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STRESS AND PROSOCIAL DECISION MAKING: THE INFLUENCE OF ACUTE STRESS ON TRUST BEHAVIOR

by

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A Dissertation submitted to the Faculty of the Graduate School,
Marquette University,
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the Degree of Doctor of Philosophy

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ABSTRACT

STRESS AND PROSOCIAL DECISION MAKING: THE INFLUENCE OF ACUTE STRESS ON TRUST BEHAVIOR

Stephanie R. Potts, M.S.

Marquette University, 2017

While acute stress exposure has been associated with modulation of risk-taking in decision making, the influence of stress on social decision making and trust has not been well-researched. The current study aims to advance scientific understanding of how stress influences trust behavior.

Ninety-six participants (49 male and 47 female) engaged in an adapted Trust Game task, randomly assigned between-subjects to either an acute stress (cold pressor test or socially evaluative cold pressor test) or control group. The Trust Game was administered at different time points with respect to stress exposure to examine the potential differential roles of temporally distinct stress pathways (i.e., sympatho-adrenomedullary versus hypothalamic-pituitary-adrenal axis reactivity). Stress-related sympathetic activation and HPA activation was observed for both acute stress groups compared to the control as well as subjective ratings of stress and affect.

Participants exposed to acute stress (with or without a social evaluative component) exhibited reduced trust investing significantly less money in their Trust Game counterparts. No significant difference in investment was observed by timing of stress. Further, across all groups males invested significantly more money than females.

Overall, exposure to acute stress elicited lower levels of trust suggesting stress may lead to “socially” risk-averse decision making. This finding replicates observations from a recent study on stress effects on trust decisions, though given limited research strong conclusions are premature. Additionally, lack of significant investment differences between stress groups involving social evaluation (or not) suggests social evaluation is not required to elicit reduced trust.

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And of course, to Mo.

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INTRODUCTION

The propensity for individuals to cooperate with each other has long been of interest to a variety of scientific disciplines. Though not exclusive to *homo sapiens*, humans are one of the few animal species to exhibit specific interpersonal patterns that lead to prosocial behaviors such as cooperation and trust in other individuals, including even non–related strangers (Fehr & Rockenbach, 2004; Krueger et al., 2007; Rilling et al., 2008). The complex motivating factors behind an individual's willingness to trust (e.g., decision-making preferences, environmental context) are not well understood. For example, stress is an environmental context observed to influence decision making (e.g., risk-taking; Starcke, Wolf, Markowitsch, & Brand, 2008; and financial decision making; Porcelli & Delgado, 2009) which may also interact with likelihood to engage in trust. In addition, substantial evidence suggests trust behavior impacts social support and positive social interactions which may act as a buffer against the negative consequences of stress (Cohen & Wills, 1985; Thoits, 1995).

Stress is pervasive in modern society and repeated exposure can negatively impact both mental and physical health outcomes (DeLongis, Folkman, & Lazarus, 1988; Monroe & Simons, 1991; Broadhead et al., 1983). Further research examining interactions between stress and decision making has the potential to lead to significant basic and applied scientific insights. While acute stress exposure has been associated with alterations in risk-taking and financial decision making (e.g., Porcelli & Delgado, 2009; Starcke et al., 2008, Pabst, 2013), the influence of stress on social decision making and trust behavior has not been well-researched (i.e., only three studies could be located; FeldmanHall, Raio, Kubota, Seiler, & Phelps, 2015; Smeets, Dziobek, & Wolf, 2009; von

Dawans, Fischbacher, Kirschbaum, Fehr, & Heinrichs, 2012). Thus, examination of the specific mechanisms underlying social decision making in the context of stress (i.e., trust) is necessitated.

