Special Honors Paper

# A psychological and physiological study of stress associated with early relationship formation, with emphasis on gender and personality differences

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## Abstract

A brief interaction with a stranger is an important first step in the formation of a new social relationship. During this brief interaction, two individuals typically evaluate one another to decide whether or not to move forward and form a relationship. Social evaluation may be perceived as mildly threatening and therefore be psychologically stressful. Differences in personality traits may moderate how individuals respond to psychosocial stress and how stress affects the subsequent social interaction between them. This study investigated the role of stress and personality in the early stages of social relationship formation in the laboratory using the Trier Social Stress Test (TSST) as experimental paradigm to induce psychosocial stress from social evaluation threat. Participants were 156 heterosexual men and women randomly assigned to either a TSST or a control condition. All participants later engaged in a brief social interaction with an opposite sex confederate. In addition, changes in self-reported personality before and after all manipulations were assessed to investigate whether stress and social interaction changes how an individual perceived oneself. There was no significant moderating effect of personality on cortisol stress responses, but a significant moderating effect of gender. Specifically, males displayed greater changes in cortisol levels than females, while females reported greater changes in anxiety scores than males after TSST. In male participants, higher Openness to Experience was associated with lower testosterone responses to social interaction regardless of treatment. All participants except TSST females reported higher extraversion score, only control females reported higher emotional stability score, and only TSST females reported lower conscientiousness score.

## Introduction

A brief interaction with a stranger is an important first step in the formation of a new social relationship, whether this is a friendship or a romantic relationship. During this brief interaction, there may be some physiological and psychological changes. Research has shown that after a brief interaction with an unfamiliar woman, heterosexual men had significant increases in cortisol and testosterone concentration levels (Roney et al., 2003; 2007; 2010; van der Meij et al., 2010) as well as changes in self-reported personality traits (Roney 2003) and impairments in cognitive performance (Karremans et al. 2009; Nauts et al. 2012).

These changes can be moderated by individual characteristics. For example, Nauts et al. (2012) demonstrated that impairments in cognitive performances occurred in heterosexual men but not in heterosexual women after an interaction with someone of the opposite sex. van der Meij et al. (2008) found that higher salivary testosterone increases after brief interactions with women were most evident in men with aggressive dominant personalities, men who were not involved in committed, romantic relationships, and men who had been sexually inactive for over a month. Roney et al. (2010) also found that lower baseline cortisol concentration levels predicted larger testosterone responses to the interactions with women, and Roney et al. (2007) found that increases in testosterone levels were correlated with baseline testosterone levels. These findings suggest that individual differences in characteristics such as gender, personality, relationship status, sexual motivation, and baseline hormone levels can moderate physiological and psychological changes after brief social interaction.

During the first brief interaction that occurs when a relationship begins, two individuals typically evaluate one another to decide whether or not to move forward and form a relationship. Social evaluation may be perceived as mildly threatening and therefore be psychologically

stressful. Research has shown that cortisol responses are elicited when one is faced with a social-evaluative situation and a psychological threat to one's self esteem (Dickerson & Kemeny, 2004; van den Bos et al., 2014). Moreover, social evaluation can be especially stressful in a courtship scenario. In multiple experiments, Roney et al. (2007) found that changes in cortisol from baseline were significantly greater among male participants who interacted with female confederates relative to males in control conditions, and van der Meij et al. (2010) found that cortisol levels of men increased when they interacted with a female whom they reported as attractive. Since cortisol increases can be a marker of stress, these findings suggest that the early phases of courtship behavior or friendship formation can be psychologically stressful.

Similar to responses to brief social interaction, responses to psychosocial stress can also be moderated by individual characteristics. For example, Maestripieri et al. (2010) showed that baseline concentrations of testosterone and cortisol predicted changes in these hormones' concentrations in response to psychosocial stress; furthermore, females showed higher increases in cortisol levels than males, and single males and females showed higher increases in cortisol levels than married individuals. Stroud et al., (2002) found that men showed greater cortisol responses to achievement stressors, while women showed greater cortisol responses to social rejection stressors. Gender has also been found to moderate the effects of stress on decision making and risk taking (van den Bos et al. 2009; Lighthall et al. 2008; Mather & Lighthall 2012; Nickels et al., 2017). Finally, Marvel-Coen et al. (2018) found that participants who were morning-types had greater cortisol repose to stress than evening-types. Taken together, these findings suggest that individual differences in characteristics such as gender, relationship status, and baseline hormone levels can moderate psychological and physiological responses to psychosocial stress, and possibly also the effects of stress on social interaction.

