Threat Appraisals Predict Cortisol Responses to Repeated Psychosocial Stress in Low but not High Subjective Social Status Individuals

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ABSTRACT

Threat Appraisals Predict Cortisol Responses to Repeated Psychosocial Stress in Low but not High Subjective Social Status Individuals

A thesis presented to the Department of Psychology

Graduate School of Arts and Sciences
Brandeis University
Waltham, Massachusetts

By Alexander Fiksdal

While a substantial body of research has demonstrated robust relationships between social status and health, the exact mechanisms involved remain unclear. Maladaptive hypothalamus-pituitary-adrenal (HPA) axis stress responses have been implicated in the pathogenesis of a variety of disorders, and subjective social status (SSS) has been found associated with HPA reactivity. Since no studies have addressed exposure to repeated stress, we set out here to test cognitive appraisal and SSS as predictors of cortisol reactivity to repeated psychosocial stress.

Twenty-six participants (14 women; mean age=21.96 yrs.) were exposed to the Trier Social Stress Test (TSST) twice on consecutive days. Appraisal processes were assessed immediately prior to each TSST. Salivary cortisol was measured 1 minute prior, and 1, 10, 30, 60, and 120 minutes post TSST. SSS relative to US and community was assessed using MacArthur ladders.
Both TSSTs induced marked HPA activation (p<.001), with lower responses to second exposure (p=.002). Community SSS was inversely related with HPA axis stress responses (TSST1: trend, r=-.35, p=.08; TSST2: r=-.59, p=.002). Further regression analyses revealed a significant interaction of threat appraisals and SSS predicting HPA responses to the second, but not the first, TSST (beta=-.478; p=.011).

In summary, in low but not high SSS individuals, threat appraisals were positively related with cortisol reactivity upon repeated exposure. Future research should investigate possible long-term health consequences associated with these relationships.
# Table of Contents

Abstract .......................................................................................................................... ii
Introduction .................................................................................................................. 1
Methods ...................................................................................................................... 5
  Procedure ................................................................................................................ 5
Participants .................................................................................................................. 5
  Acute psychosocial stress task ............................................................................. 6
Measures ..................................................................................................................... 6
Statistical analysis ..................................................................................................... 8
Results ....................................................................................................................... 8
  Preliminary analyses ............................................................................................. 8
Endocrine stress responses ....................................................................................... 9
  Associations of SSS and stress appraisals with stress responses ....................... 9
  Testing alternative pathways: objective measures of social status ................. 10
Discussion ................................................................................................................ 11
Tables and Figures ................................................................................................... 15
References ............................................................................................................... 19
List of Tables

Table 1  Means and standard deviations of PASA scores and cortisol increases in response to stress (delta cortisol) during first (TSST1) and second (TSST2) stress exposure.

Table 2  Coefficients of the regression model testing gender, depression (CES-D), SSS, threat appraisal, and SSS by threat appraisal interaction predicting delta cortisol for TSST1 and 2.
List of Illustrations/ Figures

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 1</td>
<td>Mean cortisol concentrations by time for TSST1 and 2. The gray shaded region indicates when the TSST was administered.</td>
<td>16</td>
</tr>
<tr>
<td>Figure 2</td>
<td>Scatterplots of threat appraisals and community SSS on delta cortisol concentrations for TSST1 and TSST2.</td>
<td>17</td>
</tr>
<tr>
<td>Figure 3</td>
<td>Threat appraisals predicting delta cortisol concentrations by low and high SSS for TSST2.</td>
<td>18</td>
</tr>
</tbody>
</table>
1 Introduction

Previous research has indicated that social status is an important predictor of overall health. The link between socioeconomic status (SES) and health outcomes is especially well established. Individuals lower on the socioeconomic gradient have been shown to have higher rates of disease and mortality than those with greater economic advantage (Adler, Boyce et al. 1994). However, SES-linked health disparities cannot be completely explained through conventional causes such as access to health care and nutrition (Adler, Boyce et al. 1994), and have been observed in countries with high overall standards of living (Singh-Manoux, Adler et al. 2003). Additional factors beyond those directly related to economics must play a role in this relationship as well.

