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Trust, Reciprocity, Fairness, and Mind Reading Under Stress

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TRUST, RECIPROCITY, FAIRNESS, AND MIND READING UNDER STRESS

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ABSTRACT

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by Charles J. Xie

Some hypothesized that when stressed, females activate tend-and-befriend, a stress response that enhances social abilities. Yet, critics argued this stress response is not exclusive to females and others suggested that males and females have different stress responses associated with social skills. This study intended to address these criticisms by testing whether males exhibit prosocial responses to stress and if particular stress responses improved social skills. To do this, 70 healthy introductory psychology students from a large public university in northern California were recruited to participate. Using random assignment, half of these individuals were exposed to an acute stressor and another half were not. They were then asked to complete questionnaires, social decision-making games, and a social inference task. Saliva samples containing cortisol, a stress biomarker, were collected to measure the intensity of bodily stress response. Neither stressed males nor stressed females exhibited changes to social behavior. However, this study also found that females' social cognition remained unaffected despite stress. In contrast, males who had a low cortisol stress response showed diminished social cognitive skills. This finding supports the tend-and-befriend theory's notion that females possess a specialized stress response geared towards social affiliation.

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TABLE OF CONTENTS

LIST OF FIGURES

Introduction

As seen in news headlines and through personal experiences, there are individuals who aid others despite immediate danger. During the 2015 Sousse Beach Massacre in Tunisia, hotel staff and residents repelled gunmen by forming human shields, warning beachgoers, and acting as distraction (Dearden, 2015). Their courageous actions saved countless lives and exemplify humanity's potential for self-sacrifice. This capacity for selflessness is still evident in more mundane and worrisome situations. The United States' economic downturn marked a shift in charitable giving, with low and middle-income individuals donating more than before the start of the recession (Bidgood, 2014). According to charities, less well-off donors recognized the plight of those similarly struggling and lent greater assistance (Bidgood, 2014). Even in dire situations, what motivates altruism and empathy? One avenue of neuroscience research is answering this question by examining how individuals respond to stress and the impact of stress on their thoughts and behavior towards others (Buchanan & Preston, 2014).

Stress activates a multitude of physiological and mental networks to prepare us for an ever changing and uncertain environment (Ulrich-Lai & Herman, 2009). The most widely known stress response is the fight-or-flight response. When the fight-or-flight response is activated, the body rapidly utilizes stored energy to escape from or defend against threats (Ulrich-Lai & Herman, 2009). The human stress response triggers two distinct physiological pathways, the autonomic nervous system and the hypothalamic-pituitary-adrenal (HPA) axis (Schommer, Hellhammer, & Kirschbaum, 2003). The autonomic nervous system is quick and releases a class of neurotransmitters called

catecholamines, whereas the HPA axis is slower and primarily releases a class of hormones called glucocorticoids (Ulrich-Lai & Herman, 2009). These systems have pathways spread diffusely throughout the brain and profoundly affect an individual's emotional and cognitive states (Arnsten, 2009).

Acute, uncontrollable stress directly impacts our brain and changes how the prefrontal cortex, a major brain region for goal directed behavior and inhibition, passes and receives signals from the limbic system, an important brain area for regulating reward and motivational processes (Arnsten, 2009; Maier, Makwana, & Hare, 2015). These stress-induced brain changes have functional consequences, and decision-making processes, like error monitoring and self-control, become impaired (Arnsten, 2009). As a result of these alterations, stressed individuals make riskier choices, are more attracted to rewards, are less deterred by losses, and fail to adjust their choices during changing conditions (for review, Starcke & Brand, 2012).

Effects of Sex and Stress on Decision Making

Though decision-making is greatly influenced by stress, sex may also be a key determinant in this relationship. Despite sex similarities in baseline concentrations and identical experimental procedures, cortisol, a physiological marker for HPA activity and an indicator for how intensely an individual reacts to stress, is present in higher concentration in stressed males' saliva relative to their stressed female counterparts (for review, Kudielka, Hellhammer, & Wüst, 2009). Furthermore, cortisol impairs decision-making (Starcke & Brand, 2012). To test this the connection between stress, sex, and decision-making, Lighthall, Mather, and Gorlick (2009) induced acute stress by

submerging participants' hands in ice-cold water and then measured risk-taking on a computerized task called the Balloon Analogue Risk Task. In the Balloon Analogue Risk Task, participants filled balloons with hypothetical money and had to weigh the gains of pumping the balloon for more money with the risk of losing the money if the balloon pops. Males generally took more risks than females and across all groups, stressed males took the greatest risk, whereas stressed females took the least risk. More than just exposure to stress, whether an individual is male or female predicted his or her decision-making abilities under stress (Lighthall et al., 2009).

More direct evidence for the role of sex as a moderator came from research looking at decision-making abilities and cortisol concentrations in saliva. Scientists used a public speaking task to stress participants and then used the Iowa Gambling Task to measure impulsivity and cognitive flexibility (van den Bos, Harteveld, & Stoop, 2009). In the Iowa Gambling Task, participants picked decks of cards varying in monetary gains and losses. Some decks were advantageous with greater gains than losses, whereas other decks were disadvantageous with greater losses than gains. Males who had a strong cortisol stress response were slower to learn deck payoffs and on average, chose more disadvantageous decks than males who were not stressed (van den Bos et al., 2009). In contrast, females who had a strong cortisol stress response did not statistically differ from females who had a weak cortisol stress response. Moreover, the researchers found a weak trend, where females who had a strong cortisol stress response were quicker in differentiating disadvantageous decks. These findings were consistent with earlier literature: namely, high cortisol impairs decision-making and because males have a

stronger cortisol stress response than females, stressed males made poorer decisions than stressed females (Starcke & Brand, 2012).

Effects of Stress on Social Behavior and Cognition

Recent studies suggest that stress changes social behavior, defined as an individual's actions that affect one or more persons (e.g., having a conversation with a close friend, shaking hands with a new acquaintance, or honking a car horn at a slow driver). Much in the way that stress changes decisions regarding gains and losses, stress influences social behavior often by being emotionally charged and less deliberate (Starcke & Brand, 2012). In one study, a research team had a confederate unfairly split a sum of money with a participant, 80% for the confederate and 20% for the participant (Takagishi, Fujii, Kameshima, Koizumi, & Takahashi, 2009). The participant could either accept or reject the decision. Rejections led to both the participant and the confederate receiving nothing. They found that salivary alpha amylase concentrations, a stress biomarker and a measure of autonomic system activity, correlated with increased rejections of unfair offers. According to traditional economic thought, as long as there were gains, acceptance would always be the rational choice since rejection guarantees a loss (Güth, Schmittberger, & Schwarze, 1982). Hence, Takagishi and his colleagues (2009) concluded that participants with elevated alpha amylase were more irrational, forfeiting losses gains to punish their partners for unfair splits. This finding was further reinforced by another study that directly manipulated stress levels.

Using a protocol similar to Takagishi and his group (2009), another research team observed that participants were more willing to reject unfair offers when making the

choice immediately after stress (Vinkers et al., 2013). The major difference between the Vinkers et al. (2013) and Takagishi et al. (2009) studies was that participants experienced a stressful public speaking exercise and then decided on the offers they received, either immediately or 75 minutes after being stressed. Those who made their decision later were less likely to reject unfair offers than those who made their decisions immediately after stress. Vinkers and his colleagues (2013) explained that immediately after stress, participants approached unfair splits more emotionally and were focused on the social slight. Participants, after a long delay between stress onset and the time of the decision, approached unfair splits more rationally, focusing on self-interest rather than retaliation (Vinkers et al., 2013). They did not find, however, significant correlations between their behavioral measures and concentration of stress biomarkers present in saliva, cortisol and alpha amylase (Vinkers et al., 2013). Still, both these studies found support for the idea that stress led to more emotional and impulsive judgments (Starcke & Brand, 2012).