While there may be some advantages to increased trust on both the societal (e.g., better economic outcomes in corporations and sustainment of interpersonal and institutional relationships) and individual (development of positive social relationships and mental health outcomes) levels, it must be noted that drawbacks in the decision to trust also exist on an interpersonal level (Johnson & Mislin, 2011; Guiso, Sapienza, & Zingales, 2004; Belli, Rogers, & Lau, 2012; Sutter & Kocher, 2004). For example, an individual's willingness to invest trust in a stranger may at times be motivated by conforming to social norms or conserving a positive self-image (Berg, Dickhaut, & McCabe, 1995). Individuals have been observed to engage in trust even though they are likely to experience adverse consequences related to that decision (e.g., loss of money) suggesting trust can also be maladaptive (Edelenbos & Klijn, 2007). It is clear that deciding to trust can be considered both a social/expressive action as well as reasoned economic exchange. Consequently, depending on the context in which a person chooses to engage (or not to engage) in trust behavior different consequences may be observed as to whether the outcome for the individual is adaptive or maladaptive.

The current research moves forward understanding on how stress influences prosocial behavior (i.e., trust behavior). Due to a lack of research investigating the effects of stress on trust, research focusing on economic models of decision making under risk serves as an excellent starting point to expand this undeveloped literature. For example, there is agreement across disciplines that at least two conditions are necessary within a social transaction for a behavior to be considered trust: risk and interdependence (i.e., reliance on another individual or party; Rousseau et al., 1998). Some theorists have argued that risk should be considered a subset of trust behavior while others propose perceived risk and perceptions of trust are comparable constructs (Das & Teng, 2004). Moreover, the context of a social interaction (or alterations in interdependence) may be associated with variations in trust as a behavior. Past research on trust has sometimes ignored the influence of context on trust behavior, though studies (including the current study) have begun to examine the role of the social context in which decisions to trust are made (Delgado, Frank, & Phelps, 2005).

An additional consideration relates to the differing temporal profiles of the physiological correlates of the stress response. In decision making research few studies methodologically separate two primary stress pathways: rapid activation of the sympatho-adrenomedullary (SAM) axis and the prolonged and slower activating hypothalamic-pituitary-adrenal (HPA) axis (Ulrich-Lai & Herman, 2009). It is plausible that having to make a trust decision immediately after stress exposure may have a different outcome than having to make the same decision a period of time after stress exposure. For example, Pabst, Brand, and Wolf (2013) observed individuals under acute stress made fewer risky decisions on a probabilistic dice game compared to controls 5 and 18 minutes post-stress, but more risky decisions 28 minutes post-stress. Therefore, risk-taking varied as a function of time after stress – perhaps related to the varying temporal profiles of SAM and HPA activation. Distinguishing between these two stress pathways is critical to gaining a comprehensive understanding of the willingness to trust in the presence of stress.

The present study investigated individual differences in stress responsiveness and trust behavior helping advance knowledge of decision making within social interactions and leading to further insight in protective social coping skills in the presence of stress. As mentioned earlier, social support attenuates the physiological response associated with stress and protects against negative mental or physical health outcomes. Since trust promotes social bonding, understanding motivational factors lending to trust behavior may lead to further protection from disease and provide insight in potential interventions (Evans & Kruegar, 2011).

Theories of Prosocial Behavior: A Review

Due to the multi-disciplinary nature of research on trust, different fields of research have proposed separate theories that align with each discipline's preferred definition of trust. Personality psychologists attribute trust to a stable personality trait that remains constant overtime and stems from an interaction between biophysiology, temperament, and genetics (Mischel & Shoda, 1995; Glanville & Paxton, 2007). Sociologists equate trust behavior with socially learned trust experiences which may be specific to the context of the interaction (Bandura, 1977; Glanville & Paxton, 2007). Evolutionary psychologists suggest trust behavior is a trait acquired over generations to maximize genetic fitness (Berg et al., 1995). Economists frame trust utilizing a rational choice theory which predict actions of the trustor based on individual preferences and probabilities (Buskens, 2002). As variability in theoretical perspectives of trust across disciplines is evident, devising a unitary model of trust is problematic. In addition, there is limited research on each of the aforementioned theoretical orientations. Since the current study examined the role of stress on trust decisions and other types of decision-making (e.g., risk-taking and financial decision making), the rational choice theory on trust proposed by economists delineates trust behavior as a decision-making process and thus this theory will be discussed in more detail.

