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Public speaking in front of an unreceptive audience increases implicit power motivation and its endocrine arousal signature ☆

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ABSTRACT

The present study explored the motivational characteristics of the Trier Social Stress Test (TSST; Kirschbaum, Pirke, & Hellhammer, 1993). Seventy-two participants either completed the public-speaking component of the TSST or, as a control condition, the friendly TSST (Wiemers, Schoofs, & Wolf, 2013) and wrote picture stories both before and after treatment. Stories were coded for motivational imagery related to power, achievement, and affiliation as well as for activity inhibition, a marker of functional brain lateralization during stress. The TSST had a specific arousing effect on power motivation, but not on other motivational needs, on activity inhibition, or on story length. TSST-elicited increases in power imagery, but not in achievement or affiliation imagery, were associated with a relatively greater salivary alpha-amylase response and with a relatively lesser salivary cortisol response. These findings suggest that the TSST specifically induces power-related stress.

Introduction

Since its introduction more than 20 years ago (Kirschbaum et al., 1993), the Trier Social Stress Test (TSST) has become the gold standard in human stress research, with hundreds of published studies using this procedure as well as several meta-analyses and in-depth reviews about its properties and effects (e.g., Allen et al., 2014; Campbell and Ehlert, 2012; Foley and Kirschbaum, 2010). During the original version of the TSST, research participants present, after a brief preparation period, a job talk in front of an unreceptive audience of two examiners and are then required to perform a subtraction task. Once they make a mistake, examiners ask them to start over again.

This procedure, as well as a variant of the TSST that omits the subtraction task (Wiemers et al., 2013), elicits robust and reliable activation of the hypothalamic-pituitary-adrenal (HPA) stress axis, as reflected in a transient steep increase of cortisol and the adenocorticotropic hormone (ACTH) during and immediately after the TSST (Kirschbaum et al., 1993). It also elicits robust activation of the sympathetic nervous system (SNS), as indexed by transient increases in heart rate and the sympathetic catecholamines adrenaline and noradrenaline (Schommer et al., 2003) as well as in salivary alpha amylase, a biomarker of the noradrenergic component of SNS activation (Ditzen et al., 2014; Kuebler et al., 2014; Rohleder and Nater, 2009; Wiemers et al., 2013). From a motivation science perspective, it is clear that the TSST induces a strong, aversive motivational state. However, because different types of stressors impact different motivational systems (e.g., food deprivation for energy balance; social isolation for affiliation; see also Kudielka et al., 2009; Stroud et al., 2002), the question is what *type* of motivational need is challenged by the TSST. In the present research, we address this issue by examining motivational changes induced by the TSST and how they relate to endocrine changes.

In so doing, we used measurement methods developed and extensively validated in the context of research on implicit motives. The implicit motive approach to human motivation is based on the assumption that people are characterized by a handful of universal motivational needs (McClelland, 1987; Schultheiss, 2008). The most frequently studied motives are the need for power (frequently abbreviated as n Power), a concern with having impact on others; the need for achievement (n Achievement), a concern with mastering challenging tasks; and the need for affiliation (n Affiliation), a concern with establishing, maintaining, and restoring friendly relationships with others (McClelland, 1987; Schultheiss, 2008).

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Measures for these needs were originally developed by experimentally arousing a given need and then studying how the content of fantasy stories changes that research participants write about pictures with ambiguous social cues (Winter, 1998). For instance, in the case of n Power, researchers examined the stories of individuals who were running for office versus those who were not (Veroff, 1957), of individuals who knew how to cheat on a card game versus those who did not (Uleman, 1972), or of individuals who listened to inspirational speeches versus of those who listened to travel descriptions (Winter, 1973). Across studies, individuals whose need for power had been aroused in these ways, but not control-condition participants, showed a similar tendency to infuse their stories with imagery related to strong, forceful action, control or regulation of others, persuasion and arguing, or impressing others (Winter, 1991). The resulting coding systems for n Power, and those for other motives derived in a similar manner, were thus sensitive to causal manipulations of motivational states (McClelland, 1958, 1987, chapter 6; see also Borsboom et al., 2004 Because they do not correlate substantially with self-report measures purported to assess the same motivational needs (see Köllner and Schultheiss, 2014, for meta-analytic results), picture-story measures of motives have been termed *implicit* by McClelland et al. (1989).

