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„Relationship Between Personality, Gender and the Acute Stress Response"

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Introduction

Over the last decades, public healthcare has made groundbreaking advancements in patient treatment through inventions such as vaccines and antibiotics (Fielding, 1999). However, the 21st century has brought about new threats to psychological health such as decreased job- and financial security. This has led to a paradigm shift in healthcare, making stress related mental disorders a paramount health concern for the future. According to the Global Medical Trends Survey Report (2019), mental disorders will be among the three most common and most expensive conditions for public healthcare within the next five years, with higher healthcare costs expected than those of cancer, chronic respiratory diseases and diabetes. These alarming numbers depict the importance of understanding stress and its causes, correlates and underlying mechanisms. The current paper aims to serve this purpose by investigating how personality and gender shape our psychophysiological responses to acute stress.

Stress is a construct that is of interest for academics and the general public alike. But while laypeople often use the term in an ambiguous and multidimensional way to describe a state of strain, tension, negative emotional responses (Ogden, 2005) or time pressure (Juster & Lupien, 2012), researchers have struggled for a long time to come up with a unified definition. This is because stress is basically an umbrella term for different subconstructs that interact with each other in a complex manner. For example, on a physiological level, both the autonomic nervous system (ANS) and the hypothalamic-pituitary-adrenal axis (HPA axis) are activated to respond to external pressures (Persson & Zakrisson, 2016). Also, stress has a cognitive component, as the activation of these biological systems is dependent upon the appraisal of a situation as threatening, challenging or harmless (Lazarus, 1966). On top of that, there is the distinction between negative stress, also called distress, and eustress, its positive counterpart (Ogden, 2005). Finally, researchers differentiate between acute stress, which is an immediate response to a specific event (Bibbey et al., 2013; Puig-Perez et al., 2016; Xin et al., 2017), and chronic stress, which is strain experienced over a long period of time, for example through poverty or the loss of a job (Mayer et al., 2018; Stalder et al., 2014).

Unifying all these aspects in a single paradigm and understanding the relationship between them has posed challenges to stress research. This is reflected by the fact that within the past century, numerous models of stress have been developed. One of the first of these models is Cannon's fight or flight model (1932), which asserts that threats in the outside world provoke a bodily reaction, enabling the individual to either fight the threat or escape from it. Cannon has defined stress as an adaptive response to a specific situation and did not incorporate the potential harmful effects of prolonged stress on the individual into his model. Selye paid more attention to this aspect with his model of the General Adaptation Syndrome developed two decades later (Selye, 1956). He divided the acute stress response into three phases. In the first phase, the alarm phase, the individual mobilizes resources, followed by the resistance phase, during which they try to cope with the stressor. Finally, when the resistance phase is prolonged, eventually the resources of the body are depleted and it enters the phase of exhaustion. This phase is characterized by an impairment of health, negative emotions and a feeling of overextension. While both Cannon's and Selye's model have laid an important groundwork in understanding stress and its consequences, they did not capture cognitive components and individual variability (Ogden, 2005). These limitations were later accounted for by Lazarus through his transactional stress theory (1966), which is now the leading model in stress research. According to Lazarus, the experience of stress is largely dependent upon appraisals of the stressor by the individual. These appraisals can be divided into three phases. During primary appraisal, a situation is classified as either positive, irrelevant or potentially dangerous. When potentially dangerous, the individual proceeds to secondary appraisal, in which they examine whether enough resources are available to cope with the stressor. If not, the coping process is initiated, which may include a multitude of behaviors aimed to overcome the stressor. These behaviors may very well differ in their level of adaptiveness. For example, consuming large quantities of alcoholic beverages would be a less adaptive response to a fight with the spouse than a clarifying conversation. Finally, in the third phase, the individual evaluates the success of their stress response and reappraises the stressor.

Although Lazarus‘ stress model incorporates individual differences in stress responses, it did not stimulate much research on the role of personality traits in that process in the beginning (Vollrath, 2001). This was partly to be explained by the fact that it describes stress as the result of an interactional relationship between the person and their environment. According to Lazarus, personality traits are not able to capture the complexity and variability of the stress process appropriately, which is why they were refuted as too static, too global and too reductionist (Folkman & Lazarus, 1985). However, in the middle of the 1980s, scientific interest in personality factors in stress research was rising again (Vollrath, 2001). For example, the personality researcher Krohne (1990) argued that the incompatibility that is ascribed to static personality traits in a dynamic stress process is artificial. He claimed that it is feasible to believe that a model of the stress process can contain both static and dynamic elements and that personality traits are suitable to predict its static elements. Today, there is a broad renewed interest in personality variables in stress research (Suls et al., 1996).

The current study investigates personality based on the Big Five personality model (Costa & McCrae, 1992), which is a uniform model for the taxonomy of the human personality. Developed through the combination of a lexical and a factor analytical approach, it is reliable over different theoretical frameworks, measurement tools and raters. Although not free from criticism (Saucier, 2003), the Big Five personality model is accepted as one of the best models for the representation of personality by many researchers (DeYoung et al., 2007; Hogan & Ones, 1997; MacDonald, 1995; McCrae & Costa, 1987). It contains five dimensions: Openness to experience, conscientiousness, extraversion, agreeableness and neuroticism. In the current study, the analysis is confined to the factors neuroticism and extraversion, as these are considered the most relevant traits in relation to the stress process (Vassend & Knardahl, 2005). Neuroticism describes the tendency to experience negative emotions (Jeronimus et al., 2014). Individuals who score high in neuroticism have a low tolerance for stress and aversive stimuli (Norris et al., 2007) and are thus susceptible for a more intense response in an acute stress situation. Extraversion is the inclination to engage with the external world and to derive positive emotions from that (Laney, 2002). People high in extraversion have a lot of energy, like to talk and are assertive (Olakitan, 2011). It is often argued that these characteristics are helpful to cope with stress successfully. Positive affect may reduce salience of a stressor and the tendency to actively engage with the social world might increase the chance of having a helpful social support system (Jackson & Schneider, 2014).

Vollrath identifies three ways in which personality can influence the stress process (Vollrath, 2001). The first mechanism is the *appraisal* of a stressful situation. In one study, Schallberger (1995) found that neuroticism was related to negative job descriptions among flight attendants. The second mechanism is *coping*. Research has shown that people who score high on extraversion seek social support more often and more effectively (Amirkhan et al., 1995). The third mechanism is the *selection* of stressful situations. Some studies found that neuroticism is a predictor for negative life events, even if they were defined objectively and could therefore not be explained by interpretive bias (Beck et al., 2016; Widiger & Costa, 1994). Since the current study uses a quasi-experimental paradigm in which all participants are exposed to the same stressor, namely the Trier Social Stress Test (see procedure), the current study will focus on *appraisal* and *coping* and will neglect the selection of stressful situations.

Another important factor which was overlooked by stress research for a long time, but gained an increased amount of attention in recent years, is gender. In the past, women were often excluded in stress studies, because fluctuations in menstrual cycle can affect the stress response and possibly confound the data (Juster & Lupien, 2012). Until 1995, only 17% of participants in stress research were females (Taylor et al., 2000). This was problematic, as researchers did often not account for the fact that their results might not be generalizable across genders. However, in recent years, stress researchers have become more sensitive to this problem and mostly include both genders into their studies.

Gender differences in stress response are often explained by evolutionary psychology. It has been argued that due to differences in anatomy and morphology, our ancestral men were more likely to be hunters, while our ancestral women were more likely to be gatherers (Juster & Lupien, 2012). These differences in adaptation may have led to the development of different stress response systems. An acquainted theory postulates that instead of preparing the body for physical action in the face of stress like men do, women focus on social behaviors. This is called the „tend and befriend“ response (Taylor et al., 2000). Gender differences in stress responses are indeed supported by research. For example, it was found that women report more subjective stress in general, while men respond to stress more intensely on a physical level (Juster & Lupien, 2012).

As previously mentioned, the two principal biological systems for the stress response are the HPA axis and the ANS (Persson & Zakrisson, 2016). The HPA axis is activated when an individual expects that a threat or a negative consequence is about to happen (Herman et al., 2005), leading to a series of physiological events. First, the thalamus emits corticotropin releasing factor. Second, adrenocorticotropic hormone (ACTH) is released into the bloodstream by the anterior pituitary gland. Finally, this process results in the release of cortisol from the adrenal cortex into the adrenal glands (Pruessner & Ali, 2015). The ANS regulates the fight or flight response, during which activity in the parasympathetic system is reduced, while activity in the sympathetic system is increased. Through this process, epinephrine is released into the body while heart rate and blood pressure are increased, providing the body with heightened levels of energy and arousal. Surprisingly, the exact relationship between the HPA axis and the ANS and their relationship with subjective stress has not been thoroughly investigated (Pruessner & Ali, 2015). Still, many studies report stress response as a general term, even though it is often operationalized through different physiological systems. Possibly, personality traits relate differently to subjective stress, HPA axis activation and ANS activation in an acute stress situation. Perhaps this is one of the reasons why studies often find inconclusive results about the effect of personality on the stress response.