Personality traits too, can moderate responses to psychosocial stress and the effects of stress on social interaction. Research has shown that cortisol responses to psychosocial stress were correlated to self-reported personality traits (Kirschbaum et al., 1992; Pruessner et al., 1997). Oswald et al. (2006) found that less Openness was associated with lower cortisol responses to psychosocial stress, blunted cortisol responses were associated with higher Neuroticism in women and with lower Extraversion in men. Nettle (2006) suggested that Big Five dimensions of human personality can be seen as trade-offs between different fitness costs and benefits. Moreover, we know that human courtship and affiliation strategies did not evolve in a stress-free environment. Therefore, different responses to psychosocial stress in different personalities may be adaptive results of different selective pressures, and the difference in stress responses may, in turn, moderate the effects of stress on subsequent social interaction.

This study aimed to experimentally investigate the early stages of social relationship formation in a laboratory setting using an acute psychosocial stress paradigm known as the Trier Social Stress Test (TSST; Kirschbaum et al. 1993) to simulate the social evaluation from the interaction partner, and a brief social interaction paradigm that has been used in several research studies (Roney et al., 2003; 2007; van der Meij et al., 2008) to simulate the social interaction with an opposite sex stranger. We hypothesized that individuals with different personality traits would respond to stress and social interaction differently. Based on previous research (e.g. Roney 2003), we also hypothesized that a brief social interaction with an opposite-sex stranger may change how individuals perceive themselves. To test this hypothesis, self-reported personality traits were assessed before and after stress manipulation and social interaction.

# Methods

## Participants

A total of 156 heterosexual individuals (62 males, 94 females) were recruited from the University of Chicago campus. Ages of the participants ranged from 18 to 37 years (M = 22.2, SD = 3.8). 79 participants were randomly assigned to a control condition and 77 participants to a psychosocial stress condition (Trier Social Stress Test). Three individuals did not complete the full protocol due to researcher error, participant withdrawal from the study, or computer error, and therefore were not included in data analyses. Two more individuals were excluded from all hormonal analyses due to having baseline hormonal concentrations over three standard deviations away from the mean. One participant was excluded from all hormonal analyses due to saliva samples being heavily contaminated with blood. After excluding these six individuals, data were analyzed for a total of 150 individuals, of whom 76 individuals (46 females, 30 males) underwent the TSST stress manipulation condition and 74 individuals (47 females, 27 males) underwent the control condition.

## Experimental Procedure

All experimental procedures took place between 11:30 AM and 5:30 PM. Participants always interacted with an experimenter, or "greeter", of the same sex throughout the entire experimental session. Upon arrival, participants were taken to the testing room, where they completed questionnaires for 20 minutes. An initial demographic survey asked information about participants' age, ethnicity, sexual orientation, SES, marital or relationship status (single or in a relationship), etc. At the end of this period, they provided a baseline saliva sample. They then either took part in the Trier Social Stress Test or sat in a room quietly for a similar period of time

as a control condition. Another saliva sample was collected after the TSST or the control condition. Approximately ten to fifteen minutes after the TSST or control condition had ended, participants went through a brief social interaction task with a confederate of the opposite sex. Another saliva sample was collected after the brief social interaction task. Upon completion of all procedures, subjects will be fully debriefed and given compensation.

**Questionnaires/Materials**

In addition to a demographic survey and a general health survey given before saliva samples were collected, participants completed the following questionnaires:

*Big-Five Personality Inventory* (BFI; John, Donahue, & Kentle, 1991): The Big Five Inventory is a 44-item, frequently used questionnaire measuring personality traits along five dimensions: extraversion, agreeableness, conscientiousness, neuroticism, and openness to experience.

*Ten-Item Personality Inventory* (TIPI; Gosling et al., 2003): The TIPI is a ten-item, brief measure of personality based on the Big-Five Personality Inventory. It has sufficient levels of convergence with the Big-Five inventory and is usable in situations where short measures are needed. In this study, we use the TIPI to measure pre- and post-stress and social interaction self-reported personality ratings throughout the experimental protocol.

*State portion of State-Trait Anxiety Inventory* (STAI-S: Spielberger & Gorsuch, 1983): The State-Trait Anxiety Inventory, or STAI, is a long-standing measure that uses two scales to report two measures of anxiety (state anxiety and trait anxiety). Unlike trait anxiety, which seeks to measure individuals differences in proneness to anxiety as a personality trait, state anxiety measures the intensity of anxiety as an acute, emotional state (Spielberger & Gorsuch, 1983). The

STAI state scale consists of twenty statements that have individuals rate, on a four-point Likert scale, different statements about the intensity of their anxiety “right now, at this moment”.