Although the picture-story measurement approach was subsequently used primarily to assess stable individual differences in individuals' implicit motivational needs, its sensitivity to situational changes in motivation makes it an excellent tool for exploring which specific motivational needs are aroused by a given situational cue such as the TSST (see Schultheiss and Pang, 2007, p. 338 f.). This property of the Picture Story Exercise (PSE; McClelland et al., 1989), as the method has become known, has already been used successfully in psychoendocrinological research on the effects of movies on hormonal changes. Here, the PSE was used as a manipulation check to verify that movies intended to arouse power or affiliative concerns did, in fact, also result in the expected motivational changes (Schultheiss et al., 2004; see also Wirth and Schultheiss, 2006).

So which motivational need should the TSST impact the most? We hypothesize that it is a specific stressor for n Power, because the mock job interview around which most of the TSST revolves requires a person to be persuasive and convincing, to impress others—in short: to have an impact on other people. This is the core incentive for n Power, but not for other motivational needs. If our reasoning is correct, then the TSST should lead to a specific increase in power-related imagery on the PSE, but not in other types of motivational imagery (Hypothesis 1). Some supportive evidence comes from a study by Fodor and Wick (2009), who had research participants give an impromptu speech in front of two judges acting in a negative manner. Participants with a strong dispositional n Power, measured before the task, showed greater activation of the corrugator muscle and also reported higher levels of anxiety than participants low in n Power. This difference did not emerge in a control condition in which the audience was supportive and friendly. Other supporting evidence was reported by McClelland et al. (1985), who observed that highly power-motivated individuals, but not other participants, responded with an increase in salivary noradrenaline to an exam, that is, to a situation in which an individual is subject to others' critical evaluation. Although these studies did not address whether a public-evaluation challenge actually increases power motivation in a transient manner, it is consistent with our reasoning that a situation akin to the TSST should be a relevant stressor specifically for n Power.

If our hypothesis is correct, then TSST-induced changes in n Power should be associated with a specific hormonal signature of power arousal. Arousal of n Power has been linked to the release of noradrenaline (and sometimes also adrenaline) in early psychonedocrinological research by McClelland and colleagues (e.g., McClelland et al., 1985; for reviews, see McClelland, 1987, 1989). More recent research shows that dominance success is related to quick, transient increases in testosterone among men high in n Power, an effect that Schultheiss (2007) explained as follows, based on Sapolsky's (1985, 1986) earlier work on the interaction between stress hormones and gonadal steroid release: to the extent that a challenge activates a concern for power, it will elicit a stronger response from the SNS than from the HPA axis. In men, this results in a net increase of stimulatory action of catecholamines (relative to cortisol's inhibitory action) on the testes' Leydig cells and thus to the rapid testosterone increases observed in research on male power motivation. According to this account, power motivation arousal should lead to greater SNS activation and comparatively weaker HPA activation (although both can be activated to some extent). We thus expected variations in power motivation increases in response to the TSST to be associated with greater SNS activation and lesser HPA activation (*Hypothesis 2*).

We tested these hypotheses in a study in which participants were either exposed to a variant of the TSST that featured the job interview task, but not the mental-arithmetic task (Wiemers et al., 2013), and thus represented a power-related incentive or to a control version of this task that explicitly lacked all power-related stressors, the friendly TSST (f-TSST; Wiemers et al, 2013). To assess changes in motivational states, we administered parallel forms of the PSE in a counterbalanced order before and after the treatment and later analyzed them for changes in motivational imagery related to power, achievement, and affiliation as well as for changes in activity inhibition, a linguistic marker of functional brain asymmetry (Schultheiss et al., 2009) that has been related to n Power and endocrine or physiological stress responses in past research (Fontana et al., 1987; McClelland, 1979; Schultheiss and Rohde, 2002). Analyses for activity inhibition were exploratory. To measure activation of stress axes, we repeatedly sampled saliva before and after treatment and later determined levels of cortisol (HPA axis) and alpha amylase (SNS axis).