When investigating stress systems, researchers have a variety of stress markers to choose from. For measurement of HPA axis activity, salivary cortisol is mostly used, which has been established as a reliable stress marker for many years (Hellhammer et al., 2009). Another marker for HPA axis activity is ACTH, although it is far less often used (Hellhammer et al., 2009). Considering ANS activity, no similar gold standard exists. However, one way to measure it is through salivary alpha-amylase (sAA), which is emerging as a valid and reliable biological marker (Nater & Rohleder, 2009). sAA is a starch degrading enzyme which release is stimulated by the activation of the ANS (Strahler et al., 2017). Other markers of the ANS that are often used are heart rate, respiratory rate or blood pressure (Ali & Nater, 2020; Chida & Hamer, 2008; Poppelaars et al., 2019), although they are more technologically complex to measure than sAA. In the following paragraph, a literature review is provided in which research findings are categorized according to personality, gender and stress response system.

Neuroticism and the Subjective Stress Response

Most studies report a positive relationship between neuroticism and the subjective experience of stress in an acute stress situation. This is in line with predictions of the Big Five personality model, which states that neuroticism is associated with a bias towards interpreting stimuli as stressful (Zautra et al., 2005). For example, a study by Mohiyeddini et al. (2015) used the TSST, which is a stress test with social-evaluative elements and found that neuroticism was associated with a higher level of subjective stress. Another study found that neuroticism was related to higher perceived task stressfulness and lower perceived control in participants exposed to a psychological stressor (Bibbey et al., 2013). Further, some studies did not measure subjective stress directly, but found positive associations between neuroticism and constructs related to subjective stress. For example, a study in which the TSST was also used showed that participants scoring higher in neuroticism reacted with reduced positive affect (Xin et al., 2017). Schneider et al. (2011) found that neuroticism was associated with increased threat appraisal, increased negative affect and reduced positive affect in participants faced with a mental arithmetic task. Penley and Tomaka (2002) conducted a study in which participants high in neuroticism reacted with heightened negative affect and reported less coping ability than participants low in neuroticism after a free speech task. These findings are also in line with Lazarus transactional model of stress, which states that the appraisal of a situation as a threat, the associated negative emotions and the belief that one is unable to cope with it are linked to the perception that a situation is stressful (Lazarus, 1991). Lastly, a study that found no association between neuroticism and subjective stress was conducted by Puig-Perez et al. (2016), in which a sample of participants in the age between 55–70 years was exposed to the TSST. However, these null findings might be explained by sample characteristics, as the participants‘ range of neuroticism scores was restricted.

Neuroticism and the HPA Axis Response

Even though the Big Five model of personality predicts that neuroticism is linked with increased stress sensibility (Norris et al., 2007), most studies reviewed report that neuroticism is associated with a blunted cortisol response. Oswald et al. (2006) used the TSST in their study and found that neuroticism was negatively associated to cortisol response in men. A study by Xin et al. (2017) found that participants scoring higher in neuroticism reacted with a diminished cortisol response to the TSST. Bibbey et al. (2013) also found that neuroticism was negatively associated with cortisol response. McCleery and Goodwin (2001) used the Dex-CRH test during which the HPA axis is stimulated through the injection of dexamethasone and corticotropin releasing factor and found that participants with a low score in neuroticism showed a higher cortisol response than participants with a high score in neuroticism. While it may seem puzzling that neuroticism is positively linked to subjective stress but negatively linked to cortisol response, many authors argue that this might be caused by a phenomenon referred to as hypocortisolism (Bibbey et al., 2013; Chida & Hamer, 2008;

Gunnar & Vazquez, 2001). Hypocortisolism is the tendency to respond to stressors with a flattened cortisol response. Possibly, this phenomenon is more common in people with a high score in neuroticism, since they experience daily stressors more frequently, which might in turn lead to a downregulation of the HPA axis in order to avoid overstimulation (McCleery & Goodwin, 2001). However, there are also studies that found the opposite effect of neuroticism on cortisol response. One of the studies finding a positive association was conducted by Zobel et al. (2004), in which the Dex-CRH test was administered to the participants. They found that neuroticism was related to a higher cortisol response. These findings might be explained by the fact that the latter study excluded participants with psychopathology. Many studies find that hypocortisolism is associated with psychological illnesses such as depression or PTSD (Kellner et al., 2003; Luo et al., 2015; Rohleder et al., 2004). Perhaps the relationship between neuroticism and cortisol response is positive when no dysregulation of the HPA axis caused by psychopathology is present. Additionally, some studies also report null findings. For example, a study conducted by Chopra et al. (2019) that used the TSST in a sample of depressed patients showed no association between neuroticism and the cortisol response. Possibly, this finding could be explained by the fact that neuroticism has a different effect on the stress response in a healthy population than in a population of depressed patients. Another study by Puig-Perez et al. (2016), in which the TSST was used, found no effect of neuroticism on cortisol. Possibly, this null finding can be explained through the restricted range of neuroticism scores in the sample.

Neuroticism and the ANS Response

The literature concerning neuroticism and stress responses of the ANS is relatively limited. Perhaps this is because many studies do not differentiate stress responses of the ANS and the HPA axis, so researchers tend to use the most established stress marker, which is cortisol (Ali & Nater, 2020). Still, the tendency of the studies reviewed in the present study is towards a negative association between neuroticism and ANS response (Bibbey et al., 2013; Hughes et al., 2011; Xin et al., 2017). For example, one study found that neuroticism was linked to a reduced heart rate response in participants exposed to a mental arithmetic task (Hughes et al., 2011). The authors argue that this effect might be explained by the fact that people scoring high in neuroticism are exposed to numerous daily life stressors, which prevents them from fully engaging with experimental tasks. Another interpretation provided by the authors is that neuroticism is associated with poor health, but cardiovascular reactivity with good health. Arguably, people scoring high in neuroticism might have poorer health and thus have a lesser heart rate response when faced with a stressor. This would also explain the findings of Xin et al. (2017) and Bibbey et al. (2013), who found that neuroticism was negatively linked to heart rate in participants exposed the TSST. Another study conducted by Puig-Perez et al. (2016) in which the TSST was used found no effect of neuroticism on sAA or heart rate. Again, this finding might be explained by the restricted range of neuroticism scores.

Extraversion and the Subjective Stress Response

Regarding extraversion and the subjective stress response, the literature paints a picture of a negative relationship, even though most studies reviewed did not measure subjective stress, but related constructs. Bibbey et al. (2013) found that extraversion is associated with lesser perceived task stressfulness. It is noteworthy that the stressor in this study contained both social-evaluative and nonsocial elements, making it unclear whether this effect might be limited to social stressors. One study found that extraversion was inversely related to negative affect (Xin et al., 2017), although this relationship became insignificant after the Bonferroni correction was applied. Hence, the effect size might have been small. Penley and Tomaka (2002) found that extraversion was related to positive affect after participants performed a speech task. Possibly, positive affect is linked to a lower level of perceived stress (Jackson & Schneider, 2014). Another study conducted by Kim et al. (2016) found that extraversion was negatively associated with perceived stress of negative life events. Further, some studies found no association between extraversion and the subjective stress response. For example, it was found that extraversion is unrelated to subjective stress when stress is induced through negative feedback on a video game task (Brouwer et al., 2015). In another study, Vassend and Knardahl (2005) found no relationship between extraversion and negative affect in participants exposed to a tracking task, during which participants were instructed to follow a black square on the screen with a mouse. These null findings might be explained by the nature of the stressor: Perhaps the stress buffering effect of extraversion applies to social stressors, but not to cognitive stressors such as tracking tasks (Lu & Wang, 2017).

Extraversion and the HPA Axis Response

Most studies report a negative relationship between extraversion and the HPA axis response in a stressful situation. In their study, Chopra et al. (2019) found a negative relationship between extraversion and cortisol response in depressed patients exposed to the TSST, but not in healthy controls. In another study in which cortisol levels of children in the age of 3–5 years in social settings were analyzed, children who scored low in extraversion had higher levels of cortisol than children who scored high in extraversion (Gunnar et al., 2003). One study using the TSST found that low levels of novelty seeking, a facet of extraversion, is associated with an increased cortisol response (Tyrka et al., 2007). A different study found that extraversion was associated with a reduced cortisol response in heterosexual men when exposed to the TSST (Wilson et al., 2015). However, one study found a positive relationship between extraversion and ACTH response in participants exposed to the TSST (Oswald et al., 2004). The authors argue that this effect might be due to a liability in the HPA axis that is shown by individuals with a high score in extraversion, since their need for novelty lets them seek more stressors, which in turn trains the HPA axis to become more responsive. However, the authors of the latter study found no relationship between extraversion and cortisol response. Possibly, cortisol and ACTH have an asymmetrical relationship in the acute stress response. Finally, Bibbey et al. (2013) found no relationship between extraversion and cortisol response. Perhaps this can be explained by the fact that the majority of stressors used in the latter study did not contain social-evaluative elements.