It is not completely understood what factors beyond those related to economics are driving the relationship between SES and health. Subjective Social Status (SSS) is one measure of particular interest that may help fill this gap. SSS is a form of self-rated social status, often visualized on a ladder (Miyakawa, Magnusson Hanson et al. 2011). Previous research has indicated that it is a reliable predictor of general health (Adler, Epel et al. 2000; Operario, Adler et al. 2004). Associations between self-reported health and SSS are especially robust, and have been observed across a variety of populations including young people (Karvonen and Rahkonen 2011), older Taiwanese individuals (Hu, Adler et al. 2005), and a large sample of the Swedish working population (Miyakawa, Magnusson Hanson et al. 2011).

The associations between SSS and health go beyond purely self-reported health. In a recent study of 3,080 Germans, SSS was negatively associated with hypertension, diabetes, metabolic syndrome, and obesity (Hegar, Doring et al. 2011). While factors
such as educational level and socioeconomic status (SES) certainly contribute to health outcomes (Suresh, Sabanayagam et al. 2011), the relationship between SSS and health cannot be explained fully by these measures. For example, in a 2007 study investigating SES, SSS, and cardiovascular risk in middle-aged women, SSS relative to the individual’s community was inversely related to anxiety, stress, and daytime ambulatory diastolic blood pressure after controlling for conventional measures of SES (Ghaed and Gallo 2007). Another large study of civil servants in London found that individuals who rated themselves with lower SSS showed higher rates of angina, diabetes, respiratory illness, poor self-rated health, and depression; again, these associations were not completely explained by SES (Singh-Manoux, Adler et al. 2003). Taken together, the evidence indicates that the exact mechanisms involved in the SSS-health association remain unclear.

Psychological stress has been associated with a host of negative health outcomes (Cohen, Janicki-Deverts et al. 2007). One important mechanism involved in the stress response is the hypothalamus-pituitary adrenal (HPA) axis, which affects a variety of systems that impact physical health, including inflammation and immune system functioning (McEwen, Biron et al. 1997; Sapolsky, Romero et al. 2000). Adaptive functioning of this system helps protect the body and mobilize important resources in order to confront immediate threats; however, chronic exposure to stress may result in the emergence of maladaptive responses that pose long-term disease risks (McEwen 1998; Sapolsky, Romero et al. 2000; Chida and Hamer 2008). Over time, chronic stress can lead to physiological responses that are prolonged, inadequate, or lack adaptation to repeated stress (McEwen 1998). In the case of secretion of glucocorticoids such as
cortisol, inadequate responses may in turn result in the disinhibition of pro-inflammatory cytokines (McEwen 1998). The resulting disinhibition of the inflammatory response is of particular concern, as that has been found to predict all-cause mortality in older adults (Harris, Ferrucci et al. 1999).

Researchers investigating the relationship between objective measures of social status and health have proposed psychosocial factors as possible mediators (Chen 2007; Miller, Chen et al. 2009). In particular, control has been shown to be a predictor of health, with those who perceive less of it having higher rates of heart disease and other negative health outcomes (Chen 2007). Stress is a pathway that may help explain these relationships. In a study of low and high SES adolescents, those with lower SES exhibited lower blood pressure in response to a laboratory stress task when provided with a control-enhancing intervention (Chen 2007). Additionally, low-SES individuals are more likely to interpret situations as threatening (Chen and Matthews 2003). Such threat appraisals have also been shown to mediate relationships between SES and physiological responses to stress (Chen, Langer et al. 2004; Chen, Hanson et al. 2006). These findings indicate that psychosocial factors, including subjective appraisals of situations, may help explain differences in stress responses based on measures of social status.