Rational Choice Theory

Economists conceptualize trust behavior utilizing theoretical models from game theory. Game theory is the application of specific "games" structured to measure the behavior of actors (i.e., choice) in situations that require dependence on another individual (Buskens, 2002). A game is a competitive activity in which players interact with each other according to a set of rules or a proposed model (Osbourne, 2004). For example, in the classic "Prisoner's Dilemma Game", two players are convicted of a crime and each player is interrogated separately. Each player is told if they confess and testify against the other player then their charges will be dropped with no punishment. If they do not confess and the other player testifies against them, they are given a maximum sentence or a sizable consequence. If each player confesses to the crime, both will be given a moderate sentence. Lastly, if neither player confesses then each will be charged and given a minor sentence (Adreoni & Miller, 1993). Each player decides whether to "defect" (i.e., confess and testify against the other player) or "cooperate" (i.e., choose not to confess). Rational choice theory proposes a "rational" player will chose to "defect" in order to receive the maximum benefit (i.e., no punishment). As presented in the "Prisoner's Dilemma Game", rational choice theory states the decision-maker takes into account all the possible actions and his or her own preferences and chooses the best available action (Osbourne, 2004). Game theory developed the classic "Trust Game" to examine trust behavior between other social counterparts (Berg, et al., 1995). The "Trust

Game" is a major experimental economic model of trust and the current study utilized an adapted version of the "Trust Game" (which will be expanded on later).

Operational Definitions of Trust

In general, trust behavior in the literature has been conceptualized from two theoretical frameworks: generalized trust and localized trust. An individual's predisposition to trust has been operationalized as generalized trust, defined as the probability that two randomly selected individuals will trust each other in a one-time interaction (Bjornskov, 2007). In other words, generalized trust is an individual's expectation or belief in the general benevolence of other individuals (i.e., trustworthiness behavior; Mooradian, Renzl, & Matzler, 2006; Mayer et al., 1995; Colquitt, Scott, & LePine, 2007). Another framework for trust propensity is localized trust. Localized trust is actual trust behavior in specific experiential settings (Glanville & Paxton, 2007). For example, an individual's trust behavior at work, with his or her peers, or between family members.

Measurement of generalized trust. Generalized trust is a belief or expectation in the general benevolence of other individuals. Since generalized trust is a global expectation, generalized trust is often measured by direct self-report measures. For example, the U.S. General Social Survey (1972) assessed generalized trust with the following question, "Generally speaking, would you say that most people can be trusted, or that you can't be too careful in dealing with people?" (Glaeser, Laibson, Scheinkman, & Soutter, 2000; Reeskens & Hooghe, 2008). Other generalized trust scales have been developed and utilized (e.g., General Trust Scale. Yamagishi & Yamagishi, 1994; Interpersonal Trust Scale, Rotter, 1971; the Philosophies of Human Nature Scale, Wrightsman, 1966). The current study utilized the General Trust Scale as the measure to assess generalized trust.

Measurement of localized trust. Localized trust has been conceptualized using the well-documented “Trust Game” (modified from game-theoretic models) which labels each exchange between two players as a trust situation (Berg et al., 1995; Dasgupta, 1998; Buskens, 2002). In the Trust Game, there are two players (Player A and Player B). Player A is referred to as the investor and is given an initial endowment of money. Player A is informed Player B, referred to as the trustee, is given the same endowment. The specific parameters of the endowment are variable between studies. The investor then decides whether to send any amount of the endowment to the trustee. The amount of the money the trustee receives is increased in value (i.e., often tripled) and then the trustee decides whether or not to return any amount of money back to the investor (Berg et al., 1995; Sutter & Kocher, 2007). Trust in the Trust Game is operationalized as the amount of money the investor sends to the trustee. Trustworthiness is measured by the amount the trustee returns to the investor. The larger the amount returned the greater the degree of reciprocity (Berg et al., 1995). The Trust Game has been analyzed in one-shot encounters and over repeated transactions, wherein the latter may be more representative of every day trust situations (Buskens, 2002). The current study structured the Trust Game over repeated transactions with a social counterpart to maximize external validity. Notably, referring back to rational choice theory and the Trust Game, if decision-makers were “rational” in the Trust Game, he or she should choose the available action that is most advantageous to the self.