Methods

Participants

A total of 95 (48 males) participants between 18 and 32 years initially took part in the experiment. Participants were excluded from participation if they previously participated in the TSST, smoked, had a body mass index (BMI, weight in kg/(height in m)^2) under 19 or over 30, were in medical treatment, or took medication influencing the HPA axis. Additionally, pregnant or menstruating women or those taking hormonal contraception were excluded from participation as well. Participants received a compensatory payment of 25€. The study was approved by the local ethics committee of the Faculty of Medicine of the Ruhr–University Bochum, and the Declaration of Helsinki was followed. Results from this study that were unrelated to the research questions addressed here were published by Wiemers et al. (2014).

Due to technical problems, we had to exclude 19 participants. Three further participants from the control group had to be excluded from analyses because they exhibited outlier cortisol values reflecting a stress response to the control condition. One participant of the stress group had to be excluded since he previously took part in the TSST. This left 72 participants (38 males) in the analyses, 37 in the stress, and 35 in the control group. Mean age was 24.03 years, and mean BMI was 22.63. There were no differences between the stress and control group in age or BMI ($p > .40$).

Procedure

Participants first provided informed consent and afterwards completed the first PSE (T1). Then they provided a baseline saliva sample. Afterwards, they were randomly exposed to either the stress (TSST) or control procedure (f-TSST). Both procedures took 15 min. Back in the experimental room, after the respective procedure, participants provided a further saliva sample (+1 min) and completed the second PSE (T2) before providing the third saliva sample (+15 min). A fourth saliva

sample was provided by the participants 15 min later (+30 min). Since cortisol follows a circadian rhythm, all testing was carried out in the afternoon starting between 1:00 p.m. and 4:45 p.m.

Experimental condition

To induce psychosocial stress, we used a modified version of the TSST, which reliably leads to an activation of the HPA axis and an increase of cortisol concentration (Wiemers et al., 2013). After a short preparation time, participants had to give a free speech for 10 min in a mock job interview about their personal characteristics in front of a committee (one male, one female) acting in a reserved manner and wearing white coats. Participants were also videotaped.

In the control condition, participants were administered the f-TSST (Wiemers et al., 2013). After a short preparation time, participants had to give a free speech about their career aspirations for 10 min in front of a committee. However, the committee was friendly and supporting and there was no videotaping. The f-TSST does not lead to an activation of the HPA axis (Wiemers et al., 2013).

Motive assessment

Participants' implicit motives were assessed by a 6-picture PSE (Schultheiss and Pang, 2007). Pictures were divided into two sets of three pictures each, with Set A consisting of the pictures *Boxer*, *Women in Laboratory*, and *Trapeze Artists* and Set B consisting of the pictures *Soccer Duel*, *Gymnast*, and *Workers* (see Schultheiss and Pang, 2007, for details). Pictures were selected for their ability to elicit high levels, and thus high variance, of power and achievement imagery (see Schultheiss and Pang, 2007, Fig. 19.2); they also yield, at a lower level, scores for n Affiliation (Pang, 2010; Schultheiss and Pang, 2007). One set was presented before the stress or control condition (T1), the other directly after (T2). Set sequence (AB, BA) was counterbalanced across participants and orthogonal to experimental conditions. Within each set, the presentation of pictures was random. Pictures were presented on a computer screen, and participants wrote their stories in a text box on the computer. Stories were later scored for imagery related to n Power (e.g., controlling, impressing, and persuading others), n Achievement (e.g., unique accomplishments or doing a task well), and n Affiliation (e.g., dialog or expression of friendly feelings towards others) by a trained coder using Winter's Manual for Scoring Motive Imagery in Running Text (Winter, 1994). The coder was blind to experimental condition and had previously exceeded 95% inter-scorer agreement on German calibration materials prescored by experts. Story word count and activity inhibition, defined as the frequency of the German negation *nicht* (see McClelland, 1979), were determined with the help of a word processor.