Stress may also affect social cognition, how individuals process information about their social world. Though these mental processes do not necessarily lead to action (e.g., an individual may have biases about a group of people but may not explicitly act upon them), they are important precursors for social behavior. One quasi-experimental study employed a naturalistic design to compare how stressed students waiting for an exam and relaxed students without exams differed in their ability to predict and adapt to others' behavior (Leder, Häusser, & Mojzisch, 2015). To assess this strategic ability, Leder, Häusser, and Mojzisch (2015) asked participants to choose two numbers. For the first number, participants picked a number between 0 and 100. For the second number,

participants were told to predict the "target", the number that was two-thirds the average of the first number chosen by all participants. To incentivize a thoughtful response, participants were told that the participant who was closest to predicting the target would be awarded a cash prize. The concept underlying this choice was to pick low numbers as the target because even if the average number were at the maximum, two-thirds of an average of 100 would be 66. Thus, the target was guaranteed to be a number lower than 66. The strategic aspect came into play when participants realized that others would understand this concept as well and would pick even lower numbers. To stand the greatest chance of cash reward, participants would have to adjust their targets lower than what their initial number choice was and also anticipate that others would adjust to lower numbers as well. Leder and colleagues (2015) found that stressed participants, on average, estimated the target closer to their initial pick and picked higher numbers than did relaxed participants. Thus, stress not only affected mathematical understanding but more importantly, it hampered the ability to anticipate and adapt to other's actions. On the other hand, Leder and colleagues' (2015) downplayed their results by suggesting that had they measured cortisol, their findings would have greater impact.

Effects of Sex and Stress on Social Behavior and Cognition

Sex differences play a key role in how individuals react to stress (Kudielka et al., 2009) and consequently, how they choose their course of action (Starcke & Brand, 2012). As mentioned earlier, stress impacts social behavior by swaying it to be more emotional and rash. However, is it possible that sex differences in sex response can also be a vital player in an individual's social abilities? One theory addressed this idea. The tend-and-

befriend theory described evolution molding human physiology to fit specific roles, males as the hunters and females as the caregivers (Taylor et al., 2000). To facilitate these roles, males and females adapted different stress responses. Males possessed the fight-or-flight response which stimulates aggression to acquire and protect resources. Females possessed the tend-and-befriend response which motivates social bonding and cooperation as a way of managing limited resources. Scientists have tested this theory, but found mixed results in both behavioral and cognitive measures.

A team of researchers have argued that tend-and-befriend is not female-specific and cited a literature bias for investigating prosocial stress response in females but not prosocial stress response in males (von Dawans, Fischbacher, Kirschbaum, Fehr, & Heinrichs, 2012). To demonstrate that males also possessed a tend-and-befriend response, von Dawans and colleagues (2012) recruited male participants and placed some in a stressful group-speaking task. Afterwards, they conducted a series of exercises designed to assess prosocial behaviors like sharing and trust. To measure sharing, they asked participants to split a sum of money between themselves and their assigned partner. To measure trust, they asked participants if they would like to split a sum of money between themselves and their partner. Unlike the sharing exercise, whatever cash amount they transfer to their partner would be "invested" and upon reaching the partner's hands, this transferred amount would be tripled. The partner may then decide to either share or keep the gains for him or herself. Thus, participants had to weigh the risks of trusting their partner who may share the gains so that both would benefit, or may selfishly keep the gains. Von Dawans and colleagues (2012) found that stressed males, more than non-

stressed males, shared more generously and entrusted more money to their partners. Therefore, they argued that the tend-and-befriend theory was wrong in assuming that a prosocial stress response was exclusive to females. Moreover, von Dawans and colleagues (2012) found that average heart rate correlated with sharing and trust behavior, but cortisol did not correlate with any of their behavioral measures.

Still, von Dawans and colleagues' experiment has been criticized for its methodological weaknesses (Steinbeis, Engert, Linz, & Singer, 2015). Steinbeis and colleagues (2015) replicated von Dawans and colleagues' study (2012) with a public speaking task that ran participants individually rather than as a group; but, they found no compelling differences in sharing behavior between stressed and non-stressed males, and that stressed males trusted their partners less than non-stressed males. Steinbeis and colleagues argue that by running participants in groups, von Dawans et al. (2012) inadvertently allowed social bonding to form from the shared misery. Moreover, Steinbeis and his team expanded on von Dawans et al. (2012) in two keys way. First, they manipulated in-group and out-group membership through a minimal group paradigm, randomly assigning participants to random groups, and telling participants that they belonged to their respective groups based on a trivial criteria, their preference of two artists. Second, they included a spiteful punishment task where participants and their assigned partners were allotted money, but were given the choice of giving up a portion of their own money to reduce their partner's pool of money by an amount proportional to five times whatever cash amount they sacrificed (e.g., a participant sacrifices ten cents so that their partner loses fifty cents). Using these methods, Steinbeis and colleagues (2015)

found that stressed males were more likely to use this spiteful punishment on outgroup members, partners who had a different artistic preference than them. Furthermore, unlike in von Dawans and colleagues' study (2012), they found a relationship between baseline levels of cortisol and trust for stressed males, but not unstressed males (Steinbeis et al., 2015). Steinbeis and colleagues (2015) argued that, rather than tend-and-befriend, males possessed a fight-or-flight stress response, and that social context in these experimental designs were stronger factors for prosocial behavior.

A recent experiment provided support for sex differences in the tend-and-befriend stress response by showing that stress affected males and females differently in their capacity to adopt others' viewpoint (Tomova, Von Dawans, Heinrichs, Silani, & Lamm, 2014). Perspective-taking is a social cognitive process integral to empathy and as a whole, interpersonal relationships (Zaki, Ochsner, & Ochsner, 2012). For example, individuals with diminished perspective-taking may struggle at giving driving directions through the phone since they cannot think from the driver's standpoint or may mention socially inappropriate phrases because they do not understand that others are discomforted by it. To see how stress may affect perspective-taking skills, Tomova and colleagues (2014) used a public speaking task to stress participants and afterwards, ran them through a gamut of exercises designed to assess these skills. These exercises included tasks where participants had to imitate the hand motions of another person, accurately describe how intensely another person felt about a particular sensation (e.g. how pleasant do you think this person felt when she had fur rubbed against her hand), and correctly arrange items on a shelf by listening to the instructions of a person with a

different vantage point. Across these assessments, stressed females tended to be better at perspective-taking than stressed males. This supported the tend-and-befriend theory's assertion that females were specially equipped with a stress response that enhances prosocial processes like perspective-taking. However, they did not observe a correlation between cortisol and their perspective-taking measures (Tomova et al., 2014).

Rather than arguing for a general prosocial response to stress in both males and females, some have considered certain stress responses to enhance social cognition. In a study looking at salivary cortisol, a stress biomarker, a group of scientists discovered that stress caused by a public speaking task led to sex differences in the ability to infer the thoughts and feelings of others (Smeets, Dziobek, & Wolf, 2009). Smeets and colleagues (2009) took participants, individually, through a stressful public speaking task and asked them to watch a series of short videos. In these videos, actors played out social situations such as a dinner party and participants had to correctly answer questions about a character's implicit motives and emotions (e.g., "What is Betty feeling?", "What is Cliff thinking?"). Compared to females who had high cortisol stress response, females who had a low cortisol stress response were better able to infer the characters' thoughts and feelings. Conversely, compared to males who had a low cortisol stress response, males who had a high cortisol stress response were better at making these inferences. These results suggest that the tend-and-befriend stress response may not be exclusive to females, and that particular patterns of the stress response may be associated with enhanced social cognition. Specifically, a high cortisol stress response in males and low cortisol stress response in females may enhance social awareness (Smeets et al., 2009).

Summary

Returning to the initial question, what motivates self-sacrifice even in extenuating circumstances? To survive in unfavorable environments, a cascade of cognitive and behavioral changes are initiated (Ulrich-Lai & Herman, 2009). Stressed individuals become more impulsive, basing decisions on emotion and reflex rather than logic (Starcke & Brand, 2012). In social relations, the focus is more on retribution for implied insults than on self-interest (Takagishi et al., 2009; Vinkers et al., 2013), and the capability to predict how others will behave is diminished (Leder et al., 2015). In this respect, prosocial tendencies seem less likely during stress.

Some scientists have contested this notion (Buchanan & Preston, 2014) and instead, proposed that sex may interact with stress to foster altruism and compassion (Taylor et al., 2000). There is an established basis for sex as a major player in individual stress response. Physiologically, males tend to have a stronger stress reaction than females (Kudielka et al., 2009), and these differences are also reflected in decision-making (Lighthall et al., 2009; van den Bos et al., 2009). The tend-and-befriend theory explains that sex differences in stress responses and subsequent behavior are the products of evolutionary adaptation, with males more likely possessing the fight-or-flight response that readies their bodies for combat and females more likely possessing the tend-and-befriend response that facilitates group bonding and cooperation (Taylor et al., 2000). This theory predicts that stress will lead to less sociable males and more sociable females. However, the assumptions behind the tend-and-befriend theory have been challenged by contradictory findings. Some have argued that tend-and-befriend may not be exclusive to

females but rather, represents a general prosocial response to stress (von Dawans et al., 2012). Others have suggested particular patterns of the stress response are related to social cognition, the mental processes underlying social functioning (Smeets et al., 2009).