Extraversion and the ANS Response

Evidence about the relationship between extraversion and the ANS response is mixed. A study had participants engage in an anger recall task and a mental arithmetic task (Jonassaint et al., 2009). It was found that extraversion was negatively associated with heart rate reactivity in the anger recall task, but not in the mental arithmetic task. This finding is in line with the hypothesis that extraversion has a buffering effect on ANS activity only if the stressor is emotionally relevant. This hypothesis is supported by a study conducted by Lu and Wang (2016), who found that participants scoring high in extraversion showed lesser heart rate reactivity than participants scoring low in extraversion when exposed to a social stressor. Further, Vassend and Knardahl (2005) found no association between extraversion and heart rate in participants exposed to a speech- and tracking task. One possible explanation for these null findings are that the tasks did not contain high degrees of social-evaluative elements and hence might have been irrelevant to the stress buffering effect of extraversion in social situations. Bibbey et al. (2013) found no relationship between extraversion and heart rate after exposure to a stroop task, a mirror facing task and a speech task. Perhaps these inconclusive results may be explained by the fact that only the speech task was emotionally relevant to the nature of extraversion, while the other two tasks were not, hence masking the effect. However, this interpretation should be used with caution, since one study found no relationship between extraversion and heart rate in which the TSST was used, a stressor which is arguably of high emotional valence for people scoring high in extraversion due to its social-evaluative nature (Xin et al., 2017).

Gender and the Stress Response

Another factor that might play a role in the stress process is gender. Studies report that women show more negative affect after exposure to a public speaking task than men (Carrillo et al., 2001; Childs et al., 2010; Kelly et al., 2008). In another study conducted by Traustadóttir et al. (2003), they found that men show a significantly greater increase in cortisol than women when exposed to a psychological stressor. These results are confirmed by an extensive meta-analysis of 34 studies using the TSST, which concluded that men show higher peak levels of cortisol than women (Liu et al., 2017). Regarding ANS activity, a study using a cold pressor test found that women responded with heightened levels of sAA, while men responded with reduced levels of sAA (Carr et al., 2016). Another study found that women respond with higher heart rate reactivity when exposed to the TSST than men (Childs et al., 2010). Notably, this gender difference was much larger in women in the luteal phase of the menstrual cycle than in women in the follicular phase, which portends that gender differences in stress response might be mediated by phases of the menstrual cycle. There is evidence that women show a diminished cortisol response to the TSST compared to men when tested during the follicular phase of their menstrual cycle, but not when tested during the luteal phase (Kirschbaum, 1999; Liu et al., 2017). However, a study conducted by Bouma et al. (2009) came to the conclusion that men exhibit a greater cortisol response than women in either phase of the menstrual cycle and found no effect of menstrual cycle on social stress. Further, menstrual phases might differ in their relationship with different stress response systems. A study by Duchesne and Pruessner (2013) found that negative affect and cortisol response were positively associated in women who were exposed to a social stressor during the luteal phase, while there was a negative association between negative affect and cortisol response during the follicular phase. Some studies also report no effect of gender on stress response. For example, the aforementioned study by Kelly et al. (2008) found no effect of gender on HPA axis activity in participants exposed to the TSST. Notably, this study did not assess menstrual cycle phase. Further, one study found no effect of gender on sAA in participants with borderline personality disorder after exposure to the TSST (Inoue et al., 2015). A recent study by Poppelaars et al. (2019) found no differences in subjective stress, ANS activation and HPA axis activation between men and women tested in the follicular phase when exposed to a social stressor.

Apart from these direct effects on the stress response, gender also might play a moderating role in the relationship between personality and stress response. For instance, in a study conducted by Zobel et al. (2004), high levels of neuroticism were associated with a greater cortisol response in men, but not in women, when exposed to the Dex-CRH test. Another study by Oswald et al. (2006) found that higher cortisol responses were associated with lower neuroticism scores in women and with higher extraversion scores in men. The authors of the latter study argue that these gender differences might be caused by different biological responses or different cognitive appraisals to stress in men and women.

Research Questions/ Hypotheses

As shown in the literature review above, the effects of personality traits and gender on different stress systems might diverge. The current study aims to investigate this by measuring the effects of neuroticism, extraversion and gender on subjective stress response, cortisol response and sAA response simultaneously. An acute stress response is provoked through the administration of the TSST, a psychological stressor with social-evaluative elements (see procedure).

The following research questions are formulated: Do the personality dimensions neuroticism and extraversion have an effect on the subjective stress response, the cortisol response and the sAA response when exposed to a social stressor? Does gender have an effect on the subjective stress response, the cortisol response and the sAA response when exposed to a social stressor? Does gender play a moderating role in the relationship between personality and stress response? Based on the literature review above, the following hypotheses are formulated:

1.1 There is a positive association between neuroticism and subjective stress response in an experimentally induced stress situation.
1.2 There is a negative association between neuroticism and cortisol response in an experimentally induced stress situation.
1.3 There is a negative association between neuroticism and sAA response in an experimentally induced stress situation.
2.1 There is a negative association between extraversion and subjective stress response in an experimentally induced stress situation.
2.2 There is a negative association between extraversion and cortisol response in an experimentally induced stress situation.
2.3 There is an association between extraversion and sAA response in an experimentally induced stress situation.
3.1 Men show a lower subjective stress response in an experimentally induced stress situation than women.
3.2 Men show a higher cortisol response in an experimentally induced stress situation than women.
3.3 Men show a different sAA response in an experimentally induced stress situation than women.
3.4 There is a moderating effect of gender on the relationship between neuroticism and subjective stress response in an experimentally induced stress situation.
3.5 There is a moderating effect of gender on the relationship between neuroticism and cortisol response in an experimentally induced stress situation.
3.6 There is moderating effect of gender on the relationship between neuroticism and sAA response in an experimentally induced stress situation.
3.7 There is moderating effect of gender on the relationship between extraversion and subjective stress response in an experimentally induced stress situation.
3.8 There is moderating effect of gender on the relationship between extraversion and cortisol response in an experimentally induced stress situation.
3.9 There is moderating effect of gender on the relationship between extraversion and sAA response in an experimentally induced stress situation.

Methods

Sample

The sample consisted of $N = 124$ ($n = 62$ male, $n = 62$ female) healthy, non-smoking participants with normal weight in the age between 18–34 ($M = 23.68$ years). 66% of participants reported having an education at university level. All female participants were tested in the follicular phase of their menstrual cycle. Among the exclusion criteria were autoimmune diseases, infectious diseases, heart diseases, psychological illnesses and drug consumption. Out of this sample, 42 participants underwent the TSST alone, 42 participants were tested in a group of three and 40 participants in a group of five (see procedure). Participants were recruited via flyers from different online platforms. Each participant received an expense allowance of 40 euros for complete participation.

Procedure

The current study used the TSST (Kirschbaum et al., 1993), a standardized protocol for the induction of psychosocial stress. Participants who applied for the study were interviewed via telephone to examine whether they met the eligibility conditions. Participants then had to fill out several online questionnaires, among others the NEO-FFI (see Instruments), before the appointment of the actual study. Participants were instructed not to exercise and not to consume alcohol, nicotine or chewing gums one day before the testing. The study itself took place either in a single setting in which participants were tested alone or in a group setting where either three or five participants were tested simultaneously; participants were unsystematically assigned to conditions and were blind about it until the testing started. At the day of the testing, participants were greeted at the laboratory by the examiner at 1:50 pm and guided to the first testing room. If participants were in a group setting, they were asked to wait for the other participants. As soon as all participants were present, they were asked to stow their valuables and mobile phones. Further, participants were asked to rinse their mouth with water to ensure clean saliva samples. Participants in a group setting were instructed not to communicate with each other during the study. Then, the informed consent was handed out. If participants finished these before 2:30 pm, they were allowed to read magazines for the remaining time. Afterwards, participants were led to a second room by the examiner, in which the TSST was administered. In this room, two confederates acting as an expert committee, dressed in a white lab coat with neutral face expressions, were sitting behind a table facing towards the participants. To enhance feelings of evaluation, a seemingly turned on microphone as well as a seemingly turned on camera was facing towards the participants. Participants were instructed that after a preparation period, they had to give a free speech, pretending to apply for a job of their choice while talking about their personal strengths and weaknesses. Further, participants were instructed that after the speech task, an arithmetic task would follow. Then, participants had three minutes to make notes for the interview, which they were not allowed to use during the speech. Following that, the free speech task started, which lasted two to five minutes, depending on the group setting (single setting = 5 minutes, group of three = 3 minutes, group of five = 2 minutes). Afterwards, the arithmetic task was presented, in which participants were instructed to count backwards in steps of 17. This task also lasted two to five minutes, depending on the group condition. After the arithmetic task, participants were guided back into the first room by the examiner to measure their stress levels in specific time intervals. In detail, measurements of stress through the VAS and saliva samples were obtained nine times in total, at the following times: Before participants were led to the task room (2:30 pm), after the preparation for the free speech task (2:40 pm), after the free speech task (2:54 pm), after the arrrithmetic task (3:07 pm) and then another five times in intervals between 10-15 minutes (3:22 pm, 3:32pm, 3:42 pm, 3:57 pm, 4:12pm). At 4:17 pm, the study was finished. In the end, participants were debriefed and allowed to recollect their valuables. The examiner then stored the salivary samples in a freezer at -20° Celsius.