Hormone assessment

Participants were advised to refrain from eating and drinking anything but water 1 h before testing and taking medication, drinking alcohol, or doing excessive sports the day before. Saliva was sampled with Salivettes ® (Sarstedt, Nuernbrecht, Germany). Cortisol was analyzed by an immunoassay (IBL, Hamburg, Germany). Inter- and intra-assay variabilities were below 10%. Additionally, salivary alpha-amylase was analyzed as an indirect marker for sympathetic nervous system activity as described elsewhere (Rohleder and Nater, 2009). Assay sensitivity for cortisol was 0.16 ng/ml and for salivary alpha-amylase 4 U/ml. Due to insufficient saliva sample volume, sample contamination, and sample loss, for cortisol n = 68 at baseline, 64 at +1 min, and 65 at +15 min and +30 min, respectively. For amylase, n = 65 at baseline, 64 at +1 min, and 63 at +15 min and +30 min, respectively.

Statistical analyses

We used repeated-measures ANOVA and regression/correlation analysis to test our main hypotheses, with *t* tests for follow-up testing. We report effect size estimates as partial η^2, Cohen's *d*, and correlation/regression coefficients (R^2, semipartial *r*).

Results

PSE scores

We conducted repeated-measures ANOVAs for PSE motive and AI scores (square root-transformed due to deviations from a normal distribution) and word count, with time of PSE as within-subject factor (before or after stress or control condition) and condition (stress or control) as between-subject factor. We obtained a significant time × condition effect for n Power, $F(1, 70) = 4.91$, partial $\eta^2 = .066$, $p = .03$. Planned comparisons showed that there were no differences between the stress and control group in n Power before the stress or control procedure (see Table 1). Afterwards, however, participants showed higher n Power after the stress condition than after the control condition, and participants in the stress condition moreover showed a significant increase in their n Power levels that was not in evidence for control-group participants (see Fig. 1). Additional analyses did not reveal conclusive evidence for a differential impact of TSST stress on the 6 specific coding categories for n Power. Repeated-measures ANOVAs for n Achievement, n Affiliation, or AI did not yield significant time × condition effects, all Fs < 0.71, all partial η^2s < .010, all ps > .41. Importantly, experimental condition also had no significant effect on the length of the PSE stories, that is, the matrix in which motivational imagery was assessed (for the condition × time effect, $F[1, 70] = 0.39$, partial $\eta^2 = .006$, $p = .53$). None of these findings was significantly moderated by gender.

Table 1
Mean (SD) values for PSE raw motive, AI, and word count scores and within-group (df = 36 for TSST and 34 for control) and between-group (df = 70) difference significance tests.

	Pre	Post	*t*	*d*	*p*
	n Power[a]				
Stress	2.41 (2.40)	3.35 (2.20)	2.26	0.49	.03
Control	2.54 (1.67)	2.29 (2.41)	−0.82	−0.17	.42
t	−0.48	2.35			
d	−0.11	0.55			
p	.63	.02			
	n Achievement[a]				
Stress	4.32 (2.58)	4.11 (2.60)	−0.39	−0.09	.70
Control	4.57 (3.12)	4.20 (2.81)	−0.50	−0.11	.62
t	−0.20	−0.07			
d	−0.05	−0.02			
p	.84	.94			
	n Affiliation[a]				
Stress	0.81 (1.17)	0.81 (1.35)	−0.17	−0.04	.86
Control	0.83 (1.01)	0.51 (0.52)	−1.48	−0.35	.15
t	−0.19	0.92			
d	−0.04	0.22			
p	.85	.36			
	Activity inhibition[a]				
Stress	2.81 (2.37)	2.51 (2.10)	−0.69	−0.12	.50
Control	2.23 (1.48)	2.37 (2.07)	0.06	0.01	.95
t	0.93	0.30			
d	0.22	0.07			
p	.36	.77			
	Word count				
Stress	314 (89)	304 (105)	−1.15	−0.10	.26
Control	298 (93)	296 (108)	−0.27	−0.02	.79
t	0.75	0.33			
d	0.18	0.08			
p	.46	.74			

[a] *t*-tests and effect size estimates are based on square-root-transformed variables.