Cognitive appraisal processes are subjective evaluations of stressors and one’s resources available to confront them (Lazarus and Folkman 1984). Such processes encompass the subjective interpretations of stress and control described earlier, and have also been associated with other responses to psychosocial stress. Threat and challenge appraisals have been shown to predict subjective stress and performance on laboratory stress tasks (Tomaka, Blascovich et al. 1993). Anticipatory cognitive appraisals have also
been shown to reliably predict additional physiological responses to psychosocial stress, including cortisol reactivity (Gaab, Rohleder et al. 2005; Wirtz, von Kanel et al. 2007; Denson, Spanovic et al. 2009).

In the context of subjective measures of social status, stress research has not yet incorporated cognitive appraisal processes, and has been limited to single exposure events. One study found, surprisingly, that SSS was positively related to increases in cortisol concentrations following exposure to laboratory-induced psychosocial stress (Gruenewald, Kemeny et al. 2006). The underlying mechanisms involved in this observation and how they relate to long-term health remain unclear; however a protocol incorporating repeated testing might shed light on this unexpected finding. The stress test utilized in this study, the Trier Social Stress Test (TSST), reliably induces HPA-axis responses in 70-80% of individuals (Kirschbaum, Pirke et al. 1993). However, repeated exposure may be required to uncover meaningful individual differences in HPA-axis responses (Kirschbaum, Prussner et al. 1995), especially given that some maladaptive stress responses are characterized by a lack of adaptation to repeated stress (McEwen 1998). Finally, while previous research has suggested that differences in stress responses between low and high-SSS individuals may be due in part to differential susceptibility to threat appraisals (Chen and Matthews 2003; Chen, Langer et al. 2004; Chen, Hanson et al. 2006), to date there have been no studies directly testing such associations in the context of SSS and HPA-axis reactivity to psychosocial stress.

The aim of the current study is to investigate the relationships among SSS, psychosocial stress, and anticipatory cognitive appraisal through a protocol that incorporates repeated testing. In light of previous findings indicating a possible positive
relationship between SSS and HPA-axis stress responses, we first set out to confirm the
direction of that relationship with repeated testing. Secondly, we investigated associations
between appraisal processes and HPA-axis reactivity, and how those associations relate
to SSS. We then conducted additional analyses to determine if threat appraisals are
differentially related to HPA-axis stress responses in low-SSS individuals. Finally, in
order to explore alternative pathways we investigated stress appraisals and responses in
the context of objective measures of social status.

2 Methods

2.1 Procedure

Participants were recruited from Brandeis University and the local Waltham area
by posting flyers on campus and in local shops and restaurants. All participants were
invited to the laboratory on two consecutive afternoons as part of a larger research study.
During these sessions, participants received and completed informed consent forms and a
battery of questionnaires, including those described below. Participants then provided
saliva samples before and after being exposed to a standardized psychosocial stress test
(see below). Upon completion of the second day of testing, participants were debriefed,
paid $100, and sent home.

2.2 Participants

Thirty participants took part in the current study. Four exhibited a cortisol
baseline indicative of heightened anticipatory stress (greater than 15 nmol/l), and were
removed from analysis. The final sample consisted of twenty-six healthy young adults
(n=12 men and n=14 women). The mean age was 21.96 years (SD 4.51, Range 18-34),
with a mean BMI of 24.03 kg/m² (SD 3.22, Range 18.68-29.86). All participants were
screened for factors that may influence hormone responses to stress prior to testing. Exclusion criteria included tobacco use, chronic cardiovascular or psychiatric illness, and use of medications known to affect hormone levels, and experience with the Trier Social Stress Test (TSST).

2.3 Acute psychosocial stress task

The Trier Social Stress Test (TSST) consists of a public speaking and mental arithmetic task performed in front of a neutral audience and video camera. The test has repeatedly been found to induce profound cardiovascular and endocrine responses in 70-80% of individuals (Kirschbaum et al., 1993). Participants completed the TSST on consecutive days between the hours of 15:00 and 18:00 h. Saliva samples were collected 1 minute prior, and 1, 10, 30, 60, and 120 minutes post TSST.