**Trier Social Stress Test**

The Trier Social Stress Test (TSST; Kirschbaum et al. 1993) is a standardized task that is used to study hormonal responses to mild psychosocial stress in a laboratory setting. In the current study, the experimenter explained to each participant that he or she would be giving a 5-minute presentation about himself or herself for a mock job interview. Each presentation took place in front of a “selection committee” composed of two unfamiliar confederates (“judges”) trained to maintain neutral facial expressions and provide no positive feedback to the participant. Each participant was informed that he or she must keep speaking for 5 minutes and that the presentation was video-recorded for subsequent analyses of content and non-verbal behavior. Upon completing the 5-min speech, the judges asked each participant to perform a difficult arithmetic calculation (i.e., serially subtracting the number 17 from 2,023) out loud for another 5 minutes or until he or she reached zero. Anytime the participant made a mistake, he or she was notified and asked to restart from the beginning. After this task, the confederates thanked the participant and left the room.

Participant who were assigned to the control condition simply sat by themselves in a room (where they could read magazines) for 10 minutes until their original experimental “greeter” returned to let them know they could continue moving forward in the study.

**Social Interaction**

Following the control/TSST condition and a second saliva sample, all participants partook in a social interaction task, where they interacted with an opposite-sex confederate whom they had not encountered before. The social interaction task that was used in this experiment was adapted from brief social interaction tasks that had been used in several research studies in which a social interaction involving a confederate posed as either an another participant or experimenter has led to physiological and behavioral changes (Roney et al., 2003; 2007). In our study, the experimental "greeter" let the participant know that they needed approximately five or ten minutes to pass before moving on to the next part of the study, and that the participant was free to relax until the experimenter returned. Several minutes after the departure of the "greeter", an opposite-sex confederate entered the room and introduced himself or herself as a research assistant who was there to collect data off of a digital video camera (earlier in the session, this video camera was used to collect a digital photograph of every participant, as well as used to record the TSST session for participants assigned to the TSST condition). Chairs were arranged in the room such that the participant always sat directly across from the confederate with a small conference table positioned between them. Confederates then attempted to engage in natural, friendly conversation, while simultaneously uploading data from the digital video camera onto a computer or hard drive. The research confederates were free to use whatever means of engaging in conversation seem natural to them. Script or specific prompts were not used to avoid interactions seeming excessively artificial. Conversations lasted seven minutes, at which point the experimenter re-entered the room and announced that it was time to complete the rest of the study protocol.

**Phased Debriefing**

Following the final saliva sample, we utilized a phased debriefing method to gather participants' final self-reported personality measures using TIPI.

**Saliva Sample Collection and Hormonal Assays**

All saliva samples were collected between 12:00 PM and 5:00 PM, as previous studies have shown that afternoon hormone levels, although lower than morning levels, are more stable and therefore better suited for studies of social endocrinology (e.g., Gray et al. 2004). Saliva was collected by passive drool into plastic tubes. Saliva samples were stored in a refrigerator at -20°F. Samples were assayed for testosterone and cortisol concentrations using ELISA kits purchased from Salimetrics. Saliva sample concentrations were calculated based on kit standards using a 4-parameter nonlinear regression curve fit. For cortisol, the intra-assay CV based on concentration was 4.85% and the inter-assay CV based on concentration was 7.15%. For testosterone, the intra-assay CV based on concentration was 5.38% and the inter-assay CV based on concentration was 6.63%.

# Results

## Data Transformations

In the overall sample (control and TSST participants combined), baseline cortisol levels were in line with assay protocol salivary cortisol example PM range norms (F: M=0.21, SD=0.17 μg/dL; M: M=0.18, SD=0.12 μg/dL). Baseline cortisol was positively skewed for both males and females and was therefore log transformed, which resulted in a normal distribution of baseline cortisol. Therefore, the transformed data were used in subsequent analyses. Baseline testosterone levels were in line with assay protocol salivary testosterone example norms (F: M=52.38, SD=19.51 pg/mL; M: M=152.57, SD=59.13 pg/mL). Baseline testosterone was positively skewed for both males and females. A square root transformation of female testosterone resulted in a normal distribution of baseline testosterone for females, and a log transformation of male testosterone resulted in a normal distribution of baseline testosterone for males. Therefore, the transformed data were used in subsequent analyses. Whenever delta hormonal levels that were not normally distributed were used as dependent variables, generalized linear models were used.