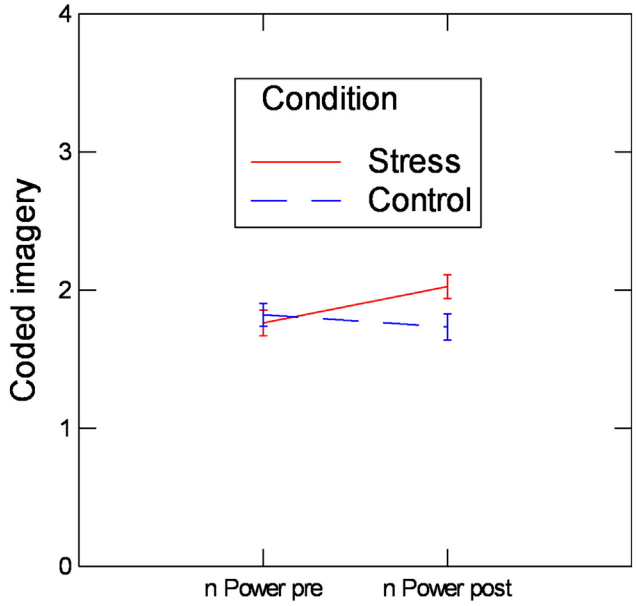

Fig. 1. n Power imagery scores (square-root-transformed, ±SEM) before and after the stress (TSST) or the control condition (f-TSST).

Cortisol

Since cortisol data were not normally distributed, all data were subjected to a log-transformation after adding a constant of 1. Experimental condition had an influence on cortisol concentrations. The TSST resulted in an increase of cortisol concentration in participants while the f-TSST did not. This was reflected in the results of a repeated-measure analysis of variance (ANOVA) conducted with time of measurement (baseline, +1, +15, +30) as within-subject variable and condition (stress vs. control) as between-subject variable. Results show a significant time × condition interaction effect, $F(3, 171) = 24.53$, partial $\eta^2 = .301$, $p < .0000005$. Follow-up t tests show that the stress group shows significantly higher cortisol concentrations than the control group in the measurements 15 min and 30 min after the end of the stressor (see Table 2).

Alpha amylase

Since amylase data were not normally distributed, all data were subjected to a log-transformation after adding a constant of 1. A repeated-measures ANOVA with time of measurement as within-subject variable and condition as between-subject variable revealed a significant main effect of time, $F(3, 168) = 5.04$, partial $\eta^2 = .082$, $p = .002$, which was mainly due to participants showing an overall amylase increase 1 min after completing the TSST or the f-TSST, $t(61) = 4.15$, $d = 0.44$, $p = .0001$, but not 15 min later, $t(61) = -1.06$, $d = -0.12$, $p = .30$. Thirty minutes later, amylase levels were significantly lower than at baseline, $t(60) = -2.74$, $d = -0.23$, $p = .008$. The condition × time effect failed to reach significance, $F(3, 168) = 1.93$, partial $\eta^2 = .033$, $p = .13$ (see Table 2).

Change correlation analyses

To test whether changes in n Power are differentially associated with changes in cortisol and amylase, we first created average scores across all three post-treatment assessments (log-transformed values) for each hormonal parameter and then residualized it for its respective log-transformed baseline (in this and all subsequent analyses reported in this section, we dropped one participant from the control condition whose post-treatment amylase residual score was identified as an outlier, studentized residual $t = -5.76$). This yielded residualized change scores for cortisol and amylase. In the stress condition, these change scores correlated at $r(32) = .47$, $p = .007$, and in the control condition, they correlated at $r(31) = .24$, $p = .18$, suggesting somewhat tighter functional coupling of stress axes in the former condition than in the latter (for the difference, $Z = 0.98$, $p = .33$). We then entered these scores, along with square-root-transformed n Power at T1, into regressions with square-root-transformed n Power at T2 as dependent variable. We thus tested whether treatment-induced changes in hormones that were independent of initial hormone levels predicted treatment-induced changes in n Power, above and beyond differences in initial n Power. As shown in Table 3, a greater increase in amylase and a lesser increase in cortisol were both associated with an overall increase in n Power among participants in the TSST stress condition, accounting for a significant overall variance increment in n Power scores. This effect did not emerge in the f-TSST control condition.