2.4 Measures

2.4.1 Sampling methods and biochemical analyses

Saliva was collected using Salivette (Sarstedt, Newton, NC) collection system, and was stored at room temperature until completion of the session. Samples were then stored at -30°C until analysis. For analysis, salivettes were centrifuged for 5 minutes at 2000g and 4°C. Salivary free cortisol concentrations were then measured using commercial chemiluminescence immunoassay (CLIA; IBL-International, Toronto, Canada). Intra- and inter-assay CVs were below 10%.

2.4.2 Self-report measures

Primary and secondary appraisals were assessed using the Primary Appraisal Secondary Appraisal (PASA) scale developed by Gaab et al. (2005). This questionnaire consists of 16 items assessing four anticipatory cognitive appraisal processes based on
Lazarus and Folkman’s (1984) model: threat, challenge, self concept of own abilities (self efficacy), and control expectancy. Subscales consist of four items with a 6-point scale ranging from “Strongly Disagree” to “Strongly Agree”. The questionnaire was administered during the TSST procedure between the preparation and speech components, and all items addressed appraisals specific to the TSST participants were about to experience.

Subjective Social Status at the community and national level was assessed in the laboratory one day prior to the first TSST using the MacArthur Subjective Social Status Scale. Participants were asked to circle the step on a ladder (out of 10) that best described their status in comparison to their community and country. Items addressing parental education as a measure of objective social status were also included in the battery of questionnaires. Maternal and Paternal Education was defined as total years of formal education, assessed on 20-point scales.

In order to control for differences in psychosocial well being, the following self-report scales were used. Depressive symptoms were assessed using the Center for Epidemiologic Studies Depression Scale (CES-D). The CES-D is a validated 20-item measure on which participants rated the frequency of depressive symptoms over the previous week on a 4-point scale ranging from “Rarely” to “Most or all of the time” (Radloff 1977). The General Health Questionnaire (GHQ-12; (Goldberg, Gater et al. 1997) was also administered to detect possible psychiatric disorders. Additionally, the Perceived Stress Scale (PSS; (Cohen, Kamarck et al. 1983) was administered to measure perceived stress.
2.5 Statistical Analysis

All variables were tested for normality of distribution prior to analysis using the Kolmogorov-Smirnov procedure. A repeated measures ANOVA with day (2 levels; first vs. second TSST exposure) and sample time (6 levels) as within-subjects factors was used to test for differences in cortisol responses to the TSSTs between sampling times and days. All reported ANOVA results with sphericity assumption violations were corrected using the Greenhouse-Geisser procedure. Overall cortisol reactivity to each TSST was determined by calculating the maximum difference in cortisol concentrations from baseline to the highest value among the samples collected at +1, +10, +30, and +60 minutes post-TSST (delta cortisol). HPA axis habituation to repeated stress was determined by calculating the difference between the delta cortisol of TSST1 and TSST2. Pearson correlations were calculated to determine associations between SSS, PASA subscales, delta cortisol, and HPA axis habituation. Delta cortisol was included in regression models examining main effects of SSS and PASA subscales. An additional regression model was then conducted controlling for gender and depression and incorporating interaction effects of SSS and PASA subscales. SSS and PASA subscale scores were centered to avoid any possible collinearity issues in the interaction term. All statistical analyses were run on IBM SPSS Statistics Version 19 software.

3 Results

3.1 Preliminary Analyses

Mean SSS scores for US and community were 5.31 (SD 2.19) and 6.23 (SD 1.70, respectively. Group means for the CES-D, GHQ-12, and PSS were 15.11, 20.19, and 17.96, respectively. The sample CES-D mean was below the cut-off score of 20
suggested by Robison et al. (2002). PSS means were within .5 SD of US national means (Cohen 1988). Maternal and paternal education had means of 14.27 (SD=5.01) and 15.54 (SD=4.25) years, respectively. Descriptive statistics of PASA subscales and delta cortisol are displayed in Table 1. T-tests revealed that PASA subscales did not differ significantly from TSST1 to TSST2 (all p’s > .1).