Limitations of Current Literature

As previously stated, evidence for the tend-and-befriend theory has been ambiguous, contradictory, and uneven in scope, applying different measures for males and females. For these reasons, the effects that sex has on stress responses and social functioning remains largely unclear. Firstly, tend-and-befriend studies employing cognitive measures have looked at both males and females (Smeets et al., 2009; Tomova et al., 2014). Yet, tend-and-befriend studies employing social behavioral measures have lagged behind and only examined males (Steinbeis et al., 2015; von Dawans et al., 2012). Thus, the female stress response and its relation to social behavior is largely unexplored.

Further compounding this issue were the inconsistent physiological findings, most notably cortisol. Of the studies that have looked only at males, Von Dawans et al. (2012) found no correlation between their behavioral measures and cortisol levels. Yet, in a study (Steinbeis et al., 2015) intended to replicate and refine the methodology of von Dawans et al. (2012), baseline cortisol was associated with greater trust. Of the studies that have analyzed cortisol in both male and female participants, only Smeets et al. (2009) have noted that particular cortisol stress responses were responsible for differences in social awareness between males and females. Another study, Tomova et al. (2014), did not find a significant correlation between cortisol and perspective-taking,

which presents the possibility that simple correlations may have glossed over potential interactions between sex, stress response, and social measures.

Goals and Hypothesis

The primary purpose of this study was to resolve discrepancies in the tend-and-befriend literature and examine how male and female stress responses influence social behavior and cognition. Specifically, this study addressed the argument that the tend-and-befriend stress response represents a general prosocial response to stress that is also present in males. If true, the predicted results would be that both males and females would exhibit a prosocial response to stress (e.g. more sharing of resources, more trust towards unfamiliar others, better social inference).

The secondary purpose of this study was to examine whether particular patterns of stress response would account for the discrepancies in literature. Several studies have used simple correlations to compare cortisol changes with their variables of interest, such as sharing behavior, but produced no significant findings. On the other hand, simple correlations may not fully capture the interplay between sex, stress response, and social functioning. Therefore, further classification based on relative cortisol stress response have been used to reveal important relationships. This study intended to expand upon the Smeets and his colleagues' study (2009) by using behavioral measures and applying their classification methods to further differentiate individuals into those with low and high cortisol stress responses. Drawing from their work, we predicted that a high cortisol response in males, and a low cortisol response in females will be related to more selfless and trusting social behavior.

The tertiary objective of this study was to replicate Smeets and colleagues' findings (2009) that showed social cognitive abilities interacted with both sex and stress response, a high cortisol stress response in males and low cortisol stress response in females improved the ability to make social inferences. As mentioned earlier, Smeets and his colleagues (2009) administered a video-based social cognitive assessment and found significant differences based on sex and stress response. However, they also administered a picture-based social inference task, but found no significant differences (Smeets et al., 2009). Though it is possible that their video-based social cognitive test was more sensitive, they did not randomize their tasks to mitigate order effects. The current study sought to examine whether administering a picture-based social inference assessment at the same time-point that Smeets and colleagues (2009) did with their video-based task, 30 minutes after the onset of the stressor, would produce similar, significant findings.

Method

Participants

In this study, 70 undergraduates (29 males, 41 females) ranging from 18 to 35 years of age (M = 19.33) were recruited from San José State University's Psychology 001 participant pool and awarded course credit for their participation. Additionally, at the end of the experiment, participants received a monetary reward that depended on their and their partners' choices on the dictator game, trust game, and ultimatum game. Participants were mostly Asian (32.9%) and Latino (32.9%), followed by White (12.9%), Biracial or Multiracial (10%), and Black (7.1%). There were also participants who were American Indian (1.4%), Pacific Islander (1.4%), and Arab (1.4%). The prescreening exclusion

criteria included past experience with experimental economics measures, pregnancy, neuroendocrine disease, chronic inflammatory disease, and diagnosed mood or anxiety disorders within the past 3 months. All experiments were conducted between 1200 hours and 1800 hours to control for diurnal variations in cortisol levels. The day before the experiment, participants were reminded, via phone and email, to abstain from eating, drinking any beverage besides water, smoking, and exercising an hour before the experiment.

In the stress condition, three participants were excluded from data analyses for failing to provide viable saliva samples; two stressed female participants did not produce enough saliva to properly conduct a cortisol analysis, and one stressed male participant showed an unreasonable ΔCORT of 21.47 nmol/L, indicating that pre-experiment restrictions on eating, drinking, smoking, and exercising were likely violated. Additionally, in the stress condition, there were 9 "non-responders" (2 males, 7 females), individuals who provided viable samples but were excluded from data analyses because they failed to meet the minimum 15.5% increase in baseline-to-peak cortisol values (Miller, Plessow, Kirschbaum, & Stalder, 2013). In total, 12 participants (3 males, 9 females) in the stress condition were excluded from data analyses. For the control condition, 5 participants (2 males, 3 females) were excluded from the data analyses for demonstrating an excessive, positive ΔCORT, suggesting an unwanted stressor or violation of the prescreening experimental constraints. Of the 70 original participants (29 males, 41 females) recruited, the final analysis used data from 53 participants (24 males,

29 females); 23 participants (13 males, 10 females) in the stress condition, and 30 participants (11 males, 19 females) in the control condition.

Measures

State Trait Anxiety Inventory. To account for pre-existing levels of stress and serve as a manipulation check, the State Trait Anxiety Inventory (STAI) was employed. The STAI is comprised of two 20 item self-report questionnaires that measure acute (state) and long-term (trait) anxiety. Each item rating is based on a descriptive statement, "I am tense" and a 4-point Likert scale with which the participant can choose the level of agreement, 1 = *not at all*, 2 = *somewhat*, 3 = *moderately so*, and 4 = *very much so* (Spielberger, 1983). The STAI is one of the most widely used measure for anxiety with high internal consistency (average Cronbach's $\alpha > .89$), test-retest reliability (average $r = .88$), and convergent and discriminative validity with other measures of state and trait anxiety (Grös, Antony, Simms, & McCabe, 2007). The State-Trait Anxiety Inventory (Spielberger, 1983) was digitally administered through Adobe Acrobat XI Pro's fillable form functionality (Adobe Systems, San Jose, California, USA).

Stress condition: Trier Social Stress Test. The Trier Social Stress Test (TSST) was a noninvasive, experimental method of inducing stress and increasing cortisol, a stress biomarker (Kirschbaum, Pirke, & Hellhammer, 1993). In this experiment, a slightly modified version of the TSST protocol was used. Participants first walked into a specially prepared room to face two confederate interviews sitting at a desk behind a video camera. Afterwards, the participant was then informed of the task, a five minute persuasive speech to "state your ideal job and convince the committee why you are the best

candidate for the job." The participant was led into a separate room and given three minutes to prepare for the upcoming speech. Once the three minutes passed, the participant was brought back to the room to deliver his or her speech to confederate interviewers. The confederate interviewers were instructed to be emotionless and recite scripted statements. During the speech, if the participant pauses for more than 20 seconds, the confederate interviews informed the participant, "You still have more time, please continue." Once the speech ended, the participant performed a mental arithmetic task where, for five minutes, the participant had to subtract 13 from 2087 until he or she reached zero. With each mistake, a confederate interviewer interrupted the participant and instruct him or her to, "Start again from 2083." In a review, the Trier Social Stress has been found to reliably elicit cortisol response in 70% to 80% of participants (Kudielka, Hellhammer, & Kirschbaum, 2007).

Control condition: Neutral video. Participants assigned to the control group watched a neutral stimulus, an excerpt from a travel video, "Yosemite: The World's Most Spectacular Valley" (Adams, 2001). The video was equal duration to the experimental manipulation which was comprised of the TSST speech preparation period and the TSST.

Economic games. Social behavior was measured through economic games, two-player interactions with monetary stakes. These games were the dictator game, ultimatum game, and trust game. These measures were chosen for the wealth of information they provide about different social behaviors, simplicity of administration, and validation by substantial bodies of literature (Camerer, 2003; Oosterbeek, Sloof, & van de Kuilen,

2004). These games were played through paper forms adopted from Holt (2005). To control for order effects, the sequence of the economic games was randomized.