When we repeated the analyses reported in Table 3, but included either achievement or affiliation scores instead of power scores, cortisol and amylase change scores failed to predict changes in these motives in the stress condition, $ps > .17$. The same was also true for the control condition, $ps > .32$, with the exception of a specific positive association between cortisol changes on affiliation changes, $B = 0.55$, $SE = 0.22$, semipartial $r = .17$, $t(27) = 2.55$, $p = .02$.

Discussion

We conducted the present research to characterize the type of motivation that the TSST, a widely used procedural protocol for the assessment of stress responses in humans, arouses in research participants. The present findings provide clear-cut support for our first hypothesis, which stated that the TSST arouses power motivation. Participants in the TSST condition showed a significant increase in power imagery in

Table 2
Mean (SD) raw values for salivary alpha-amylase and cortisol.

	Baseline	1 min	*d*	15 min	*d*	30 min	*d*
Amylase (U/ml)							
Stress	69.30 (49.61)	116.39 (77.94) ***	0.65	81.10 (69.92)	0.04	65.51 (47.42)	−0.13
Control	83.09 (79.85)	134.66 (116.28)	0.33	83.78 (92.39)	−0.12	70.02 (79.56) *	−0.29
t(*df*)	−0.45 (63)	0.30 (62)		0.25 (61)		0.32 (61)	
d	−0.11	0.08		0.06		0.08	
p	.66	.76		.80		.75	
Cortisol (nmol/l)							
Stress	7.92 (4.75)	10.64 (5.97) ***	0.58	14.92 (10.27) ***	0.98	11.56 (7.07) ***	0.66
Control	9.19 (4.42)	8.69 (4.70)	−0.13	8.28 (4.11)	−0.21	6.56 (2.87) ***	−0.69
t(*df*)	−1.43 (66)	1.49 (62)		3.53 (63)		3.97 (63)	
d	−0.35	0.37		0.88		0.99	
p	.16	.14		.0008		.0002	

Note. Asterisks (***$p < .005$, *$p < .05$) and horizontal *d*s denote differences relative to baseline. Degrees of freedom vary due to missing data. All *t* tests and effect size calculations were performed on log-transformed variables.

Table 3
Testing for effects of amylase and cortisol (residualized change scores) on n Power at T2 (transformed scores) in stress (TSST) and control (f-TSST) conditions.

	Stress					Control				
	B	*SE*	Semipartial *r*	*t*	*p*	*B*	*SE*	Semipartial *r*	*t*	*p*
n Power T1	−0.068	0.152	−.07	−0.45	.66	0.263	0.238	.21	1.11	.28
Amylase	0.517	0.209	.41	2.47	.02	−0.013	0.205	−.01	−0.06	.95
Cortisol	−0.577	0.222	−.43	−2.59	.02	−0.288	0.434	−.12	−0.66	.51
		$R^2 = .240$, $F(3, 28) = 2.94$, $p = .05$				$R^2 = .061$, $F(3, 27) = 0.58$, $p = .63$				

their PSE stories from before to after the treatment. Post-treatment, their n Power scores were also significantly higher than those of participants who had been administered the friendly TSST, a non-stressful control task. The n Power scores of these latter participants did not change from before to after the treatment.

These findings are due to the specific content of the stories that participants wrote. They cannot be attributed to differential changes in overall story length because the latter variable did not significantly change as a function of experimental condition. They are also specific to n Power because we failed to observe significant effects for the needs for achievement and affiliation as well as for activity inhibition, a frequent moderator of physiological and behavioral correlates on n Power. We acknowledge, however, that our PSE measure was more suitable for the assessment of power and achievement than for the assessment of affiliation imagery, as reflected in the overall lower scores of the latter, compared to the former. Replication studies should therefore employ PSEs that elicit higher levels of affiliation imagery.