Nash equilibrium and the Trust Game. Analyzing the Trust Game from a game-theoretical perspective, rational players should also make decisions based on the Nash Equilibrium (Buskens, 2002). Unlike rational choice theory (i.e., a Bayesian approach) which operates under the assumption that when given a choice the actor should make the choice that yields the most expected utility, when actors are faced with a decision that involves other actors, the individual should make choices based on the probabilities of the other actors' behavior over time (i.e., Nash Equilibrium; Risse, 2000). The Nash Equilibrium established in the Trust Game is computed as the following exchange: the investor should strategically "never trust the trustee" and the trustee should always hold onto the money and "never reciprocate" (Buskens, 2002). However, contrary to game theory and rational choice theory, individuals consistently place trust in the trustee and the trustee consistently reciprocates in the exchange (Cesarini et al., 2008). Thus, trust behavior observed in an experimental setting reveals information *contrary* to rational choice theory (Sturgis et al., 2010; Fehr & Fischbacher, 2004). The current study investigated behavioral trust variations in relation to expected behavior demonstrated in rational choice theory.

Major Stress Pathways and Classes of Stressors

The presence of a threat or a stressor can lead to direct physiological stress (systemic stress) or psychological stress (processive stress). Systemic stressors are events in the environment that pose a direct physiologic threat to a person (Herman & Cullinan, 1997). Systemic stressors demand urgent response from the body's respiratory and cardiovascular systems to respond to the immediate threat, bypassing any higher order interpretation of the event. Blood, pain, hypoxia, and infection are all examples of systemic stressors (Herman & Cullinan, 1997). Processive stressors are events that lead to higher order interpretation from specific brain structures (i.e., frontal lobe and limbic brain regions; Herman & Cullinan, 1997; Day, Masini, & Campeau, 2005). Once the perceived threat is interpreted by limbic-sensitive structures, the limbic circuitry is than capable of heightening or reducing the physiological stress response based on an accumulation of previous experiences with the present stressor. For example, an individual may interpret a dog as threatening if he or she had previously been attacked by a dog; however, over time the individual may learn the presence of a dog is non-threatening. Additionally, systemic and processive stress may involve partially separable neurobiological stress pathways and levels of activation in each system (i.e., SAM system and HPA axis) by stress type can vary.

Physiological Correlates of the Stress Response

Sympathetic-adrenomedullary system. The sympathetic-adrenal-medullary (SAM) system activates when there is a direct threat to the body and sympathetic reactivity is immediate and fast-acting (Ulrich-Lai & Herman, 2009). For example, if an individual has carbon monoxide poisoning there is a reduced level of oxygen reaching the body and the SAM system rapidly activates to promote homeostasis by elevating heart rate and blood flow to increase an individual's oxygen supply (Cannon, 1988). The SAM system is activated by efferent preganglionic fibers located along either side of the spinal column (Tsigos & Chrousos, 2002). The preganglionic sympathetic neurons project to pre- or paravertebral ganglia which then directly project to the heart, kidney, abdomen, skeletal muscles and other organs. Notably, the sympathetic systems has also been associated with an immune system reaction in part by activating the adrenal medulla to produce catecholamines (i.e., norepinephrine, epinephrine, and dopamine) into the system (Pabst et al., 2013). Catecholamines modulate immune functions (e.g., cell proliferation, cytokine, and anti-body production) and activation of catecholamines may enhance the immune system's ability to deal with acute stress or threat (Dhabhar, 2008; Padgett & Glaser, 2003). Catecholaminergic pathways then communicate with neurons in the paraventricular nucleus of the hypothalamus (PVN) which eventually trigger the HPA axis to simulate glucocorticoid release (e.g., cortisol; Swanson & Sawchenko, 1980). However, if the SAM system is chronically activated, catecholamines may dysregulate the immune system leading to negative health outcomes. Past research has demonstrated chronic activation of the SAM system can lead to reduced individual responsiveness to vaccinations, slowed wound healing, and increased susceptibility to viruses (Glaser, 2005).

