long time interval (24 h) between each repetition. Habituation of cardiovascular parameters (which may mainly be influenced by the cold pressor) may be particularly sensitive to the number of repetitions and the time interval between the repetitions. When the time interval was one day, no habituation towards the CPT was observed after five repetitions (Ingersoll and Brent, 1992). In contrast, habituation of blood pressure was observed when the CPT was repeated seven times during a 45-min session (Zbrożyna and Krebbel, 1985). Perhaps these differences in habituation result from the fact that the response recovers following a period of time without stimulus confrontation (Rankin et al., 2009).

In addition to the stressor, the preceding mental confrontation with it can induce a stress reaction. Such anticipation effects have been described for blood pressure, which can rise before the CPT begins (Kolk and van Well, 2007). Additionally, psychological stressors with a social evaluative component can trigger anticipatory increases in blood pressure (Bielfeldt, 2001), heart rate (Preston et al., 2007), and cortisol (Verschoor and Markus, 2011). Furthermore, these stressors can also elicit feelings similar to stress, such as anxiety (Preston et al., 2007).

Given that we combined physiological and psychological stress, we also expected to observe anticipatory effects, at least in some of the measured stress parameters; however, such an effect could not be observed, although the stress test induced affective and physiological stress responses. This may have been because the stressor was relatively moderate, and the participants consequently were not overly concerned with it in advance.

There is a limitation of the present study: we did not measure the menstrual cycle phase of the female participants. According to Kudielka et al. (2009), women in their follicular phase exhibit a lower cortisol stress response compared to those in the luteal phase. However, it was not feasible for us to control for the phase of the menstrual cycle because most of the naturally cycling woman did not known in which menstrual phase they were in.

In summary, the present study demonstrates that a stress reaction towards the SECPT can be induced in a group design. Both the HPA axis and the SNS were successfully activated. Thus, we have described a rapid and effort-saving method that enables the simultaneous examination of stress responses in several participants. Furthermore, the running costs after acquisition of the basic equipment (blood pressure monitors, cameras) are only marginal. Thus, the SECPT for groups is also a very cost-effective way to investigate several participants over a prolonged period of time.

Further, the repeated administration of the grouped SECPT leads to habituation exclusively regarding heart rate.

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Conflict of interest

None declared.

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