3.2 Endocrine stress responses

A repeated measures ANOVA was computed to determine cortisol responses across sampling times and TSSTs. Results revealed a significant main effect of sampling time, F(2.19, 55.38)=16.98, p<.01, in line with HPA axis responses to the stress induction. A significant day by time interaction was found (F(2.41, 55.38)=3.82, p=.02, indicating differences in stress responses between the two TSSTs (see Figure 1). The results also revealed a significant day by time by gender interaction (F(2.63, 60.49)=4.03, p=.014. Comparison of maximum cortisol responses using independent samples t-test revealed significantly lower cortisol responses on secondary exposure (t(26)=3.09, p<.01).

3.3 Associations of subjective social status and stress appraisals with stress responses

In order to confirm the direction of the relationship between SSS and HPA-axis stress responses with repeated testing, we computed Pearson correlations testing the associations among community and national SSS, delta cortisol for both TSSTs, and HPA axis habituation. Community SSS was inversely related to delta cortisol (TSST1: trend, r=-.35, p=.08; TSST2: r=-.59, p<.01; see Figure 2). Associations between US SSS and HPA stress responses did not reach significance on either TSST (TSST1: r=-.14, p=.51; TSST2: r=-.3, p=.14). HPA axis habituation was not significantly associated with SSS (national SSS: r=.24, p=.24; community SSS: r=-.26, p=.1). To test the hypothesis that
stress appraisals are associated with HPA axis reactivity, we computed additional Pearson correlations testing the associations between PASA subscales and delta cortisol for both TSSTs. Threat appraisals were positively related to HPA stress responses with both TSSTs (TSST1: r=.43, p=.04; TSST2: r=.51, p=.01; see Figure 2). No other relationship between PASA subscales and corresponding TSST max deltas reached significance (all r’s < .33, all p’s > .13).

To test our hypothesis that low-SSS individuals experience increased stress responses concurrently with greater threat appraisals, we conducted hierarchical linear regression analyses for both TSSTs using a model predicting delta cortisol from gender, depression, community SSS, threat appraisals, and a threat X SSS interaction. Model coefficients for both TSSTs are displayed in Table 2. The model was significant for TSST2 (R^2=.68, p=.01), but not for TSST1 (R^2=.36, p=.27). Consistent with the observed Pearson correlations, community SSS and threat appraisals were reliable predictors of TSST2 delta cortisol (community SSS: β=-1.21, p=.04; threat appraisals: β=1.76, p=.05). The regression analysis also revealed a significant community SSS X threat interaction (β=-1.30, p=.01). As shown in figure 3, high threat appraisals were associated with higher cortisol reactivity in low but not high community SSS individuals.

3.4 Testing alternative pathways: objective measures of social status

In order to determine if SSS covaried with objective SES measures, we computed Pearson correlations between community and national SSS, paternal education, and maternal education. No associations between community SSS and objective measures of status reached significance (all r’s < .148, all p’s > .46). National SSS was positively associated with maternal education (r=.40, p=.04). To test whether parental education
was related to stress responses or appraisals, we computed Pearson correlations testing the associations between parental education, delta cortisol for both TSSTs, HPA-axis habituation, and PASA subscales. Parental education was not significantly associated with HPA-axis reactivity or habituation (all r’s < .17, all p’s > .41). The results also failed to reveal any significant relationships between maternal and paternal education and PASA subscales (all maternal r’s < .37, p’s > .08; all paternal r’s < .24, p’s > .27).