Instruments

Subjective stress was measured through a a visual analogue scale (VAS) containing the question „how stressed are you?“. Participants could mark their degree of agreement on a horizontal line. The left end represented 0 and meant „not at all“, the right represented 100 and meant „very much“.

To assess neuroticism and extraversion, the NEO-FFI (Costa & McCrae, 2008) was administered, a validated and reliable tool for measuring Big Five personality traits. This study used a shortened version that is limited to the dimensions of neuroticism (α = .89) and extraversion (α = .79), in which each dimension is assessed through 12 items. Sample items for neuroticism included „I am easily troubled“ or „I am tense and nervous“, sample items for extraversion included „I enjoy the company of many people around me“ or „I like to be the center of attention“. These questions are assessed on a Likert scale ranging from 1 („highly disagree“) to 5 („highly agree“).

Cortisol and sAA levels were measured through salivary samples from the participants via passive drool method: Before saliva collection, participants were asked not to speak or swallow for two minutes. Then, participants were instructed to deliver the accrued saliva into a plastic tube through a tubule and store it in a box. These plastic tubes were later sent to a biological laboratory for further analysis. Cortisol scores were measured in nmol/l, sAA scores were measured in u/ml. The current study is embedded in a larger project in which more variables were measured, but for reasons of clarity, no overview of measurement instruments that are not in the scope of the current analysis is provided.

Design/Analyses

The current study is a quasi-experiment without a control group. To measure the acute stress response, delta scores were calculated to capture the difference between the peak values of the respective stress response and its baseline. Since the HPA axis, the ANS and feelings of subjective stress have different response times (Pruessner & Ali, 2015), peak values differ for each stress marker had to be identified manually. This was accomplished by selecting the values significantly above the mean value for all measurement time points of the respective variable (Table 1). For subjective stress, peak values were defined at measurement point 3, 4 and 5. For cortisol, peak values were defined at measurement point 4, 5 and 6. For sAA, peak values were defined at measurement point 4 and 5. Because this is, to the best of my knowledge, the first study to assess subjective stress response relative to baseline levels, it might be interesting to investigate whether different results are obtained when only peak values are considered and not delta scores. Hence, analysis of peak values for subjective stress will be included in the results section for exploratory purposes.

For H1.1–H1.3, one tailed Pearson correlation analyses between neuroticism and subjective stress, cortisol and sAA were conducted. For H2.1–H2.3, correlation analyses between extraversion and subjective stress, cortisol and sAA were conducted. For H2.1–H2.2, a one-tailed Pearson correlation analysis was used, while for H2.3, a two-tailed Pearson correlation was used. Hypotheses H3.1–H3.3 were analyzed using simple *t*-tests with independent groups, with gender as the grouping variable and subjective stress, cortisol and sAA as dependent variables. For H3.4–H3.9, moderation analyses were conducted using the PROCESS 3.4.1 macro (Hayes, 2018) for SPSS 22, resulting in 6 models with neuroticism and extraversion as independent variables, gender as a moderator variable and subjective stress, cortisol and sAA as dependent variables, respectively. In total, this resulted in 6 correlation analyses, 3 *t*-tests and 6 moderation analyses. Further, for the *t*-tests, analyses of effect sizes were conducted using Cohen's *d* (Cohen, 1988), a popular measure for the strength of a relationship. Benchmarks for Cohen's *d* are 0.2 for a small effect size, 0.5 for a medium effect size and 0.8 for a large effect size.

Table 1

Mean Values for VAS scores, Cortisol Scores and sAA Scores Across Measurement Times.

	MT1	MT2	MT3	MT4	MT5	MT6	MT7	MT8	MT9
VAS	12.86	**45.20**	**42.39**	**37.72**	14.48	11.15	7.83	5.93	6.39
Cortisol	4.93	4.41	4.99	**7.38**	**9.12**	**8.31**	4.64	3.40	2.73
sAA	53.89	80.28	**147.25**	**141.35**	91.80	69.43	83.40	78.84	56.77

Note. Peak values are highlighted in bold.

Results

Descriptive Results

Table 2

Descriptive Results for the Personality Dimensions Neuroticism and Extraversion.

	Mean	Median	*SD*	Minimum	Maximum
Neuroticism	2.26	2.17	0.76	0.75	4.33
Extraversion	3.11	3.17	0.57	1.83	4.5

Assumptions

Concerning the independent variables, the assumption of normality was violated for neuroticism scores, $D(124) = 0.09$, $p < .01$. Further analysis showed that the distribution is right skewed with a value of 0.41, $SD = 0.22$. However, according to the Kolgomorov-Smirnov test, normality could be assumed for extraversion scores, $D(124) = 0.06$, $p = .2$. Moreover, the assumption of normality was violated for delta scores of subjective stress, $D(122) = 0.12$, $p < .01$, cortisol, $D(121) = 0.14$, $p < .01$, and sAA, $D(118) = 0.16$, $p < .01$. Additionally, visual inspection of P-P plots showed a deviation from normality of the residuals for all regression models. It was renounced to apply log transformations on these variables, because Kolmogorov-Smirnov tests showed that log transformations did not resolve the issue of non-normality. Still, because of the high sample size in the current study, robustness against these violations was assumed. Several outliers were observed in scores of neuroticism, subjective stress, cortisol and sAA. However, it was assumed that this was due to the non-normality in their distribution rather than due to measurement errors. Hence, no outlier was excluded. Visual inspection of scatterplots for neuroticism or extraversion as independent variables and subjective stress, cortisol or sAA as dependent variables showed that homoscedasticity and linearity were given for all models. The Durbin-Watson statistic showed no problem with autocorrelation in either model. Levene's test showed that homogeneity of variances could be assumed in men and women for subjective stress scores, $F = 0.12$, $p = .07$, cortisol scores, $F = 2.72$, $p = .1$, and sAA scores, $F = 1.51$, $p = .22$.

Stress Manipulation

Whether the stress manipulation was successful was analyzed through the inspection of delta scores. These were $M = 28.59$, $SD = 24.54$ for subjective stress, $M = 3.34$, $SD = 4.93$ for cortisol and $M = 137.09$, $SD = 157.1$ for sAA. One sample *t*-tests showed that delta scores differed significantly from 0 for subjective stress, $t(121) = 13.03$, $p < 0.01$, cortisol, $t(120) = 7.66$, $p < 0.01$, and sAA, $t(117) = 9.48$, $p < 0.01$, showing that the TSST successfully induced stress for all stress systems. Trajectories of the stress response systems can be seen in Figure 1.