Dictator game. In the dictator game, one player acted as the proposer and another player acted as the receiver (Forsythe, Horowitz, Savin, & Sefton, 1994). The proposer decides to either split a pool of money with the receiver or keep all the money for him or herself. This pool of money was set to $1. There were no repercussions for acting selfishly so the dictator game is considered a measure of true altruism, acting out of concern for another. As originally reported in Forsythe et al. (2004), the absence of punishment in the dictator game was associated with a greater proportion of participants acting selfishly and keeping more of the pool. A meta-analysis reported that the average split for dictators was 28.35% of the pool (Engel, 2011). Female proposers tended to be more magnanimous and when gender was made explicit, female receivers received larger splits (Engel, 2011).

Ultimatum game. The ultimatum game was a two-player bargaining interaction where one player, the proposer, divvies a pool of money between him or herself and a second player, the responder (Güth et al., 1982). For the purposes of this study, the pool of money was set to $1. The responder then decided to accept or reject this split. If the responder accepted this division, the money was split as the proposer offered. Unlike the dictator game, there were consequences for selfishness. If the responder refused this allocation, both the proposer and responder received nothing. The ultimatum game was used as a measure of strategy, predicting the optimal division that would be accepted, and altruism, sacrificing for the sake of another. This design has been replicated across many

experimental economics studies varying on gender, cultural background, and market integration (Camerer, 2003). The typical offer that proposers gave was 40.4% of the pool and the average chance of rejection was 16.2% (Oosterbeek et al., 2004). Gender influences on proposals and rejections tend to be mixed (Camerer, 2003).

Trust game. The trust game is a two-player game where one player acts as an investor and a second player acts as a trustee (Berg, Dickhaut, & McCabe, 1995). The investor decides whether or not to entrust none, all, or a portion of a pool of money to the trustee. As part of this study's protocol, the cash pool was set to $1 and the amount transferred to and held by the trustee was then multiplied threefold. The trustee can decide to reciprocate the investor's trust by transferring back a portion or all of the multiplied pool of money but has no obligation to do so. Because the trustee is not obligated to return any of the initial investment, the investor risks placing faith in the trustee to share the gains. A review looking across 46 studies in the United States found that the average trust given was 51% of the pool and the average return was 34% of the entrusted pool (Johnson & Mislin, 2011). One study found that males placed greater trust in the trustee, and females returned a greater portion of entrusted money, but participants' readiness to trust or be trustworthy was unaffected by the gender of the trustee (Croson & Buchan, 1999).

Reading the Mind in the Eyes Test Revised. The Reading the Mind in the Eyes Test Revised (RMET-R) was an assessment of "theory of mind," the ability to adopt the perspective of others and infer their mental state and predict their behavior (Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 2001). The RMET-R used 36 still images of

eye regions depicting either an emotional or neutral state. Each picture was accompanied by four "mental state descriptors" (e.g., reflective, irritated, or impatient) and the participants matched the appropriate descriptor to the mental state represented in the images. The maximum score for this test was 36, and participants were allowed as much time as they needed to make a choice. If there were words that were unclear, participants were encouraged beforehand to refer to an included glossary of terms. Psychometric assessment of RMET-R (Vellante et al., 2013) has shown high internal consistency (Cronbach's $\alpha = .605$) and high test-retest reliability ($r = .833$). The Reading the Mind in the Eyes Task has concurrent validity with the Emotional Quotient ($r = .44$), another measure of empathy (Ali & Chamorro-Premuzic, 2010). For this experiment, the RMET-R was presented through PsychoPy version 1.82.01 (Peirce, 2007, 2008), a stimulus presentation software, running on either a Dell Precision M65 under Windows 7 or a Lenovo U410 under Windows 8.

Saliva sampling and analysis. Salivary cortisol levels correlate closely with plasma cortisol levels and serve as an excellent, non-invasive, indirect indicator of HPA axis activity (Vining & McGinley, 1987). Two saliva samples were collected over the course of the study with Salivetters® (Sarstedt AG & Co., Nümbrecht, Germany), plastic tubes with cotton swabs that participants would chew for one minute. The first sample (S1) served as the baseline measurement for cortisol concentration and was collected immediately after initial questionnaires but before the TSST was introduced. The second sample (S2) was collected after participants played all the economic games, trust game, dictator game, and ultimatum game. Samples were kept at 5^{o} C until they were analyzed

using an expanded range high sensitivity salivary cortisol immunoassay kit. The kit's manufacturer has reported intra-assay coefficients of variation in the 4% to 7% range, inter-assay coefficients of variation in the 3% to 11% range, and cross-reactivity with other major steroid hormones of less than 1% (Salimetrics LLC, State College, PA). Samples were analyzed in duplicate to insure measurement reliability. The first saliva sampling time-point, S1, was designated the baseline and second saliva sampling time-point, S2, was chosen as the peak. This decision was based on a review of 208 laboratory studies that showed that cortisol concentrations in response to stress peaked 21 to 40 minutes after the onset of stress (Dickerson & Kemeny, 2004). The difference between cortisol concentrations at the baseline, S1, and the peak, S2, represented ΔCORT, how intensely an individual reacted to the stressor, the TSST.

Procedure

Experimental sessions had two participants running in tandem. In cases where only one participant was available, the participant's choices on the economic games would be matched with a previous solo participant. One participant was randomly assigned to stress condition and the other to the control condition. Upon filling out consent forms, participants completed screening and demographic questionnaires. At this point, participants provided the first saliva sample (S1). After filling out forms, participants in the stress condition underwent the TSST protocol, whereas participants in the control condition watched a neutral video with the same duration as the TSST protocol. Participants then played the trust game, dictator game, and ultimatum game. The order of these games was randomized to mitigate order effects. To preserve

anonymity between participants, two experimenters acted as intermediaries to pass along the responses. In the first round, both players acted as the proposers and made their decisions known only to the experimenter. In the second round, both players acted as the responders and the experimenters notified the players of their counterpart's earlier choices on the ultimatum game and trust game. Once the participants finished replying to their counterpart's decisions, they provided the second saliva sample (S2) and then completed the RMET-R. Monetary rewards were awarded based on the choices that the participants and their counterparts made. Finally, they were debriefed and were asked if, during the social behavioral measures, they knew their partner or believed that their partner was another actual participant. Figure 1 visually encapsulates this experimental timeline.

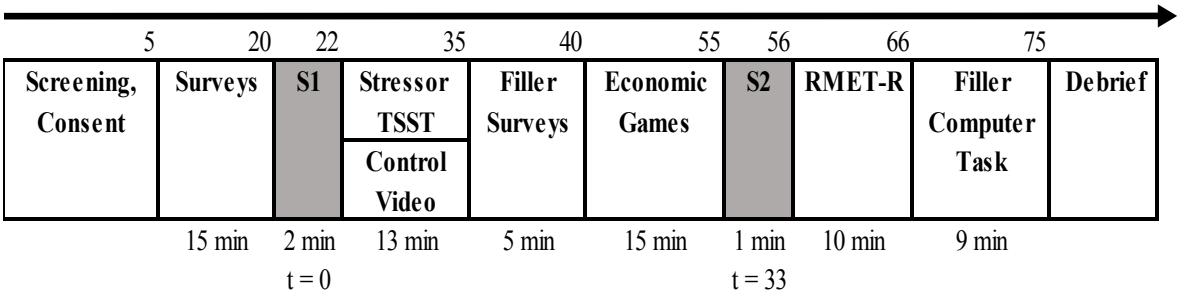

Figure 1. Experiment timeline. Participants are randomly assigned to either the stress condition that involves the Trier Social Stress Test (TSST) or the control condition, a neutral video. RMET-R stands for the Reading the Mind in the Eyes Task-Revised. Saliva collection time points are listed as S1 and S2. The top numbers right below the arrow indicate the time course of the study. Middle numbers represent the duration of each measure. Bottom numbers points out the duration of time elapsed since the onset of the stressor or control video.

Results

Manipulation Check

This study analyzed data from 53 participants (24 males, 29 females) to test the efficacy of the stress protocol, the TSST. A one-way ANOVA using Welch's adjusted *F* ratio corrected for any homogeneity of variances violation. Results indicated that the TSST was successful in inducing stress. Cortisol concentrations were significantly elevated following exposure to the TSST (M = 9.23 nmol/L, SD = 4.53) relative to cortisol concentrations observed in the control conditions (M = 2.64 nmol/L, SD = 1.86), $F(1, 28) = 42.97$, $p < .001$, $d = 1.42$. As shown in Figure 2, there were clear differences in ΔCORT values between the stress (M = 4.61 nmol/L, SD = 3.58) and control groups (M = -1.39 nmol/L, SD = 1.26). The stress group displayed a significantly greater baseline-to-peak increase in cortisol than the control group $F(1, 26) = 59.03$, $p < .001$, $d = 1.53$.