4 Discussion

We set out in the present study to investigate whether subjective social status would be related with more negative appraisals of a repeated acute stress situation, and with higher endocrine stress responses. Results indicate that individuals who rated themselves lower on community, but not US social status showed heightened HPA axis responses to initial and repeated acute stress exposure. In addition, HPA axis responses to initial and repeated stress were higher in those individuals who rated the situation as more threatening. Further analyses revealed an interaction of community SSS and threat appraisal in predicting cortisol responses to the second, but not initial stress exposure. This finding shows significantly stronger relationship of threat appraisals with HPA axis stress responses in individuals rating themselves lower on social status in the community.

Consistent with previous research showing that appraisal processes predict stress responses (Denson et al., 2009; Wirtz, 2007; Gaab et al., 2005), threat appraisals were positively associated with HPA-axis activation in response to psychosocial stress. Contrary to previous findings indicating a negative relationship between SSS and stress responses (Gruenewald, Kemeny et al. 2006), Community SSS was negatively related to HPA axis reactivity, with individuals rating themselves lower on the SSS ladders
showing higher cortisol stress responses. The interaction of threat and community SSS revealed in response to secondary stress exposure is in line with previous findings suggesting an increased susceptibility of low-status individuals to threat appraisals (Chen and Matthews 2003; Chen, Langer et al. 2004; Chen, Hanson et al. 2006). However, our analysis of income did not reveal a similar interaction for either TSST.

Previous research has indicated that low-SES individuals may be more prone to elevated threat appraisals, and it has been suggested that this plays a role in lower overall health related to low SES (Chen and Matthews 2003; Chen, Langer et al. 2004; Chen, Hanson et al. 2006). Our results indicate that SSS shares a similar relationship with threat appraisals, and support the hypothesis that SSS plays an important role in the relationship between such appraisals and physiological stress responses. The interaction of community SSS and threat appraisals revealed in this study suggests that low-SSS individuals may be more vulnerable to stressors they perceive as threatening. This finding reflects recent research indicating that threat appraisals play an important role in mediating the relationship between perceived stress reactivity to social evaluation and cortisol responses to social evaluative threats (Schlotz, Hammerfald et al. 2011). In light of these findings and the results of this study, it is possible that SSS may play an important role in determining individual differences in HPA-axis reactivity to socially threatening events. Future research should attempt to clarify the exact psychophysiological mechanisms and pathways involved in these relationships.

The increased sensitivity of low-SSS individuals to threat appraisals and subsequent HPA-axis stress responses may imply greater long-term health risks. Repeated activation of the stress response could be a significant contribution to an
individual’s allostatic load, the cumulative ‘wear and tear’ on the body that can eventually lead to dysregulation of important bodily systems (McEwen 1998). Over the long-term, elevated allostatic load has been associated with declines in general cognitive and physiological functioning, as well as increased risk of cardiovascular disease (Seeman, Singer et al. 1997). In terms of our findings, chronic activation of the stress response could result in elevated exposure to cortisol and other HPA-axis stress hormones, potentially leading to inadequate or prolonged hormone responses (McEwen 1998). This type of HPA-axis dysregulation could disrupt normal anti-inflammatory responses (such as cortisol secretion), and increase the risk of inflammation-related disorders (McEwen 1998). Indeed, recent research has identified an inverse relationship between SSS and baseline concentrations of interleukin-6 (IL-6), a pro-inflammatory cytokine normally down-regulated by cortisol during a typical response to psychosocial stress (Saxton, John-Henderson et al. 2011). However, the long-term role of psychosocial stress and appraisals in the context of HPA-axis reactivity and inflammation remains unclear. Future studies investigating social status, stress appraisals, HPA-axis reactivity, and inflammation in older populations would offer valuable insight into the long-term implications of these relationships.

The findings of this study have to be interpreted in light of some limitations. All participants in this study were students in a rigorous university setting, with relatively high socioeconomic status. Considering the competitive nature of the university environment, it is possible that these individuals perceive SSS in a way that is not generalizable to a larger population. Our sample size was relatively small, and limited to young adults. However, the significant relationships revealed in spite of the modest
sample and narrow demographic indicates SSS and threat appraisals are especially robust predictors of HPA-axis stress responses. Future research should investigate these relationships in older individuals to determine if there are significant age-related differences.