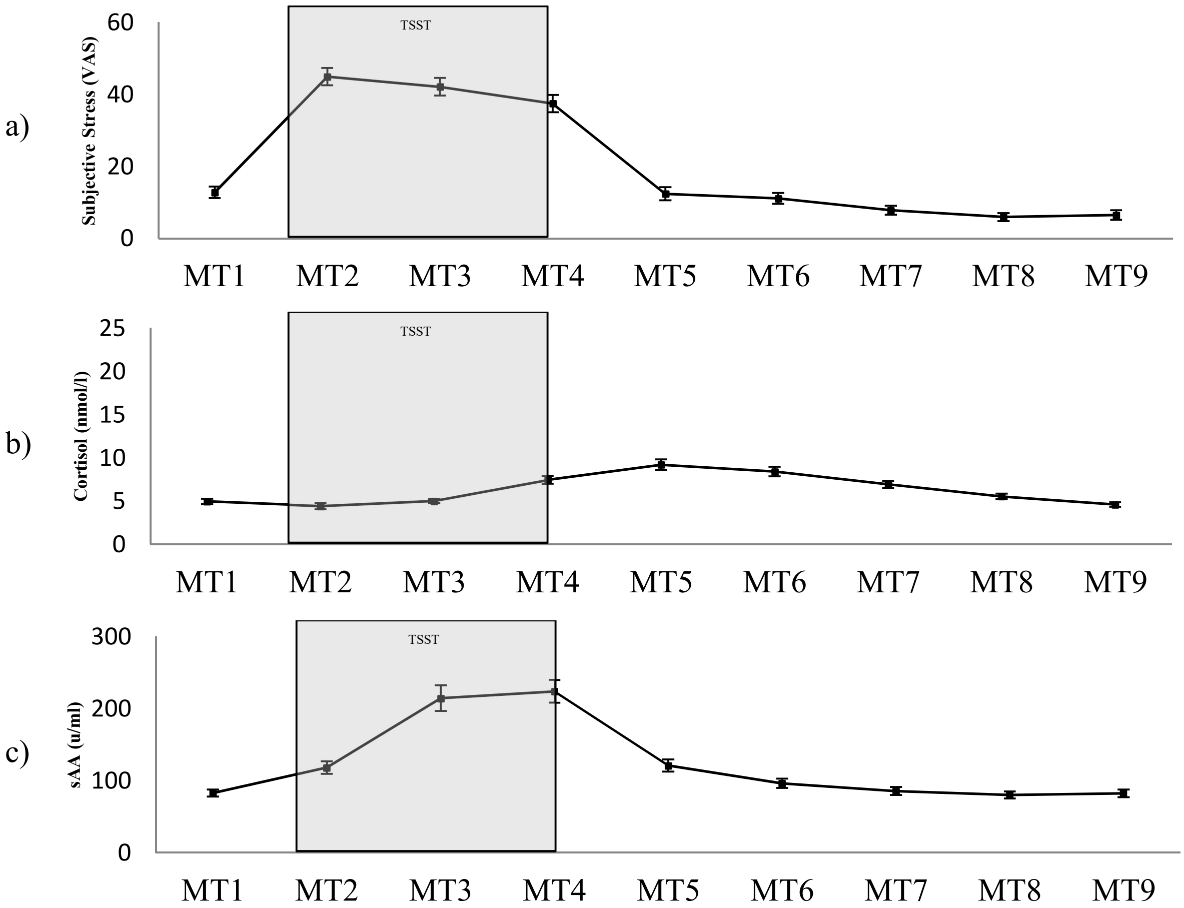

Figure 1. Trajectories of stress responses for a) subjective stress, b) cortisol, c) sAA. MT is the measurement time. Error bars represent standard errors of the mean of the respective measurement time.

H1.1–H1.3: Neuroticism and the Stress Response

No significant correlation between neuroticism and delta scores of subjective stress was found, $r(120) = .01$, $p = .15$, resulting in a rejection of H1.1. However, there was a significant correlation between neuroticism and peak values of subjective stress, $r(120) = .42$, $p < .01$. Further, H1.2 was discarded as no significant correlation between neuroticism and cortisol was found, $r(119) = -.01$, $p = .14$. Finally, no significant correlation between neuroticism and sAA was found, $r(116) = -.13$, $p = .09$, hence H1.3 is discarded as well.

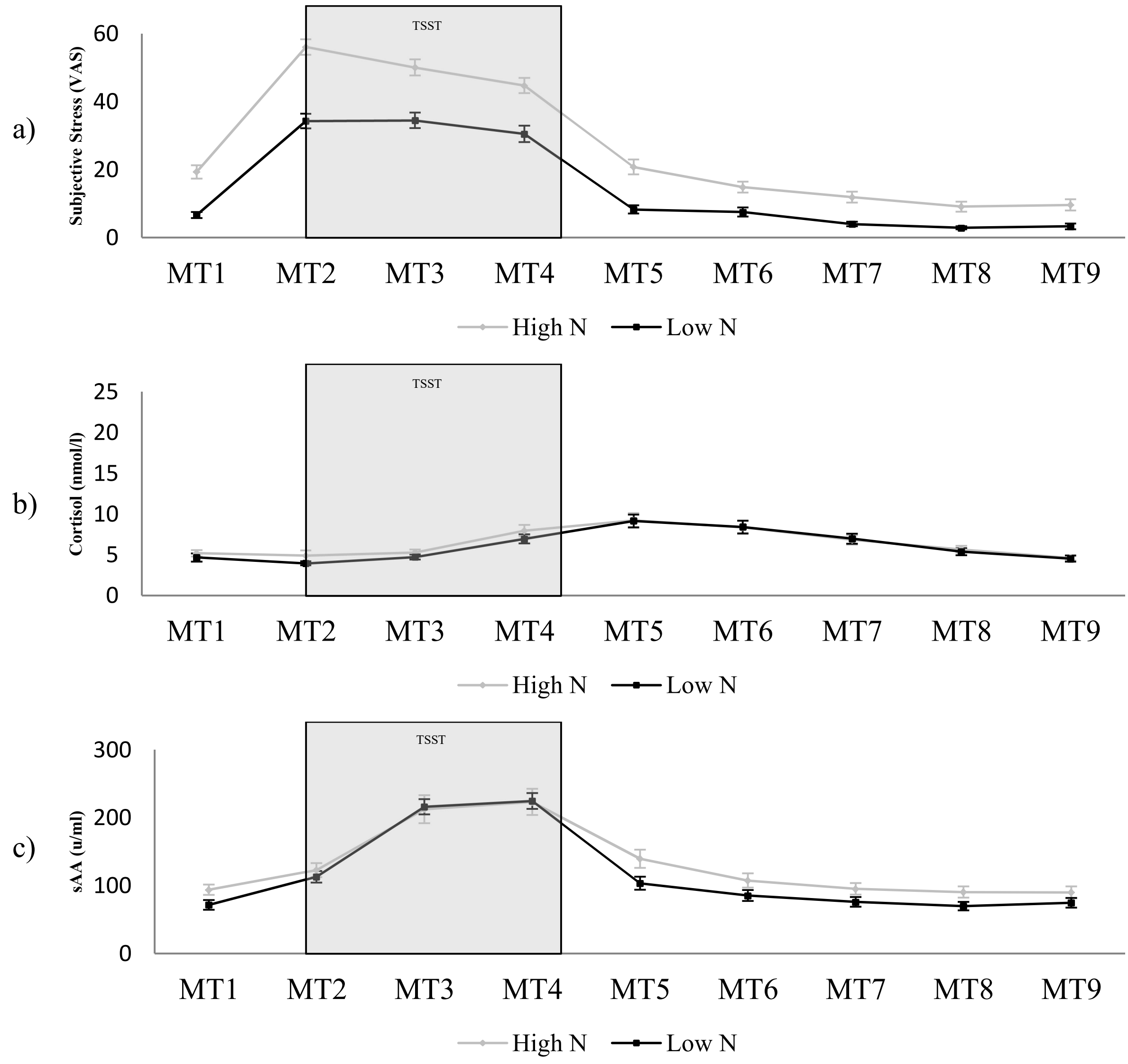

Figure 2. Trajectories of stress responses for a) subjective stress, b) cortisol, c) sAA, grouped by median splits on neuroticism scores. MT is the measurement time. Error bars represent standard errors of the mean of the respective measurement time.

H2.1–H2.3: Extraversion and the Stress Response

H2.1 was discarded since no significant correlation between extraversion and subjective stress was found, $r(120) = .01$, $p = .45$. However, there was a significant correlation between extraversion and peak scores of subjective stress, $r(120) = -.17$, $p = .03$. No significant correlation between extraversion and cortisol was found, $r(119) = 0$, $p = .49$, so H2.2 was refuted as well. Lastly, a significant negative correlation between extraversion and sAA was found, $r(116) = -.22$, $p = .02$, leading to a confirmation of H2.3.