Hypothalamic-pituitary-adrenal (HPA) axis. The hypothalamic-pituitary-adrenal (HPA) axis can be activated directly under acute (systemic, see below) stress and/or when limbic-brain structures determine based on previous experience or fear conditioning that an external stimulus is a homeostatic threat (Herman & Cullinan, 1997). At times when stimuli do not serve as an immediate threat to an individual's homeostasis, after higher order interpretation of the stimuli, a stimulus may be identified as threatening and the stress response will then be activated. Under both conditions the PVN of the hypothalamus triggers activation of the HPA axis. Once triggered, the PVN of the hypothalamus secretes corticotrophin-releasing hormone (CRH) which triggers secretion of adrenocorticotropic hormone (ACTH) from the pituitary gland, which then leads to the secretion of glucocorticoids (i.e., cortisol) from the adrenal cortex. Glucocorticoids play a role in the termination of the stress response by communicating with the hypothalamus and the pituitary gland to inhibit ACTH secretion once the necessary level of glucocorticoids are met to restore homeostasis (i.e., negative feedback). The negative feedback nature of the HPA axis limits glucocorticoid release and duration of presence in the body (Tsigos & Chrousos, 2002).

Biomarker in stress research. A critical glucocorticoid in humans that is released into the body as a result of HPA axis activation is cortisol. Cortisol has multiple roles in regulating stress in the body and repairing homeostasis. The stress hormone energizes the body by increasing blood glucose levels and breaking down fat to promote more effective metabolic functioning (Dickerson & Kemeny, 2004). In addition, cortisol has anti-inflammatory effects and maximizes functioning of certain physiological systems (e.g., cardiovascular system; Dickerson & Kemeny, 2004). Based on the extensive role of cortisol within the stress response, cortisol levels have been regarded as a useful biomarker in stress research (Lupien, 2007). HPA axis activation is not immediate, but sequential which leads to cortisol concentrations peaking approximately 20-40 minutes post-stress (Pabst et al., 2013). The current study involved salivary cortisol measurements to determine fluctuations in HPA activation based on the form of stress being employed. Different classes of stressors (systemic and processive) were employed in the laboratory; these have been associated with differential activation of the SAM and the HPA axes and therefore associated with dissociable temporal profiles in terms of the effects of stress exposure.

Classes of Stressors

Systemic stress: Induction and measurement. The classic cold pressor test (CPT) is a systemic stress induction technique much-utilized in stress research (Lovallo, 1975), that was originally developed as a means to increase blood pressure in research on hypertension (Hines & Brown, 1932; Loyke, 1995). The procedure begins by measuring baseline sympathetic arousal (e.g., blood pressure, skin conductance, and heart rate). After recording baseline measures, the individual is instructed to place his or her dominant hand into a bowl of ice cold water. The amount of time and the temperature of the water varies between studies. On average the individual is instructed to keep his or her hand in the water between 1 and 3 minutes with water temperatures ranging from zero degrees 0° C to 5° C (Lovallo, 1975). Sympathetic arousal may be measured throughout the procedure and sympathetic reactivity have reliably been observed (Lovallo, 1975; Buchanan, Tranel, & Adolphs, 2006). For example, skin conductance levels (SCL) have been observed to increase immediately at the start of immersion of the hand into the water and then return to baseline post-retrieval of the hand from the water. In addition, respiration, finger temperature, and blood pressure are observed follow a similar physiological pattern (Lovallo, 1975). Mild to moderate activation of the HPA axis (i.e., cortisol levels) has also been reported (Lovallo, 1975; Porcelli, 2012). Other systemic stress induction techniques include exposure to heat by instructing individuals to sit in an environmental chamber with high temperatures and high humidity for a duration of time and inducing the threat of receiving a shock throughout a cognitive task (McMorris et al., 2006; Robinson, Overstreet, Charney, Vytal, & Grillon, 2013; Cronwell et al., 2007).