In summary, the results of this study suggest that SSS and threat appraisals are important and interrelated predictors of physiological responses to psychosocial stress. Low SSS individuals tend to show increased HPA axis reactivity to an acute psychosocial stressor, particularly when they appraise it as threatening. If such responses are activated chronically, these individuals may be at increased risk of negative health outcomes, especially in the case of diseases involving inflammation. Future studies should continue to explore the mechanisms involved in these processes and their implications for long-term health. Considering that anticipatory cognitive appraisal appears to play an important role in the stress response of these individuals, interventions or preventions targeted at these processes would be a promising avenue of research.
5 Tables and Figures

Table 1

Means and standard deviations of PASA scores and cortisol increases in response to stress (delta cortisol) during first (TSST1) and second (TSST2) stress exposure.

<table>
<thead>
<tr>
<th>Variable</th>
<th>TSST1 M</th>
<th>TSST1 SD</th>
<th>TSST2 M</th>
<th>TSST2 SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>PASA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Threat</td>
<td>3.17</td>
<td>1.16</td>
<td>3.26</td>
<td>1.16</td>
</tr>
<tr>
<td>Challenge</td>
<td>3.87*</td>
<td>0.83</td>
<td>3.79</td>
<td>0.93</td>
</tr>
<tr>
<td>Self-Concept</td>
<td>3.79</td>
<td>0.67</td>
<td>4.08</td>
<td>0.92</td>
</tr>
<tr>
<td>Control</td>
<td>4.12</td>
<td>0.86</td>
<td>4.13</td>
<td>1.04</td>
</tr>
<tr>
<td>Delta Cortisol (nmol/l)</td>
<td>3.37*</td>
<td>6.45</td>
<td>0.75</td>
<td>5.70</td>
</tr>
</tbody>
</table>

* indicates significant difference between TSST1 and TSST2

Table 2

Coefficients of the regression model testing gender, depression (CES-D), SSS, threat appraisal, and SSS by threat appraisal interaction predicting delta cortisol for TSST1 and 2.

<table>
<thead>
<tr>
<th>Variable</th>
<th>β</th>
<th>SEM</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TSST1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>0.96</td>
<td>2.92</td>
<td>0.33</td>
<td>0.75</td>
</tr>
<tr>
<td>CES-D</td>
<td>-0.10</td>
<td>0.16</td>
<td>-0.66</td>
<td>0.52</td>
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<tr>
<td>SSS (Community)</td>
<td>-1.07</td>
<td>0.89</td>
<td>-1.21</td>
<td>0.24</td>
</tr>
<tr>
<td>Threat</td>
<td>2.10</td>
<td>1.39</td>
<td>1.51</td>
<td>0.15</td>
</tr>
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<td>Threat X SSS</td>
<td>-1.08</td>
<td>0.94</td>
<td>-1.15</td>
<td>0.27</td>
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<tr>
<td><strong>TSST2</strong></td>
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<td>3.12</td>
<td>1.72</td>
<td>1.81</td>
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<td>-0.79</td>
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<td>0.55</td>
<td>-2.20</td>
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<td>Threat</td>
<td>1.76</td>
<td>0.85</td>
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<td>Threat X SSS</td>
<td>-1.30</td>
<td>0.46</td>
<td>-2.81</td>
<td>0.01</td>
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Figure 1: Mean cortisol concentrations by time for TSST1 and 2. The gray shaded region indicates when the TSST was administered.
Figure 2: Scatterplots of threat appraisals (a and b) and community SSS (b and c) on delta cortisol concentrations for TSST1 and TSST2.
Figure 3: Threat appraisals predicting delta cortisol concentrations by low and high SSS for TSST2.
6 References


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