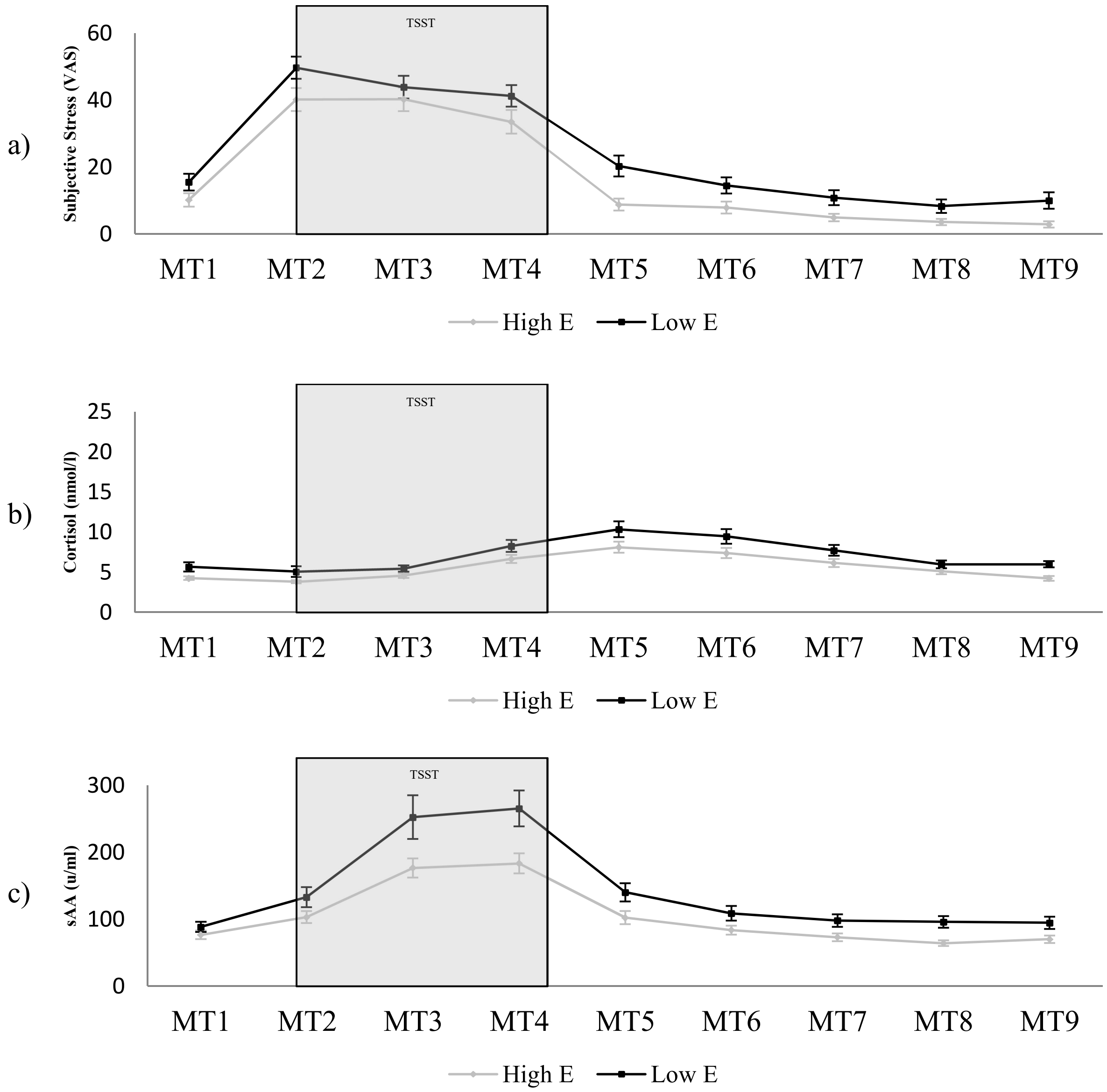

Figure 3. Trajectories of stress responses for a) subjective stress, b) cortisol, c) sAA, grouped by median splits on extraversion scores. MT is the measurement time. Error bars represent standard errors of the mean of the respective measurement time.

H3.1–H3.3. Gender and the Stress Response

There was a significant effect of gender on delta scores of subjective stress, $t(120) = 1.92$, $p = .03$, $d = 0.35$, while women ($M = 33.17$, $SD = 24.74$) showed higher scores than men ($M = 24.74$, $SD = 21.62$). Hence, H3.1 was confirmed. Further, a significant effect of gender on peak values of subjective stress could be observed , $t(120) = 3.06$, $p < .01$. H3.2 was validated, too: Men showed a significantly higher level of cortisol ($M = 5$, $SD = 5.01$) than women ($M = 1.84$, $SD = 4.26$), $t(120) = 3.7$, $p < .01$, $d = 0.67$. There was no significant effect for gender on sAA, $t(116) = -1.68$, $p = .1$, $d = 0.31$, despite men ($M = 159.96$, $SD = 190.77$) showing higher scores than women ($M = 111.78$, $SD = 104.41$), leading to a disconfirmation of H3.3.

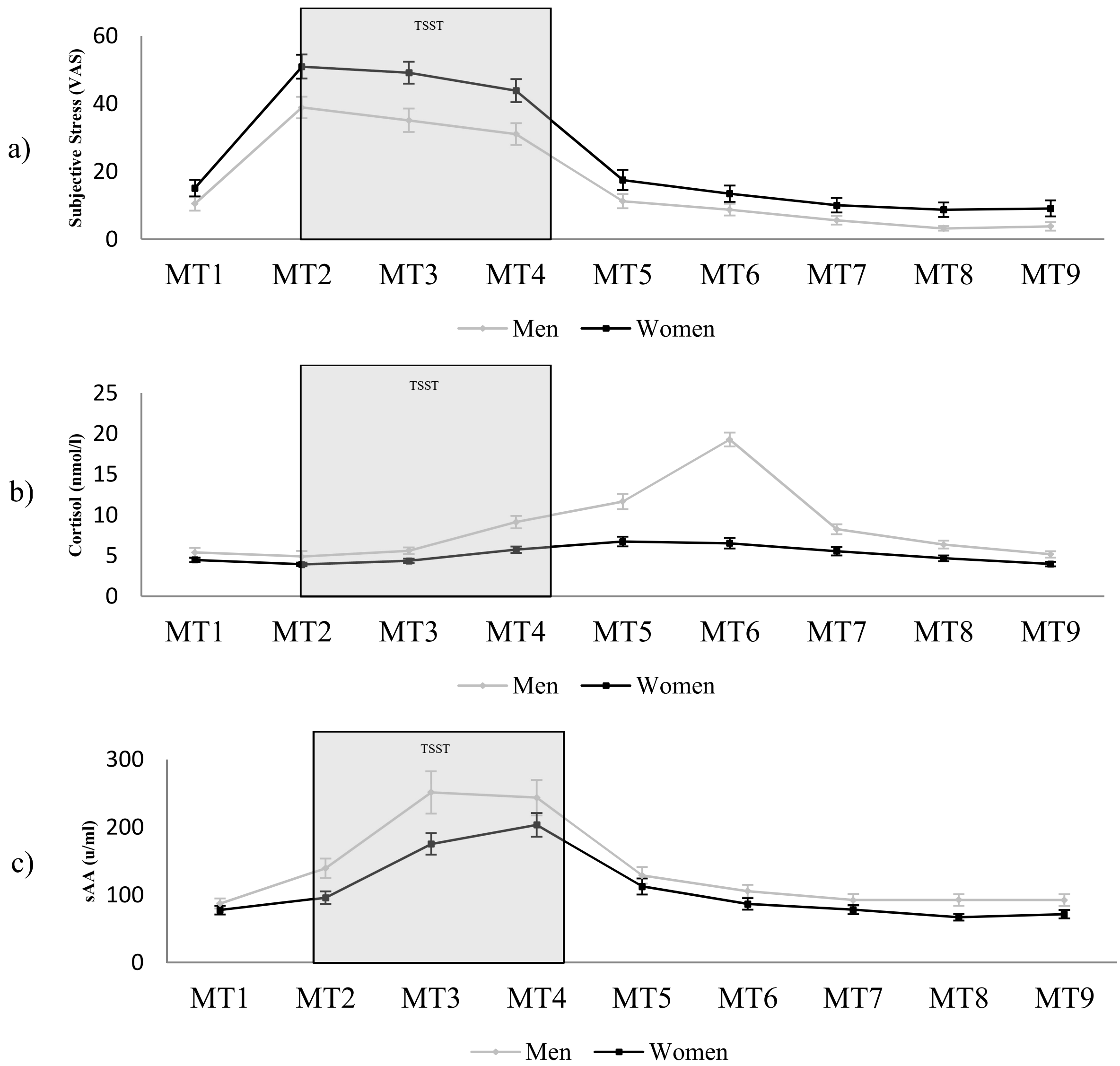

Figure 4. Trajectories of stress responses for a) subjective stress, b) cortisol, c) sAA, grouped by gender. MT is the measurement time. Error bars represent standard errors of the mean of the respective measurement time.

H3.4–H3.6 Moderation Analyses

For the interaction between neuroticism and gender, no significant effects could be found on subjective stress, $\beta = -4.18$, *95% CI* (-16.33, 7.8), $p = .5$; cortisol, $\beta = -7.77$, *95% CI* (-3.1.4, 1.61), $p = .52$ or sAA, $\beta = -69.62$, *95% CI* (-9.6, 148.85), $p = .08$. For the interaction between extraversion and gender, no significant effects could be found on subjective stress, β = 4.43, *95% CI* (-11.25, 20.11), p = .58, cortisol, β = 0.22, *95% CI* (-2.79.4, 3.23), p = .88 or sAA, β = 3.8, *95% CI* (-95.26, 102.86), p = .94. These findings result in a dismissal of H3.4–H3.9.

Discussion

As stress is becoming an increasing concern for public healthcare (WillisTowersWatson, 2019), it is vital that research reveals how different factors relate to the acute response. The current study aimed to address this question by inquiring whether personality variables and gender have an influence on an acute stress response elicited via the TSST paradigm and if so, if the effect is similar for different stress markers like subjective stress, cortisol or sAA. It was found that the effect of the factors depends upon the stress system inquired.

Induction of Stress

Requirement for all further analyses was a successful induction of stress by the TSST, which could be found on all stress systems tested. As can be seen in Figure 1, subjective stress reached its peak at after the preparation of the free speech (MT2), declined slightly during the speech- and the arithmetic task (MT2–MT4) and then dropped steeply during the recovery phase (MT5–MT9). Cortisol had a delayed response, with a steady increase between MT2 and MT5 and a similarly decreasing pace towards MT9, which is in line with prior research denoting cortisol as a somewhat deferred stress marker (Kirschbaum & Hellhammer, 1989). sAA increased rapidly during the TSST (MT–MT4) and seceded as rapidly during the recovery phase (MT5–MT9). Hence, the TSST induced stress in a way that was expected. These results reinforce its usefulness as a reliable and easy to administer protocol for the induction of psychosocial stress.