## Differences in TSST vs. Control Participants

There were no significant differences between participants who were assigned to the control group and participants who were assigned to the TSST in terms of age, ethnicity, sexual orientation, marital status, income, subjective social status relationship status, and relationship length. There were no significant differences between control and TSST participants in terms of any measured personality scales. There were no significant differences between control and TSST participants in terms of the following variables that may impact hormonal levels, such as: exercise in the last 24 hours, whether they drink alcohol, whether or not they are currently using hormonal

medication, the time of day they were tested, menstrual cycle phase (for females), how many hours they had slept the previous night, time they went to sleep the night before the day of testing, time of waking the morning of the day of testing, whether they had eaten or drank in the past hour, whether anything had worried them that day, and whether they had felt sick at all in the past week.

TSST participants and control participants did not differ in trait anxiety (STAI-T; $t(149)=-0.094$, $p=0.925$) or state anxiety STAI-S; $t(149)=-1.244$, $p=0.925$) as measured prior to the treatment/control session.

**Differences between Males and Females**

There were no significant sex differences in age, ethnicity, sexual orientation, marital status, relationship status, relationship length, income, subjective social status, autistic-like characteristics, loneliness ratings, or trait anxiety scores. There were significant sex differences between male and female participants in BFI-C personality scores [Conscientiousness subscale: $F(149)=7.88$, $p=0.006$] and BFI-N personality scores [Neuroticism subscale; $F(149)=12.96$, $p<0.001$]. Specifically, female participants reported higher score than males in Conscientiousness (F: M=33.32, SD=6.60; M: M=30.23, SD=6.48) and higher scores than males in Neuroticism [F: M=25.46, SD=6.46; M: M=21.60, SD=6.26]. There were significant sex differences in math anxiety ratings [sMARS ; $F(149)=11.67$, $p=0.001$], such that females (M=58.84; SD=18.25) displayed higher levels of math anxiety than males (M=48.77, SD=16.26). There were also significant sex differences in short-term mating orientation measures [STMO; $F(149)=18.64$, $p<0.001$], such that females (M=35.88; SD=15.77) had lower scores on the short term mating orientation inventory than males (M=48.77; SD=16.26). Therefore, further analyses that combined

data from male and female participants controlled for these following scales: BFI-C, BFI-N, sMARS, STMO.

There were no significant sex differences in terms of the following variables that may impact hormonal levels, such as: exercise in the last 24 hours, whether they drink alcohol, whether or not they are currently using hormonal medication, the time of day they were tested, menstrual cycle phase (for females), how many hours they had slept the previous night, whether they had eaten or drank in the past hour, whether anything had worried them that day, and whether they had felt sick at all in the past week. There were significant differences between male and female participants in terms of what time participants went to sleep the night before testing [$F(144)=15.70$, $p<0.001$], such that females went to bed earlier than males. However, there were no significant differences between males and females in terms of hours of sleep the night before or wake-up time the morning of testing. Finally, 37 females reported using some form of hormonal contraception, and 56 females reported to using no form of hormonal contraception.

**Baseline Cortisol**

No significant differences in baseline cortisol were found between control participants and TSST participants: $t(148)=-1.17$, $p=0.242$. The difference in baseline cortisol between men and women was also not significant: $t(148)=0.99$, $p=0.325$.

Across all male participants, baseline cortisol was significantly related to baseline testosterone ($r=0.41$, $p=0.002$). Baseline cortisol in males was significantly related to relationship status [$F(1,57)=3.65$, $p=0.033$], such that males who were in a relationship had significantly lower levels of baseline cortisol than male participants who were single ($M=0.14$ μg/dL, $SD=0.08$; $M=0.21$ μg/dL, $SD=0.13$, respectively). No other variables that may impact hormone levels were

related to baseline levels of cortisol in men. Therefore, for further cortisol analyses with male participants, baseline testosterone and relationship status were controlled for.

Across all female participants, baseline cortisol was significantly related to baseline testosterone ($r=0.459$, $p<0.001$) and whether or not the participant had eaten or drank anything within the last hour $F(1,92)=4.01$, $p=0.048$). Specifically, female participants who had eaten or drank within the last hour had significantly lower baseline cortisol levels than females who had not ($M=0.14$ μg/dL, $SD=0.08$; $M=0.22$ μg/dL, $SD=0.18$, respectively). No other variables that may impact hormone levels were related to baseline levels of cortisol in females. Therefore, for further cortisol analyses with female participants, baseline testosterone and whether the individual had eaten or drank anything within the last hour were controlled for.