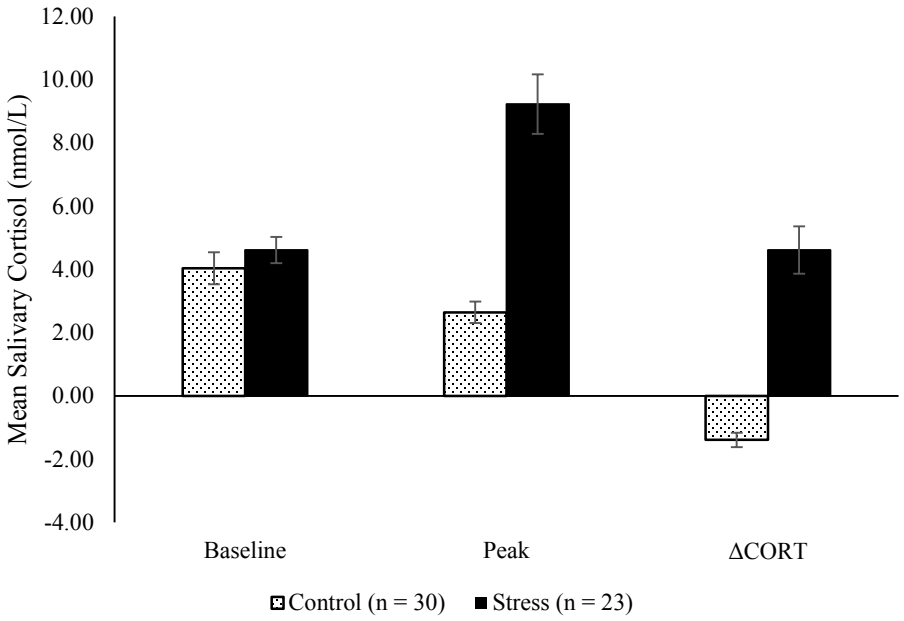

Figure 2. Mean salivary cortisol concentrations (nmol/L). Higher salivary cortisol concentrations suggest higher levels of physiological stress. Baseline measurements are taken after participants acclimated to surroundings, approximately 20 minutes after arrival. Peak measurements are taken 33 minutes after the onset of the stressor or control manipulation. Mean ΔCORT represents cortisol reactivity to stress, the difference between baseline and peak cortisol concentrations. Standard error of the mean is presented in the error bars.

Possible pre-existing confounding differences between groups were also checked. A one-way ANOVA did not produce statistically significant differences in baseline cortisol concentrations between the stress (M = 4.62 nmol/L, SD = 1.99) and control groups (M = 4.03 nmol/L, SD = 2.75), $F(1, 51) = .528$, $p > .05$. Likewise, age did not significantly differ between the stress and control groups ($F(1, 51) = 0.528$, $p > .05$). Self-reports of state anxiety did not significantly differ between the groups, ($F(1, 51) = 2.64$, $p > .05$). However, there was a difference between the stress and control groups for chronic anxiety. A one-way ANOVA produced statistically significant comparisons

between the stress and control groups for STAI's trait scale, a long-term anxiety measure. Participants in the stress condition (M = 38.61, SD = 10.59) reported greater long-term anxiety than participants in the control condition (M = 45.1, SD = 7.68), $F(1, 50) = 6.59$, $p < .05$, $\omega^2 = 0.1$.

Effects of Sex and Stress on Social Behavior

The primary goal of this study was to test whether males and females would both exhibit prosocial behavioral response to stress (e.g., sharing and trust). The secondary goal of this study was to assess whether or not particular patterns of stress response, high stress response in males and a low stress response in females, would be associated with prosocial behavior. Consistent with previous research (Smeets et al., 2009), a median split for ΔCORT values divided the stress group into low responders (7 males, 5 females) and high responders (6 males, 5 females). For males, mean ΔCORT was 1.81 nmol/L (SD = 1.02) for low responders and 9.05 nmol/L (SD = 2.66) for high responders. For females, mean ΔCORT was 1.69 nmol/L (SD = .63) for low responders and 6.12 nmol/L (SD = 1.70) for high responders.

Tests for social behavior followed a 2 X 3 design that crossed sex (male and female) with stress response (control, low responders, and high responders). As noted previously, there were preexisting differences between the stress and control groups on trait anxiety. Other unplanned factors that may influence our findings were the pairing of participants and the participants' belief that they played another participant. To control for these confounds, these variables were entered as covariates into an ANCOVA. The percentage of money given to a partner in the dictator game and ultimatum game capture

altruism, the extent an individual forwent self-interest for the sake of another. Figure 3 shows the mean splits in the ultimatum game and dictator game between the stress and control groups. For the dictator game, an ANCOVA produced no significant differences for sex ($F(1, 48) = .51$, $p > .05$), stress response ($F(2, 48) = 1.73$, $p > .05$), or an interaction between the two variables ($F(2, 48) = .18$, $p > .05$). There was a significant effect of one covariate, whether or not participants were paired with another participant nearby ($F(1, 48) = 5.13$, $p < .05$). A one-way ANOVA, using a Welch's adjusted F ratio to correct for a homogeneity of variance violation, did not produce a significant difference in money given to partners ($F(1, 20.875) = 2.77$, $p > .05$) between the 17 participants who were unpaired ($M = .57$, $SD = .28$) with 36 participants who were paired ($M = .44$, $SD = .16$).

For the ultimatum game, an ANCOVA produced no significant differences for sex ($F(1, 48) = .34$, $p > .05$), stress response ($F(2, 48) = 2.47$, $p > .05$), and no interaction between the two variables ($F(2, 48) = .93$, $p > .05$). Unlike the dictator game, the ultimatum game was a two-way decision-making process, one person proposed how the money should be split and another person accepted or rejected this split. Offers were overwhelmingly accepted (100%) rather than rejected.

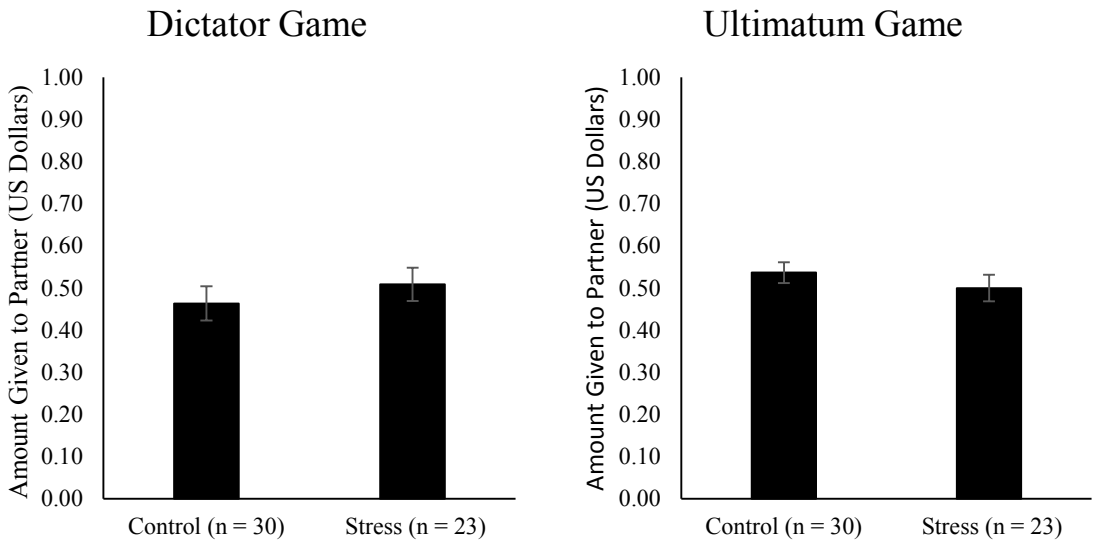

Figure 3. Mean cash amount given in the dictator game and the ultimatum game. In both the dictator game and the ultimatum game, participants had to decide how to split $1 between themselves and their partners. Greater cash amounts given to their partners represented altruism whereas greater cash amounts kept to themselves represented selfishness. Error bars indicate the standard error of the mean.