We also found support for our second hypothesis, which stated that TSST-induced increases in n Power should be associated with a specific hormonal signature reflecting relatively greater SNS activation than HPA activation (see Sapolsky, 1985, 1986; Schultheiss, 2007). Consistent with this prediction, increases in n Power in response to the TSST were associated with significantly greater amylase increases as a marker of SNS activation and significantly weaker cortisol increases as a marker of HPA activation, despite the fact that both stress markers increased in response to the TSST. Thus, although the power stress inherent in the TSST activates both stress axes, a relatively greater SNS activation predicts a greater increase in n Power. This finding is fully consistent with McClelland's (1989) conclusion, based on his early psychoendocrinological research on human motivation that stressed power motivation leads to sympathetic activation. However, in contrast to this earlier research, which typically used measures of blood pressure, adrenaline, or noradrenaline to assess SNS activation (see McClelland, 1989, for a summary), we show here for the first time that it is also possible to document this phenomenon with salivary alpha amylase, a biomarker of SNS activity (Nater and Rohleder, 2009). The associations between motivational and hormonal changes in the stress condition were specific to n Power, too: cortisol and amylase changes elicited by the TSST did not predict changes in n Achievement or n Affiliation. (In the control condition, hormonal changes were related to motivational changes only in one instance: cortisol increases were associated with n Affiliation increases. This finding is reminiscent of, but not identical with, Wirth and Schultheiss's (2006) observation of positive associations between *basal* cortisol and n Affiliation scores on the PSE.)

However, although the differential effect of amylase and cortisol changes on n Power are consistent with earlier research and our second hypothesis, it nevertheless represents a correlation, and strong causal inferences are therefore impossible to make. Future studies could address the causality issue by, for instance, examining effects of sympathetic catecholamine administration or hydrocortisone administration on changes in n Power or by blocking either adrenergic or glucocorticoid and mineralocorticoid receptors before participants enter the TSST and determine how such manipulations affect post-TSST n Power levels (see, for instance, Schwabe et al., 2010; Schwabe et al., 2013).

Another limitation of our study was the use of a modified TSST protocol that omitted the mental arithmetic task. Although we expect this task to be a power stressor as well, because the participant's behavior is subject to others' evaluation and control, and empirical replication of the present study with the full TSST protocol would be desirable to test this prediction.

A final limitation of our study is the failure to find a differential effect of experimental condition on changes in amylase. Amylase immediately and significantly increased in response to both the TSST and the f-TSST control condition, an effect that was in marked contrast to cortisol, which increased only in response to the TSST. Differential effects of amylase to public-speaking stressors such as the TSST have been obtained in previous studies that used rest or non-social tasks as control conditions (see Rohleder and Nater, 2009). We think it is actually a strength of the present study that the control condition is much more comparable to the stress condition, because it uses a similar task, including the presence of others, but replaces the social evaluation aspect with a social support context. Our findings are consistent with those of Wiemers et al. (2013), whose validation study for the f-TSST also documented an increase in salivary alpha amylase in the absence of a cortisol response. These authors concluded from their findings that the f-TSST features a mild emotional arousal or a slight physical demand aspect that is sufficient to elicit an SNS response, but not an HPA response (see also Nater and Rohleder, 2009). Note that mere SNS activation by itself apparently does not suffice to increase n Power because we failed to observe an increase in n Power or a correlation between n Power changes and amylase changes in the control condition.

To conclude, using content-coding of imaginative stories written before and after the TSST or a control task, we have shown in the present study that the TSST arouses participants' implicit power motivation, but not their needs for achievement or affiliation. We have also shown that the TSST's power-arousing effect is associated with relatively greater SNS activation, as approximated by salivary alpha-amylase increments, than HPA activation, as assessed by salivary cortisol increments. Our results therefore suggest that the TSST primarily induces power stress, but not achievement- or affiliation-related stress, in test takers, and that this characteristic of the TSST should be taken into account when interpreting results obtained with this procedure.

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