**Baseline Testosterone**

As expected, the difference in baseline testosterone (T) between men and women was significant: $t(147)=-16.41$, $p<0.001$; F: $M=52.38$, $SD=19.51$ pg/mL; M: $M=152.57$, $SD=59.13$ pg/m. Therefore, further analyses involving testosterone were run for males and females separately. No significant differences in baseline T were found between control participants and TSST participants in both males [$t(54)= 1.11$, $p=0.27$] and females [$t(91)=0.12$, $p=0.91$].

Across all male participants, baseline T was significantly related to baseline cortisol ($r=0.41$, $p=0.002$). No other variables that may impact hormone levels were related to baseline levels of T in men. Therefore, for further T analyses with male participants, baseline cortisol was controlled for.

Across all female participants, baseline T was significantly related to baseline cortisol ($r=0.46$, $p<0.001$), time of waking the morning of testing ($r=0.22$, $p=0.037$), and whether or not

the participant had eaten or drank anything within the last hour [F(1,92)=5.38, p=0.023]. Specifically, female participants who had eaten or drank within the last hour had significantly lower baseline cortisol levels than females who had not (M=40.39 pg/mL, SD=10.45; M=54.16 pg/mL, SD=19.94, respectively). Baseline T in females was significantly related to contraceptive use [F(1,92)=8.22, p=0.005], such that female participants using contraceptives had significantly lower levels of baseline T than female participants not using contraceptives (M=45.51 pg/mL, SD=15.52; M=56.92 pg/mL, SD=20.64, respectively). No other variables that may impact hormone levels were related to baseline levels of T in women. Therefore, for further T analyses with female participants, baseline cortisol, hormonal contraceptive use, time of waking, and whether or not the participant had eaten or drank anything in the last hour were controlled for.

**Personality and Stress Responses to TSST Manipulation**

*State Anxiety*

TSST participants: a linear model using STAI-S change scores as response variable, BFI-E, BFI-A, BFI-N, BFI-O, and BFI-C as predicting variables, and sMARS and STMO as covariates revealed no significant main effect of personality variables on STAI-S change scores.

*Cortisol Response*

TSST Females: A linear model using delta cortisol response as response variable, BFI-E, BFI-A, BFI-N, BFI-O, and BFI-C as predicting variables, and log baseline cortisol concentration, square root baseline testosterone concentration, and whether the individual had eaten or drank anything within the last hour as covariates revealed no significant main effects of personality variables on delta cortisol response.

TSST Males: A linear model using delta cortisol response as response variable, BFI-E, BFI-A, BFI-N, BFI-O, and BFI-C as predicting variables, and log baseline cortisol concentration, log baseline testosterone concentration, and relationship status as covariates revealed no significant main effects of personality variables on delta cortisol response.

*Testosterone Response*

TSST Females: A linear model using delta testosterone response as response variable, BFI-E, BFI-A, BFI-N, BFI-O, and BFI-C as predicting variables, and log baseline cortisol concentration, square root baseline testosterone concentration, hormonal contraceptive use, time of waking, and whether or not the participant had eaten or drank anything in the last hour as covariates revealed no significant main effects of personality variables on delta testosterone response.

TSST Males: A linear model using delta testosterone response as response variable, BFI-E, BFI-A, BFI-N, BFI-O, and BFI-C as predicting variables, and log baseline cortisol concentration and log baseline testosterone concentration as covariates revealed no significant main effects of personality variables on delta testosterone response.

**Personality and Testosterone Response to Social Interaction**

Females: A linear model using delta testosterone response as response variable, BFI-E, BFI-A, BFI-N, BFI-O, and BFI-C as predicting variables, and log baseline cortisol concentration, square root baseline testosterone concentration, square root testosterone concentration after TSST/control treatment, TSST/control treatment, hormonal contraceptive use, time of waking, and

whether or not the participant had eaten or drank anything in the last hour as covariates revealed no significant main effects of personality variables on delta testosterone response.

Males: A linear model using delta testosterone response as response variable, BFI-E, BFI-A, BFI-N, BFI-O, and BFI-C as predicting variables, and log baseline cortisol concentration, log baseline testosterone concentration, log testosterone concentration after TSST/control treatment, and TSST/control treatment as covariates revealed that higher BFI-O significantly predicted lower delta testosterone levels [$\beta_{\text{BFI-O}}$=-0.11, p=0.009]. Post-hoc analyses revealed no significant interactive effect between BFI-O and TSST/control treatment [$\beta_{\text{BFI-O:TSST}}$=-0.62, p=0.434]. There was no other significant main effect of personality variables on delta testosterone response.