In the trust game, the percentage of money invested in a partner signified the willingness to risk trusting another person. All money invested in a participant was tripled and the percentage of invested money this participant returned to the investor exemplified trustworthiness, the eagerness to reciprocate trust. Figure 4 shows the average dollars entrusted to a partner and the average percentage of investments returned. In regards to the tendency to trust, an ANCOVA produced no significant effects for sex ($F(1, 48) = 1.67$, $p > .05$), stress response ($F(2, 48) = .32$, $p > .05$), or an interaction between the two ($F(2, 48) = .78$, $p > .05$). Likewise, for trustworthiness, there were no significant statistical outcomes for sex ($F(1, 46) = .097$, $p > .05$), stress response ($F(2, 46) = .009$, $p > .05$), or an interaction between the variables ($F(2, 46) = 2.57$, $p > .05$). There

was a significant effect of one covariate, whether participants believed they played another participant ($F(1, 46) = 5.37$, $p < .05$). A one-way ANOVA produced a significant difference in trustworthiness ($F(1, 47) = 5.29$, $p < .05$). The 34 participants who believed they played another participant ($M = .48$, $SD = .24$) were more trustworthy than the 14 participants who believed otherwise ($M = .31$, $SD = .20$).

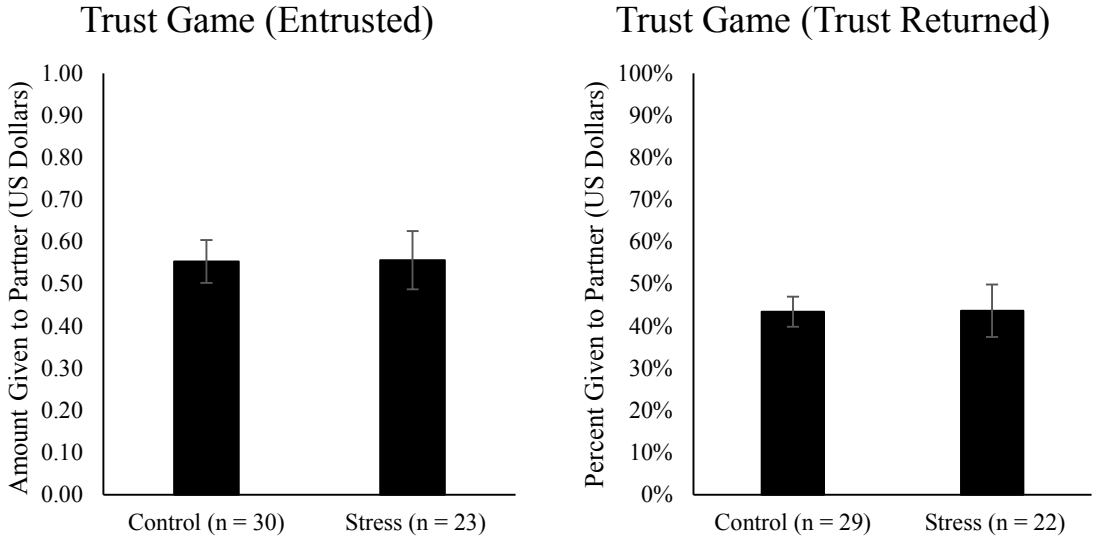

Figure 4. Mean cash amount entrusted and percentage reciprocated in the trust game. The trust game was comprised of two phases. In first phase, participants were given $1 to split between themselves and their partners. They were informed that whatever amount was transferred to their partner will be "invested" and multiplied threefold but this partner can decide to share or keep this "investment". The amount transferred to the partner represents the level of trust. In the second phase, whatever cash amount that the participant receives from his or her partner was tripled, and the participant had to decide whether or not to share these gains with his or her partner. The percentage of cash that the participant returned to his or her partner indicated the level of trustworthiness.

Effects of Sex and Stress on Social Cognition

The tertiary goal of this study was to replicate Smeets and his colleagues' findings (2009), which linked different patterns of stress response to social cognition, the ability to process social information. Particularly, a high cortisol stress response in males and a low

cortisol stress response in females were associated with improved social cognition. Social cognition was assessed through a percentage score on a facial recognition task called the Reading the Mind in the Eyes Test Revised (RMET-R). This was 2 X 3 design that crossed sex (male and female) with stress response (control, low responders, and high responders). RMET-R data were irretrievable from one male participant in the stress condition and one female participant in the control condition. In the final analysis, the median ΔCORT value divided the stress group into low responders (6 males, 5 females) and high responders (5 males, 5 females). For males, mean ΔCORT was 1.82 nmol/L (*SD* = 1.12) for low responders and 9.84 nmol/L (*SD* = 2.03) for high responders. For females, mean ΔCORT was 1.69 nmol/L (*SD* = .63) for low responders and 6.12 nmol/L (*SD* = 1.70) for high responders. Average RMET-R percent scores for males and females by stress response are presented in Figure 5.

An ANCOVA was initially performed to adjust for preexisting chronic anxiety differences between the control and stress groups. There was a significant main effect of sex ($F(1, 48) = 4.86$, $p < .05$, $\omega^2 = .067$), and an interaction between sex and stress response ($F(2, 48) = 6.06$, $p < .01$, $\omega^2 = .18$). However, the influence of chronic anxiety was not statistically significant ($F(1, 48) = .76$, $p > .05$). Thus, a standard factorial ANOVA was used instead.

A factorial ANOVA generated a significant main effect of sex ($F(1, 49) = 4.24$, $p < .05$, $\omega^2 = .05$) and a significant interaction between sex and stress response ($F(2, 49) = 6.66$, $p < .01$, $\omega^2 = 0.19$). Entering stress response did not produce significant effects

($F(2, 49) = .81$, $p > .05$). In order to parse out the significant effects, a Fisher-Hayter post-hoc test was used to perform multiple comparisons between the groups.

Social cognitive skills for males who had a low stress response ($M = .65$, $SD = .07$) were significantly worse than males in the control condition ($M = .77$, $SD = .072$), $qFH = 4.52$, $p < .05$, $g = 1.65$. There were no statistically significant score differences between males in the control condition ($M = .77$, $SD = .072$) versus males who were high responders ($M = .69$, $SD = .084$), $qFH = 2.94$, $p < .1$, $g = 1.14$. Additionally, no substantial statistical significance was produced from comparing performance between males who had a low stress response ($M = .65$, $SD = .07$) and males with a high stress response ($M = .69$, $SD = .084$), $qFH = 1.19$, $p > .05$, $g = 0.51$.

On the other hand, social cognitive abilities for females were relatively unaffected by stress. There were no statistically significant difference between the female control group ($M = .72$, $SD = .068$), low responders ($M = .77$, $SD = .066$), and high responders ($M = .76$, $SD = .072$), $F(2, 44) = 1.6$, $p > .05$. Comparisons between male controls ($M = .77$, $SD = .072$) and female controls ($M = .72$, $SD = .068$) were not statistically significant but appeared to be trending, $F(1, 44) = 3.4$, $p = .072$. Male low responders ($M = .65$, $SD = .07$) were significantly worse in the RMET-R than females low responders ($M = .77$, $SD = .066$), $F(1, 44) = 7.8$, $p < .01$, $\omega^2 = 0.11$. Differences between male high responders ($M = .69$, $SD = .084$) and female high responders ($M = .76$, $SD = .072$) were non-significant, $F(1, 44) = 2.8$, $p > .05$.

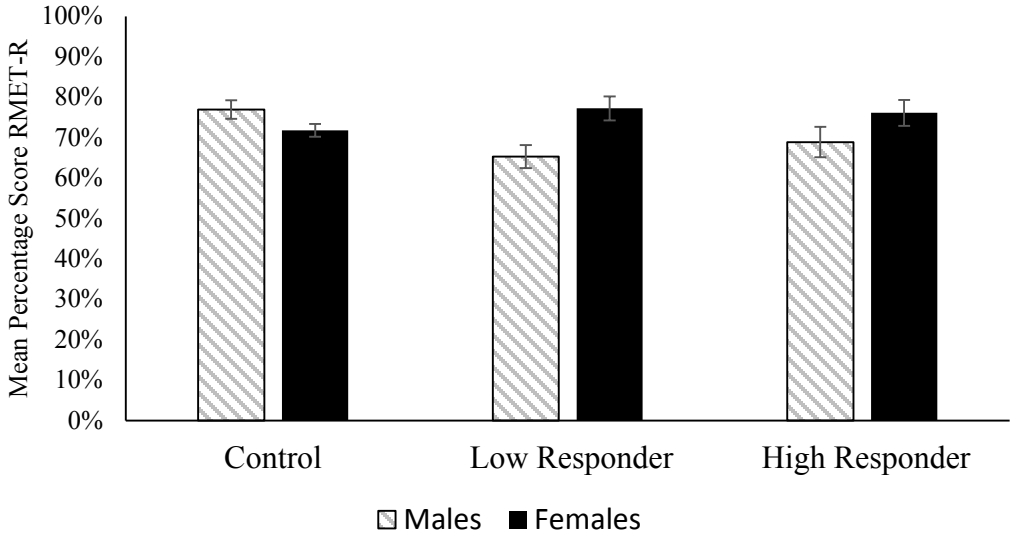

Figure 5. Reading the Mind in the Eyes Revised (RMET-R) mean percentage score by sex and stress response. The RMET-R is an assessment of theory of mind, the ability to guess the feelings and thoughts of others. The RMET-R consists of correctly identifying mental states based on pictures of the eye regions of faces. Percentage score is derived from emotions correctly identified and divided by 36, the total number of facial images available. Error bars represent the standard error of the mean (SEM).