Neuroticism and the Stress Response

Regarding neuroticism and the subjective stress response, no association could be found, leading to a rejection of H1.1. This finding is surprising, as research has established a negative association between these constructs quite robustly (Bibbey et al., 2013; Mohiyeddini et al., 2015; Penley & Tomaka, 2002; Schneider et al., 2012; Xin et al., 2017). One reason for this discrepancy might be due to the fact that the present study operationalized the acute stress response through delta scores between subjective stress during stress exposure and subjective stress at baseline level, while other studies reviewed did not consider the baseline level of stress and measured subjective stress after stress exposure only. This argument is supported by the fact that a significant positive association between neuroticism and subjective stress was found when the baseline level of stress was not controlled for. As can be seen in the data, people scoring high in neuroticism in this sample had a higher level of subjective stress at baseline level than people scoring low in neuroticism (Figure 2). To my knowledge, this is the first study to investigate this relationship using delta scores, hence providing new insights via this operationalization. In light of these findings, the positive association between neuroticism and subjective stress found in other studies might be explained by a higher perception of stress overall in people scoring high in neuroticism, but not by a higher increase in perceived stress when exposed to an acute stressor. Future studies should explore this question by including delta scores in their analysis. Another possible explanation for these null results is that the mean of neuroticism scores in this sample was relatively low (Table 2), with many participants scoring a value of less than 2.

Concerning H1.2, no association between neuroticism and cortisol could be found, a result that was found a by two others studies as well (Chopra et al., 2019; Puig-Perez et al., 2016). However, these findings contradict those of the majority of studies reviewed that found a negative relationship (Bibbey et al., 2013; McCleery & Goodwin, 2001; Oswald et al., 2006; Xin et al., 2017). One reason for these null findings could be that the sample in the present study was rather young. Many researchers argue that the negative relationship between neuroticism and cortisol response is caused by hypocortisolism, a condition that becomes stronger with more stressful life events encountered (Bibbey et al., 2013) and with increasing age, the possibility to encounter stressful life events becomes larger. Another reason why the present study found inconclusive results might be that hypocortisolism can only be observed in individuals with very high scores in neuroticism (Puig-Perez et al., 2016). For example, the study of Mcleery and Goodwin (2001) found an effect of neuroticism on cortisol response using extreme groups, comparing individuals of the highest quartile and the lowest quartile in neuroticism scores. On the contrary, the analysis of the present study also included individuals with neuroticism scores close to the mean. Another important sample characteristic of the present study is that only psychologically healthy participants have been included. As neuroticism is associated with psychopathology (Puig-Perez et al., 2016), this might have led to a bias excluding participants with high neuroticism scores in which the effect of hypocortisolism could have been observed. Finally, Oswald et al. (2006) reported a significant negative relationship between neuroticism and cortisol response in women, but not in men. As the present sample contained 50% men and 50% women, perhaps the effect of neuroticism on cortisol response was shrouded by the data of the male participants.

H1.3 was discarded as well, as no significant association between neuroticism and sAA was found. This finding is in line with those of Puig-Perez et al. (2016). While these results are contradictory to those of other studies reviewed (Bibbey et al., 2013; Hughes et al., 2011; Xin et al., 2017), it should be noted that those studies used heart rate instead of sAA as an indicator for ANS activity. As the exact relationship between sAA and heart rate is not clear (Pruessner & Ali, 2015), it is plausible to consider that neuroticism could only be related to heart rate, but not to sAA. Further research should address this question by measuring the effect of neuroticism on sAA and heart rate simultaneously.

Extraversion and the Stress Response

The current study did not find a relationship between extraversion and the subjective stress response, hence H2.1 is discarded. Even though these findings are in line with some other studies reviewed (Brouwer et al., 2015; Vassend & Knardahl, 2005), it was hypothesized that null findings of these studies can be explained by characteristics of the stressor, as they did not use stressors with social-evaluative elements. However, this argument does not apply for the present study in which the TSST, a stressor that is highly social-evaluative, was used. One reason why the present study contradicts the results of other studies using the TSST (Bibbey et al., 2013; Xin et al., 2017) could be a similar one like for neuroticism and subjective stress: The subjective stress response was operationalized using delta scores, comparing the level of subjective stress between peak values and baseline, while the other studies did not. This argument is supported by the fact that the relationship between extraversion and subjective stress became negatively significant when peak values only were considered. As can be seen in Figure 3, the slopes of the subjective stress responses have rather similar trajectories in people scoring high and low in extraversion. One way to interpret that data is that extraversion is associated with a lower baseline level of subjective stress, but not with a relative increase in stress when a stressor is experienced. Further, the present study used a single item on a VAS to measure subjective stress, while other studies measured other constructs like affect (Penley & Tomaka, 2002; Xin et al., 2017) using validated questionnaires. Possibly, the single item on a visual scale „how stressed are you?“ did not have enough validity to find solid results. Finally, the results of the present study also contradict those of Kim et al. (2016), who found that extraversion was negatively related to perceived stress about stressful life events. Perhaps, this effect is based on a higher perception of stress in general in people scoring low in extraversion rather than by a higher stress response to stressful life events in specific.

H2.2 was rejected since no relationship between extraversion and cortisol was found. Although these findings are in line with those of Bibbey et al. (2013), it was hypothesized that a negative relationship would be found because the present study, other than the study by Bibbey et al., used a stressor that contained social-evaluative elements, making it an emotionally relevant stressor for the trait of extraversion (Jonassaint et al., 2009). A possible explanation for this null finding is that the cortisol buffering effect of extraversion applies more to men than to women, as the present study had a sample consisting of an equal amount of men and women. Support for this argument comes from the fact that one study found a negative association between stress and cortisol response in men, but not in women (Oswald et al., 2006). Further, another study that found similar results had a sample consisting of men only (Wilson et al., 2015). However, this argument is questionable for the present study since the moderation analysis showed no interaction effect between extraversion and gender. Another argument for these discrepancies might be that the effect of extraversion on cortisol response is mediated by psychopathology, which was an exclusion criterion for the present study. This is supported by the fact that the study of Chopra et al. (2019) found a negative relationship between extraversion and cortisol response in depressed patients, but not in healthy controls. However, another study found a negative relationship between novelty seeking and cortisol in a healthy, young sample (Tyrka et al., 2007). Another study showing contradicting results to the present one found a negative relationship between novelty seeking and cortisol levels in preschoolers in a social setting (Gunnar et al., 2003). Possibly, this can be explained by the nature of the stressor: The latter study was a field study, observing children in a naturalistic setting, while the present study used an experimental stressor. Perhaps the real-world situation invoked more emotional relevance in the participants than the arbitrary laboratory situation.

A negative association between extraversion and sAA was found, leading to a confirmation of H2.3. These findings are in line with other studies using an emotionally relevant stressor (Jonassaint et al., 2009; Lu & Wang, 2017) and might be explained by the fact that the talkative and social nature of people scoring high in extraversion makes them interpret stressors with social-evaluative elements as less threatening. Other studies that found no effect between extraversion on ANS activity perhaps did so because the stressor applied was not emotionally relevant (Bibbey et al., 2013; Vassend & Knardahl, 2005). One discrepancy which is not explainable by this argument are the results of a study by Xin et al. (2017), who found no effect of extraversion on heart rate. One reason for this might be the fact that extraversion relates differently to heart rate and sAA. To my knowledge, this is the first study assessing the effects of extraversion on sAA in an acute stress situation. Although sAA is nowadays considered as a valid and reliable marker of ANS activity (Ali & Nater, 2020), studies suggest that the enzyme might not correlate perfectly with other markers of ANS activity. For example, one study found that sAA was uncorrelated to heart rate variability when measured in a resting state (Kobayashi et al., 2012). Although this study did not measure sAA and heart rate variability in response to acute stress, these results still leave room for debate whether sAA can be adequately classified as a measure of similar physiological activity as heart rate. Further, an early study conducted by Borgeat et al. (1984) measuring numerous biomarkers in response to a stressful and a relaxing activity found that heart rate, but not sAA, differed significantly over the experimental conditions. Apart from these methodological unclarities, the present study provides novel insights into the relationship between extraversion and sAA. As can be seen in Figure 3, the effect of extraversion on sAA was especially stark during the TSST, while extraversion did not have such a strong effect on baseline values of sAA. This shows that the significant association between extraversion and sAA is indeed in indicator for a personality difference in reaction to acute stress and not only for an overall difference in the amount of sAA.