**Change in Self-Reported Personality after TSST/Control treatment and Social Interaction**

The change in self-reported personality was tested using one-sample t-test on the TIPI change scores. TIPI-E change score was significant in control females (M=0.51, SD=1.21): t(46)=2.9, p=0.006, control males (M=0.45, SD=1.15): t(28)=2.1, p=0.05, and TSST males (M=0.63, SD=1.45): t(29)=2.4, p=0.02, but not significant in control females. TIPI-A change score was not significant in any groups. TIPI-ES (Emotional Stability) change score was significant only in control females (M=0.53, SD=1.28): t(46)=2.84,p=0.007. TIPI-C change score was significant only in TSST females (M=-0.37, SD=1.14): t(45)=-2.19,p=0.033. TIPI-N change score was not significant in any groups. Two-sample t-test on the TIPI change scores between TSST and control participants for each gender further revealed that control females had significantly higher TIPI-C change score than TSST females: t(89)=2.20,p=0.034. There was no significant difference in other TIPI change scores between TSST and control participants for each gender.

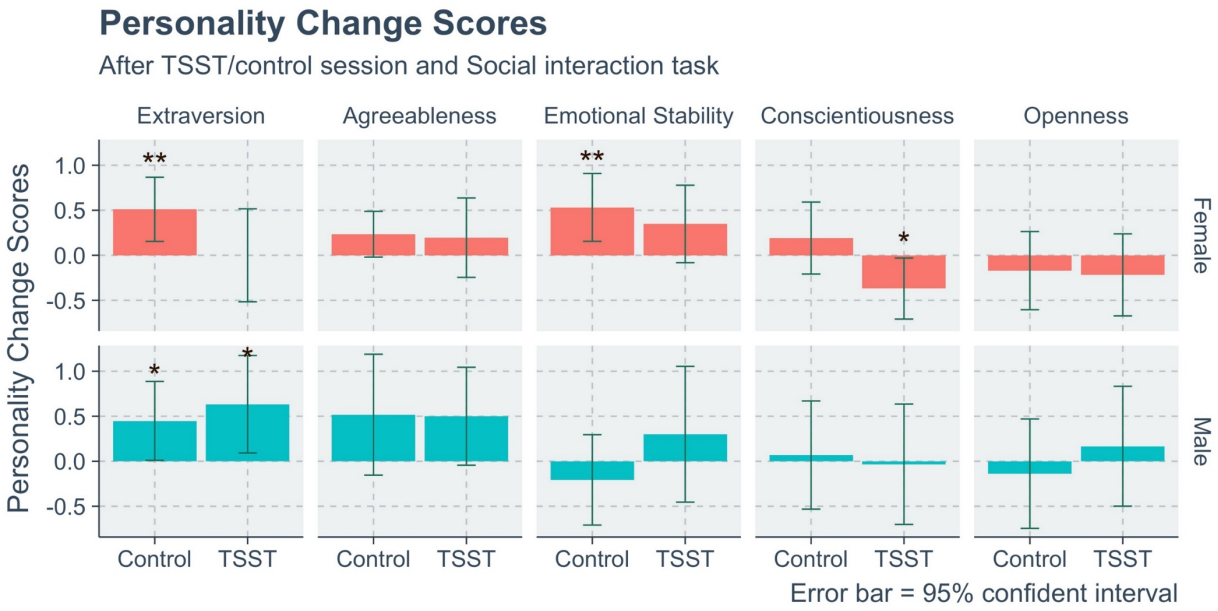


Figure 1 – TIPI change scores in control females, control males, TSST females, and TSST males

(* p-value < 0.05, ** p-value < 0.01, *** p-value < 0.001)

**Post-hoc Analyses on Gender and Stress Responses to TSST Manipulation**

*State Anxiety*

A linear model using state anxiety change scores as response variable, TSST/Control treatment, gender, and interaction term between treatment and gender as predicting variables, and BFI_N, BFI_C, sMARS, and STMO as covariates revealed significant main effects of treatment [$\beta_{TSST}$=13.66, p<0.001] on delta cortisol response. Post-hoc analyses showed that control males (M=-4.15, SD=9.40) did not differ in state anxiety change scores from control females (M=-2.94, SD=5.19): t(39)=0.50, p=0.6, and 2), whereas TSST males (M=5.10, SD=11.25) displayed lower state anxiety change scores when compared with TSST females (M=10.63, SD=11.12):t(62)=2.1, p=0.04.