Unplanned Results

Alongside pre-existing differences for chronic anxiety between the stress and control groups, there were also unplanned variables that may have influenced the behavioral measures. To check for experimental realism and perceived anonymity, experimenters asked two post-experiment questions, if participants recognized their game partners and whether they believed they played actual participants. Out of the 53 participants, 48 people reported that they did not recognize their partner (90.6%), 3 participants reported that they did recognize their partner (5.7%), and 2 participants did not provide conclusive responses (3.8%). There were 35 participants who believed they played with another participant (66%), 15 participants who did not believe that they

played with another participant (28.3%), and 3 participants who did not provide firm responses (5.7%).

Furthermore, due to a small sample size, a sizable portion of the 53 participants (32.1%, $n = 17$) were not paired with another participant in a nearby room. A Pearson's chi-square did not reveal any differences between participants who were paired or unpaired with respect to their beliefs about whether or not they played another actual participant (χ^2 (1, $N = 50$) = .51, $p > .05$).

Discussion

What could motivate someone to stand in front of gunmen to stop them from shooting innocent people, or to give even when one has little? Scientists have tried to look into the human stress response to formulate ideas on what brings about these selfless actions (Buchanan & Preston, 2014). Historically, fight-or-flight has been assumed to be the dominant response to stress but there is evidence for another. Certain scientists theorize that when met with challenges, females have a specialized stress response called tend-and-befriend which promotes social affiliation (Taylor et al., 2000). However, support for tend-and-befriend has been ambiguous and contradictory. First, there has been evidence that the tend-and-befriend stress response may not be exclusive to females (Smeets et al., 2009; von Dawans et al., 2012). Second, despite cortisol's key role in the stress response, the research literature has not reliably established a relationship between cortisol and social functioning. Following these shortcomings and inconsistencies in the literature, the current study intended to clarify the relationship between sex, stress response, social behavior, and social cognition. The current study's primary and

secondary objectives were to find whether males and females possessed a prosocial responses to stress and whether this relationship could be further differentiated by the type of stress response. However, the current study found no compelling differences in social behavior (sharing, trust, or trustworthiness) associated with differences in sex or stress response. Following remarks from researchers who found similar results, it was possible that stress and group membership interact to influence social behavior (Steinbeis et al., 2015). The current study's tertiary objective was to replicate past results that showed that differences in social cognition were associated with differences in sex and stress response. Indeed, the current study found significant differences linked to sex and stress response; specifically, males who had a low cortisol stress response were worse at making social inferences. This was consistent with past research (Smeets et al., 2009; Tomova et al., 2014).

As mentioned earlier, this study's primary purpose was to test whether stress would promote prosocial behavior (e.g., sharing and trust) in both males and females. The secondary purpose was to examine whether certain patterns of the stress response, high cortisol stress response in males and low cortisol stress response in females, were associated with prosocial behavior. Our data failed to support these predictions. In the dictator game and the ultimatum game, outside of random chance, this study produced no significant differences between stressed and non-stressed participants when measuring the amount they shared. Likewise, in the trust game, there were no significant differences between stressed and non-stressed participants when measuring how willing they were to trust their partners with cash and how willing they were to reciprocate their partners'

trust. Even when considering sex and cortisol stress response, there were no significant statistical differences between the stressed and non-stressed groups. Contrary to von Dawans and colleagues' finding (2012), these results partially supported the argument from Steinbeis and colleagues (2015) that stress alone does not motivate males to behave more altruistically or be more trusting, and outside factors such as group membership and shared suffering may play a bigger role. Even so, the lack of significant behavioral differences between stressed and non-stressed females was surprising. Much like Steinbeis and colleagues (2015) observed for males, it is also possible that stress alone does not motivate females to behave more selflessly or to be more believing of others' good faith.

The current study's tertiary goal was to replicate the findings from Smeets et al. (2009) and demonstrate that particular patterns of the stress response, high cortisol stress response in males and low cortisol stress response in females, were associated with better social cognitive abilities. Smeets and his team (2012) found significant effects of sex and stress response on a video-based social inference assessment, Movie for the Assessment of Social Cognition (MASC), but not their picture-based social inference task, Reading the Mind in the Eyes Test Revised (RMET-R). However, because they did not randomize the order of their tasks, it was possible that the timing of the assessments may be a factor. Administering the RMET-R at the same time point that Smeets and colleagues had administered the MASC in their experiment (2009), 30 minutes after the onset of stress, our study found that males who had a high cortisol stress response and females who had a low cortisol stress response did not significantly differ from their control counterparts.

Rather than showing an improvement, these results suggested that social cognitive abilities in these groups were unaffected by the stressor's detrimental effects on cognition. Also contrary to Smeets et al. (2009), a high cortisol stress response did not hamper females' social abilities. Females, across all conditions, did not significantly differ in social cognitive performance. This implied that females' social cognitive abilities were generally unchanged by stress, and lent credence to the tend-and-befriend theory's assertion that females possessed a uniquely prosocial stress response. On the other hand, consistent with what Smeets and colleagues found with MASC (2009), males who had a low cortisol stress response performed especially worse when compared to both males who had a high cortisol stress response, and males who were not exposed to stress.

Thus, the timing of the assessment and the corresponding cortisol levels at those time points seemed to explain the differences between our findings and those of Smeets and colleagues (2012). Yet, it may be possible the MASC and the RMET-R measured distinct aspects of social cognition, and the authors behind MASC state that their video-based test was more naturalistic and more sensitive to subtle cognitive deficits like overthinking social cues (Dziobek et al., 2006). Incorporating the MASC along with the RMET-R would have strengthened the current study, but, at the time, the MASC was not readily available. Although not backed by as much studies assessing reliability and validity as the RMET-R has (Vellante et al., 2013), it would still be prudent for future studies to include the MASC.

Limitations

This study expanded on past research by measuring social behavior in both males and females and evaluating the influence of specific stress responses. Still, there were inherent issues that may have weakened the impact of our conclusions. First, a larger sample size would have increased the power of statistical tests and estimates of effect sizes. This study's final sample size of 53 was somewhat smaller than studies with comparable methods, which ranged from 67 to 145 participants (Smeets et al., 2009; Steinbeis, 2015; von Dawans et al., 2012). This led to difficulty in pairing participants and may have presented unwanted confounds.

Second, following recommendations from a past review (Dickerson et al., 2004), this study set 33 minutes after the start of the TSST as the time point for peak salivary cortisol concentrations. However, the time point in which cortisol concentrations peak in response to stress may vary greatly across individuals, and it might be useful for future studies to consider collecting multiple samples to determine each individuals' peak cortisol concentrations, a methodology that was too cost prohibitive for this study.

Third, participants had relatively fair mean splits between themselves and their partners. This was more generous and trusting than what was typically observed in experimental economics (Engel, 2011; Johnson & Mislin, 2011; Oosterbeek et al., 2004). In particular, a past meta-analysis of the dictator game studies has found that in Western societies, students, compared to non-students were more likely to give nothing and less likely to split equally; 40% of students gave nothing, 20% gave even split, and 5% gave everything away. In addition, a review of trust game experiments also found that in 161

studies from all continents, there was a strong effect of students being less trustworthy, returning less of the entrusted pool of money, than non-students (Johnson & Mislin, 2011). Hence, for this study, the greater generosity and trust presented the possibility that participants assumed that their partner was a classmate who underwent the same stress protocol and sympathized with them. In-group formation and comradery from shared distress has been noted to influence social behavioral measures and may lead to more sharing and trust (Steinbeis et al., 2015). Future studies should either control for group membership or include a post-experiment check that gauges participants' pre-existing beliefs and biases about their partners. Yet, this may not be the most optimal option. The current research used economic games that were intended to be the most basic forms of social interaction to avoid group dynamics and other factors that may come into play. In natural settings, it is commonly known that group dynamics are ever present and should not be ignored. Following Steinbeis and colleagues' conclusions (2015), future research may be more informative if group membership were incorporated into their design rather than viewed it as a nuisance or ignored.