Gender and the Stress Response

Concerning gender, women showed a higher subjective stress response than men, a finding that is in line with research stating that women report more subjective stress than men in general (Juster & Lupien, 2012). Hence, H3.1 can be confirmed. Analysis of Cohen's *d* showed a small effect size for this effect. As was the case with neuroticism and extraversion, the effect of gender on subjective stress was also significant when only peak values were considered and not delta scores. As can be seen in Figure 4, gender differences of subjective stress at baseline were only marginal, while the highest difference can be observed at the peak values. These results are in line with the majority of studies reviewed when menstrual cycle is considered. For example, Childs et al. (2010) found a large gender difference in subjective stress response between men and women tested in the luteal phase, but only a small gender difference between men and women tested in the follicular phase. This is somewhat in line with our findings of a small gender difference in the present sample consisting of women in the follicular phase only. The other studies reviewed that found a large gender difference did not assess menstrual cycle (Carrillo et al., 2001; Kelly et al., 2008). Since the luteal phase and the follicular phase are approximately equal in length, it can be assumed that a significant proportion of the sample in these studies were tested in the luteal phase. Interestingly, one study found no significant gender difference between men and women in the luteal phase on state anxiety or state approach motivation, even though evidence of other studies reviewed suggests that the luteal phase should increase gender differences on subjective stress response (Poppelaars et al., 2019). Further research is needed to unmask the underlying effect of menstrual cycle on subjective stress response.

Men in this sample showed a greater cortisol response than women with a medium to large effect size, leading to a validation of H3.2. These findings are echoed by the literature reviewed (Traustadóttir et al., 2003), including a large meta-analysis (Liu et al., 2017). Possibly, this gender difference is due to differences in hormones or brain areas like the hippocampus, the prefrontal cortex and the amygdala (Barrera et al., 2001). However, it contradicts the findings of some other studies (Kelly et al., 2008; Poppelaars et al., 2019). Possibly, this contradiction might be once more explained by menstrual cycle. The study by Kelly et al. (2008) did not assess menstrual cycle phase and the study by Poppelaars et al. (2019) tested women in the luteal phase of their menstrual cycle. Perhaps, the effect of gender on cortisol response is only apparent in women that are in the follicular phase of their menstrual cycle. However, the authors of the meta-analysis reviewed came to the conclusion that men exhibit greater cortisol responses irrespective of menstrual cycle phase (Liu et al., 2017). These findings provide further support for the hypothesis that men exhibit a different HPA axis response pattern than women when exposed to a stressor. Further research should focus on isolating the underlying factors like menstrual cycle, hormone levels and biological structures that underlie this gender difference.

As no significant effect of gender on sAA response was found, H3.3 was discarded. These findings are in line with those of Poppelaars et al. (2019) and Inoue et al. (2015), who found no effect of gender on ANS response in participants exposed to the TSST. However, these results contradict those of Carr et al. (2016), who found an increase in sAA in men, but a decrease in sAA in women exposed to a cold pressor test. Another discrepancy is that the latter study found that men had a higher baseline level of sAA than women, while the present study found equal baseline levels of sAA in men and women (Figure 4). These baseline differences are hard to explain through characteristics of the stressor, as the stressor was not yet applied when the baseline level was assessed. Hence, the most plausible explanation for this difference lies in sample characteristics. Namely, the latter study sampled females in different menstrual phases, which might have affected baseline levels of sAA in women. However, this does not explain why the latter study found that men show a decrease in sAA in response to a stressor, while the present study found a significant increase in sAA in response to the stressor compared to their baseline. Findings of the present study and those of other studies reviewed (Poppelaars et al., 2019) contradict the hypothesis of Carr et al. (2016) that men have an increased baseline level of sAA due to anticipatory anxiety or heightened tonic arousal. Possibly, the study by Carr et al. (2016) did not evoke enough stress through the use of threatening faces in men, which might have led to a gradual reduction of their sAA levels. Another study found that men showed lesser heart rate reactivity compared to women in the luteal phase, but not to women in the follicular phase, when the TSST was applied (Childs et al., 2010). These results once again point to the importance of considering menstrual cycle phase when sampling females for stress experiments and corroborates the argument that the present study did not find gender differences in sAA response because all females were tested in the follicular phase.

No interaction effect between personality traits and gender was found for any of the stress systems. Hence, H3.4–H3.9 can be discarded. Even though insignificant, the strongest interaction effect that could be observed was between neuroticism, gender and sAA. Possibly, an interaction effect could have been found here if the study had more power. These findings contradict those of other studies reviewed that found an interactional effect between personality, gender and cortisol (Oswald et al., 2006; Zobel et al., 2004).

Conclusion

This study has proven the importance of considering personality traits and gender when analyzing the acute stress response and has shed light upon the specific circumstances under which these factors play a significant role. Extraversion appears to be especially relevant for ANS activation, while gender has an effect on subjective stress and cortisol response. A distinguishing mark of the present study was the use of delta scores, enabling a differentiated analysis of acute stress responses that allows controlling for baseline levels. It is hoped that this paper will inspire future research to consider delta scores in their analysis as well when studying other variables in relation to the acute stress response. Further, the present study highlights the complexity of the stress systems, especially the relationship between HPA axis and ANS. The question why extraversion relates to sAA, but not to cortisol and why gender relates to cortisol, but not sAA remains to be unmasked by future research.

The current study is not without limitations. Firstly, the statistical assumption of normality was violated for scores of neuroticism, subjective stress, cortisol and sAA. Even though the sample size was potentially large enough to compensate for this, the present results should still be interpreted with care, as this aggravated the correct detection of outliers. In the second place, the females in this sample were tested by a different team of researchers than the males. This is a potentially confounding factor for the analysis of gender differences. Thirdly, the present study used the TSST both in a single setting, a group of three setting and a group of five setting. Whether this might be a potentially confounding factor will be analyzed by my colleagues, but for now it is not clear whether this might have affected the results. Finally, the present sample was rather young and excluded individuals with psychopathology, narrowing the generalizability of the results.

In sum, the present study has shown that personality traits and gender relate differently to different stress systems. This has important implications for future studies. Researchers are advised to be sensitive to their choice of methodology when measuring stress, as it may very well affect the results. Even markers for the same physiological systems such as sAA and heart rate may provide differing outcomes depending on the nature of the stressor and the psychological construct that is analyzed.

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Appendix

Abstract

The acute stress response is a complex phenomenon that involves different psychophysiological systems such as subjective stress experience, activation of the hypothalamic–pituitary–adrenal axis and activation of the autonomic nervous system. However, it is not clear whether these systems relate differently to other constructs that are found to be relevant for the stress process such as personality traits or gender. The current study aimed to address this question by measuring the effect of neuroticism, extraversion and gender on subjective stress response, cortisol response and alpha-amylase response using the Trier Social Stress Test in a sample of N = 124 healthy participants (50 % female). Personality traits were assessed using the NEO-FFI. Subjective stress was measured through a visual analogue scale, while cortisol and alpha-amylase were collected through saliva samples. Acute stress response was operationalized using delta scores between peak values and baseline. Results showed that extraversion was negatively related to alpha-amylase. Further, women showed a higher level of subjective stress, while men had a higher cortisol response. No relationship between neuroticism and the stress response was found. There was no interaction effect between personality, gender and the stress response. This paper highlights the importance of considering that personality and gender relate differently to different stress response systems.

Zusammenfassung

Die akute Stressreaktion ist ein komplexer Prozess, welcher die Aktivierung unterschiedlicher psychophysiologischer Systeme wie subjektiven Stress, die Hypothalamus-Hypophysen-Nebennierenrinden-Achse und das autonome Nervensystem beinhaltet. Unklar ist jedoch, ob sich diese Systeme unterschiedlich zu anderen Konstrukten verhalten, die im Stressprozess von Relevanz sind, so wie Persönlichkeitseigenschaften oder Geschlecht. Die aktuelle Studie widmet sich dieser Frage, indem sie den Effekt von Neurotizismus, Extraversion und Geschlecht auf die subjektive Stressreaktion, die Cortisolreaktion und die Alpha-Amylasereaktion untersucht. Es wurde der Tier Social Stress Test in einer Stichprobe von N = 124 TeilnehmerInnen (50 % weiblich) angewandt. Persönlichkeit wurde anhand des NEO-FFI erfasst. Subjektiver Stress wurde durch eine visuelle Analogskala gemessen, Werte von Cortisol und Alpha-Amylase wurden durch Speichelproben erfasst. Die akute Stressreaktion wurde durch Deltawerte zwischen Höchstwerten und Baselinewerten operationalisiert. Es wurde herausgefunden, dass Extraversion negativ mit Alpha-Amylase verknüpft war. Frauen zeigten ein höheres Level an subjektiven Stress, während Männer eine höhere Cortisolreaktion aufwiesen. Es wurde kein Zusammenhang zwischen Neurotizismus und der Stressreaktion gefunden. Es gab keinen Interaktionseffekt zwischen Persönlichkeit, Geschlecht und der Stressreaktion. Diese Studie zeigt, dass es wichtig ist zu beachten, dass Persönlichkeit und Geschlecht unterschiedlich zu den Systemen der Stressreaktion verknüpft sind.