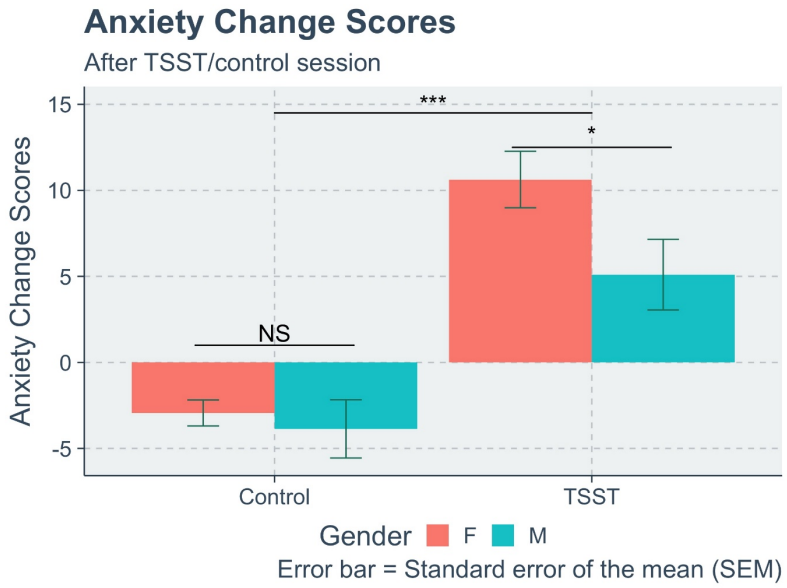


Figure 2 – State Anxiety Change Scores in control females, control males, TSST females, and TSST males

(* p-value < 0.05, ** p-value < 0.01, *** p-value < 0.001)

*Cortisol Response*

A linear model using delta cortisol response as response variable, TSST/Control treatment, gender, and interaction term between treatment and gender as predicting variables, and log baseline cortisol concentration, square root baseline testosterone concentration, BFI_N, BFI_C, sMARS, and STMO as covariates revealed significant main effects of treatment [$\beta_{TSST}$=0.05, p=0.011] and significant interactive effects between treatment and gender [$\beta_{TSST:Gender}$=0.07, p=0.017] on delta cortisol response. Post-hoc analyses showed that control males (M=-0.02, SD=0.04) did not differ in delta cortisol responses from control females (M=-0.02, SD=0.05): t(65)=-0.19, p=0.9, whereas TSST males (M=0.09, SD=0.13) displayed higher delta cortisol responses when compared with TSST females (M=0.02, SD=0.10):t(54)=2.4, p=0.02.

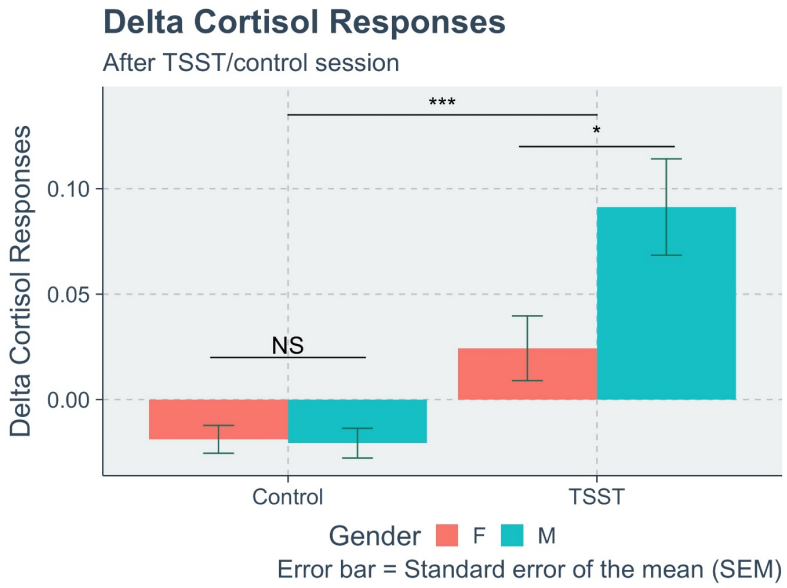


Figure 3 – Delta Cortisol Responses in control females, control males, TSST females, and TSST males

(* p-value < 0.05, ** p-value < 0.01, *** p-value < 0.001)

*State Anxiety and Cortisol Response*

For post-hoc analyses, STAI-S and cortisol responses were categorized into either increasing (change scores/delta response > 0) or not increasing (change scores/delta response ≤ 0), creating 4 possible situations for responses to TSST manipulation in total: 1) increasing in both STAI-S and cortisol responses, 2) increasing in STAI-S response without increasing in cortisol response, 3) increasing in cortisol response without increasing in STAI-S response, and 4) no increasing in both STAI-S and cortisol responses. A 3-way contingency table (cortisol response x STAI-S response x gender) was constructed for TSST participants (Table 1).