Fourth, this study produced cognitive results but lacked behavioral consequences. Stressed males who had a low cortisol stress response showed a diminished capacity to infer the thoughts of others. However, this did not translate to the anticipated decrease in sharing, trust, or trustworthiness. The incongruity between cognitive and behavioral measures has presented a major obstacle that affects the field of social neuroscience as a whole (Zaki et al., 2012). Many constructs describe empathy, and operationalizing these constructs present a persistent hurdle. Still, this challenge poses a fundamental question

that social neuroscientists must tackle. The theoretical differences between constructs such as cognitive empathy, the ability to infer the thoughts of another, and emotional empathy, vicariously feeling the emotions of another, represent distinct and dissociable functions in the brain (Nummenmaa, Hirvonen, Parkkola, & Hietanen, 2008; Shamay-Tsoory, Aharon-Peretz, & Perry, 2009). Even with these constraints, the current research does confirm that the relationship between stress response and social functioning remains a fruitful avenue for further exploration.

Implications

Many unknowns still underlie the relationship between stress response and social functioning. The hypothalamic-pituitary-adrenal (HPA) axis regulates cortisol and exerts far-reaching changes in response to stress. Nevertheless, the HPA axis is one component of a vast, interconnected system. The autonomic nervous system (ANS) also regulates the stress response but is a distinct system from the HPA axis. Unsurprisingly, the autonomic nervous system (ANS) has also been implicated to play a role in emotion and social decision-making. Salivary alpha amylase, a stress biomarker that is released when the ANS is activated, was related to more emotional decision-making and altruistic punishment, penalizing individuals who violate fairness norms (Takagishi et al., 2009). In the field of neuroeconomics, scientists are increasingly interested in implementing ANS measures, such as heart rate variability, to identify emotional influences on social decision-making (Dulleck, Ristl, Schaffner, & Torgler, 2011). Scientists have also identified social hormones, like oxytocin and testosterone, which play an important role in social functioning.

Oxytocin is a neuropeptide that acts on stress systems with its anxiolytic properties (Taylor, 2006). Intranasal oxytocin has been shown to reduce cortisol levels during arguments between couples (Ditzen et al., 2009), and also works alongside social support to lower perceived stress and cortisol levels (Heinrichs, Baumgartner, Kirschbaum, & Ehlert, 2003). Oxytocin is more commonly associated for its involvement in social bonding and caregiving functions for the young (MacDonald & MacDonald, 2010). Oxytocin has been shown to promote trust (Kosfeld, Heinrichs, Zak, Fischbacher, & Fehr, 2005), altruism (Zak, Stanton, & Ahmadi, 2007), and the ability to read subtle facial cues (Domes, Heinrichs, Michel, Berger, & Herpertz, 2007). This is especially relevant to the current research as oxytocin has been hypothesized to be a major component of the tend-and-befriend stress response, as well as a marker of social distress (Taylor, 2006). Yet, oxytocin may have some undesirable social effects such as promoting in-group favoritism and out-group competition (De Dreu, 2012). In addition, many of the mentioned studies have incorporated experimental designs that involve oxytocin administration, but oxytocin's chemical actions and pathways in the body remain unclear (Heinrichs, von Dawans, & Domes, 2009). In almost the opposite spectrum, testosterone, a hormone associated with aggression, has been shown to have desirable social properties.

Testosterone is an anxiolytic known to act on the HPA axis through its antagonistic relationship with cortisol (e.g., higher testosterone leads to lower cortisol, higher cortisol leads to lower testosterone) (Salvador, 2012). Once popularly thought of as an anti-social hormone that motivates aggression, testosterone has been found to be

involved in socially desirable behaviors like fair bargaining (Eisenegger, Naef, Snozzi, Heinrichs, & Fehr, 2010), reciprocity (Boksem et al., 2013), and honesty (Wibral, Dohmen, Klingmüller, Weber, & Falk, 2012). Still, the social effects of testosterone are thought to depend heavily on social context. When a group has stable resources, testosterone is believed to drive prosocial behavior as a means of helping individuals advance and cement their position in the group hierarchy (Eisenegger, Haushofer, & Fehr, 2011). Conversely, when an individual's group standing is challenged, testosterone is postulated to drive competiveness and aggression (Eisenegger et al., 2011). A recent naturalistic study has provided evidence for the involvement of both cortisol and testosterone in social networks. A group of researchers tracked members of an undergraduate marching band and the development of their social network, the friendships that were made, broken, or maintained over the course of several months (Kornienko, Schaefer, Weren, Hill, & Granger, 2016). During assessments at the end of the month, these researchers collected saliva samples and kept abreast of their participants' social networks. They found that friendships were more likely to be maintained when friends share similar cortisol levels, but also, that new friendships were less likely (Kornienko et al., 2016). For testosterone, they found that individuals with the lowest and highest levels of testosterone were most likely to form new friendships (Kornienko et al., 2016). The current study has avoided examining group dynamics as a means of experimental control; yet, such factors are intrinsically important to describing social structures and the involvement of social hormones.

Expanding to a larger picture, the interconnectedness of brain systems have led some to consider how social cognition and decision-making processes are linked. A group of scientists hypothesized that the evolutionary pressures that created the tend-and-befriend stress response may also be responsible for decision-making differences between stressed males and stressed females (Lighthall et al., 2009). Indeed, there are ties between the two systems. Drawing from brain imaging research, a recent neuroeconomic model has proposed that cooperative decisions emerge when two neural networks, a cognitive control system and a social cognition system, receive information from the brain's reward systems and perform cost-benefit analyses for selfish or cooperative choices (Declerck, Boone, & Emonds, 2013). Hence, there is an open avenue for the tend-and-befriend theory to further broaden its scope.

Conclusion

The current research sought to describe how different stress responses for both males and females would impact social behavior and social cognition. Even accounting for sex and particular stress response classes, contrary to our initial predictions, stress did not significantly alter social behavior. A compelling explanation for why there were no statistically significant findings is that stress plays a mediating role to primary factors like in-group membership and mutual suffering.

The effects of sex and stress response on social cognition followed prior expectations to an extent. Consistent with past findings (Smeets et al., 2009), social-cognitive abilities were especially impaired in males who had a low cortisol stress response. However, males who had a high cortisol stress response and females who had a

low cortisol stress response demonstrated remarkably similar social-cognitive skills as their control counterparts. Furthermore, females' social-cognitive performance across all conditions was also unexpectedly similar. This suggested that having a low cortisol stress response was especially detrimental for male social cognitive performance. On the other hand, females' social cognitive abilities were generally unaffected by stress. This fell in line with the tend-and-befriend theory's idea that females were specially equipped to handle stress through social means. Still, methodological variation may explain these incongruences between predicted and observed results.

Though this study could not fully capture the complexity of social decision-making or the physiological system that underlies these functions, the current research does emphasize the significance of stress in everyday cognitive processes. The findings of this study suggested that the social cognitive abilities of males who had a low cortisol stress response were particularly vulnerable. Sustaining or even improving the ability to sympathize with others under critical conditions do carry heavy real-world implications. A recent meta-analysis of studies examining burnout, a type of strain that is associated with chronic, job-related stress, found that burnt-out males were more likely to be socially withdrawn than females (Purvanova & Muros, 2010). This may be especially problematic for occupational fields like mental health service occupations which have a high prevalence of emotional burnout and depersonalization (Morse, Salyers, Rollins, Monroe-DeVita, & Pfahler, 2012). A past review found that strained males who were round-the-clock caregivers of spouses afflicted with Alzheimer's Disease were more likely to avoid social support, suppress depressive symptoms, and adopt maladaptive

coping strategies that focuses on controlling the situation (Hubbell, Hubbell, & Hubbell, 2002). However, due partly to societal expectations, male caregivers tend to be underrepresented and this was reflected in research (Hubbell et al., 2002). A practical application of this research would be to use stress biomarkers, like cortisol, as early detectors of depersonalization in vulnerable males before they become harmful to both caregivers and the people they serve. Finally, social neuroscience is still a relatively young field, but technological advancements in fields like brain imaging, endocrinology, genetics, mathematical modeling, and animal models are allowing scientists to come closer to the origin of humanity's capacity for self-sacrifice (Zaki et al., 2012).

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