A Fisher's Exact Test for the 3-way contingency table revealed a significant difference between females and males in the distributions of number of TSST participants across 4 possible responses to TSST manipulation [p=0.02]. Partitioning the 3-way contingency table into 2 sub-tables—1) the "increasing in both STAI-S and cortisol responses" condition, the "increasing in

cortisol response without increasing in STAI-S response" condition, and the "no increasing in both STAI-S and cortisol responses" condition, and 2) aggregated 3 conditions from the first sub-table and the "increasing in STAI-S response without increasing in cortisol response" condition—revealed that the significant difference in the distribution between TSST females and males resulted from the "increasing in STAI-S response without increasing in cortisol response" condition [$p_{sub\text{-}table1}$=0.8; $p_{sub\text{-}table2}$=0.005], where the conditional proportion in this condition was higher in TSST females (0.46) than males (0.13).

| **Responses to TSST manipulation** | | **Number of TSST Participants (Conditional Proportion)** | |
|---|---|---|---|
| | | **Females** | **Males** |
| No increasing in cortisol | No increasing in STAI-S | 4 (0.09) | 4 (0.13) |
| | Increasing in STAI-S | **21 (0.46)** | **4 (0.13)** |
| Increasing in cortisol | No increasing in STAI-S | 2 (0.04) | 4 (0.13) |
| | Increasing in STAI-S | 19 (0.41) | 18 (0.61) |
| Total | | 46 (1.00) | 30 (1.00) |

Table 1 – 3-way contingency table (cortisol response x STAI-S response x gender) with number and conditional proportion by gender for TSST participants

## Discussion

Contrary to our hypothesis regarding personality as a moderator of responses to stress, we did not find any moderating effects of personality on changes in self-reported state anxiety, cortisol concentrations, or testosterone concentrations following the TSST. We did not replicate the moderating effects of Openness, Extraversion, and Neuroticism on cortisol responses reported by Oswald et al. (2006). This might be because of Oswald et al. (2006) ran a number of analyses without correction for multiple comparisons, and thus their findings might be subject to type I error, and/or because they used the Revised NEO Personality Inventory five-factor model of personality, whereas we used the Big-Five Personality Inventory.

Regarding our hypothesis that personality can moderate the effects of stress on social interaction, we found that higher Openness to Experience in males was associated with lower changes in testosterone in response to social interaction. However, the association between Openness and testosterone responses was independent of TSST manipulation. Therefore, our findings suggest that personality, specifically Openness in males, moderated testosterone responses to social interaction but not the effects of stress on social interaction.

As predicted by our hypothesis regarding changes in self-reported personality, both stress and social interaction changed how the participants self-reported their personalities. Furthermore, our findings suggest that these changes depended on gender. In males, social interaction elicited higher report in Extraversion regardless of TSST manipulation. In females, social interaction without stress elicited higher report in Extraversion and Emotional Stability, while social interaction with preceding stress elicited lower report in Conscientiousness. These findings raised questions about the internal reliability of personality measures, specifically the Ten-Item Personality Inventory, as well as about the convention to treat personality as a static trait.

In addition to personality as a moderator, post-hoc analyses demonstrated gender differences in responses to TSST. In response to TSST, females reported higher changes in state anxiety than males, while males displayed higher changes in cortisol concentrations. Higher changes in self-report state anxiety after TSST in females were consistent with Kelly et al.'s (2008) findings. However, Kelly et al. (2008) did not find gender differences in cortisol responses to TSST. Higher changes in cortisol responses after TSST in males were consistent with Childs et al.'s (2010) findings. However, Maestripieri et al. (2010) found that a mild psychosocial stress manipulation (not TSST) elicited higher changes in cortisol in females than in males. The gender differences in state anxiety might be due to gender differences in self-report as we found that there was significantly higher proportion of females who did not display increases in cortisol but reported increases in state anxiety after TSST when compared to males. In terms of cortisol responses, Stroud et al. (2002) showed that men showed greater cortisol responses to achievement stressors, while women showed greater cortisol responses to social rejection stressors. Both mock job interview and mental arithmetic task used in TSST might be more similar to achievement stressors than social rejection stressors. We observed higher cortisol responses to TSST in males than in females. In general, different studies of gender differences in cortisol responses to psychosocial stress, including the present one, have provided inconsistent results. Therefore, this is an issue for which further investigations are needed.

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