Processive stress: Induction and measurement. According to social self-preservation theory, individuals are motivated to preserve social identity (Dickerson & Kemeny, 2004). Threat to an individual's social identity, by social rejection or social exclusion, increases negative self-evaluations and cortisol reactivity. A meta-analysis conducted by Dickerson and Kemeny (2004) discovered psychosocial stressors comprised of socio-evaluative threat and an added layer of uncontrollability elicited high levels of cortisol activation. Socio-evaluative threat is present in a situation when an individual's self-identity can be negatively judged. Uncontrollability occurs when an individual is unable to behaviorally react to a situation and thus is unable to avoid negative consequences (Dickerson & Kemeny, 2004). Tasks with socio-evaluative threat and uncontrollability can be identified as processive stressors that require higher order processing and trigger activation of the HPA axis.

The Trier Social Stress Test (TSST) is a psychosocial stressor employed to induce psychological stress (Kirschbaum, Pirke, & Helhammer, 1993). The TSST consists of three parts: the anticipation stage, the test stage, and the mental arithmetic stage. The anticipation and preparation stage begins by the experimenter informing the individual that he or she is applying for a position within a company and must prepare a speech to convince the judges they are the best candidate for the job. During the test stage, the individual stands in front of a panel of judges and delivers the speech while also being video recorded. After the speech is completed, the judges inform the individual to perform a mental arithmetic task (e.g., subtract 13 from 2011; Kirschbaum et al., 1993). After each error on the mental arithmetic task, the individual is instructed to start again.

The TSST is a reliable processive stressor based on activation of the HPA axis (i.e., elevation in cortisol).

Other examples of processive stress induction techniques with varying degrees of socio-evaluative threat and uncontrollability include aversive acoustic stimuli and the anticipatory stress of delivering a speech outlining perceived negative attributes of his or her body and physical appearance to a panel of judges (Kirschbaum et al., 1993; Day, Nebel, Sasse, & Campeau, 2005; Preston, Buchanan, Stansfield, & Bechara, 2007).

Hybrid approaches. Social evaluative cold pressor test (SECPT) is a physiological stress induction technique similar to CPT with added social evaluative threat (Schwabe, Haddad, & Schachinger, 2008). The individual is instructed to undergo the CPT procedure previously explained, however, an experimenter in a white lab coat informs the individual that he or she will be video recorded during the procedure to analyze facial expressions of stress and the individual must direct their gaze into the camera for the duration of the procedure (Schwabe et al., 2008). The added socio-evaluative component in the SECPT procedure significantly increased cortisol levels compared to the CPT (Schwabe et al., 2008). Elevations in blood pressure and cortisol observed from the SECPT are comparable to elevations observed from the TSST (Schwabe et al., 2008; Dickerson & Kemeny, 2004).

Emerging Neuroeconomics Research on Stress, Trust, and Risk-Taking

Neuroeconomics is an emerging field that integrates neuroscience, economics, and psychology (among other disciplines). As mentioned earlier, both rational choice theory and game theory have developed preexisting models for decisions humans make while interacting with other players as applied in the Trust Game. Individuals may compute actions in any given decision by analyzing all available actions in their environment and choosing the action that leads to the most "rational" or advantageous decision in terms of the self (Zak, 2004). As was previously mentioned, trust behavior observed in the Trust Game contradicted outcomes predicted by rational choice theory and Nash Equilibrium theoretical models constructed by economists.

The role of neuroeconomics is to further delineate steps within the decision process, offering further insight into aspects of decision making that are otherwise ignored in experimental models provided under rational choice or game theory. Neuroeconomics may be able to broaden research on trust via elucidation of the neural substrates and neurobiological correlates (investigated in the current study) associated with each stage of the decision making processes involved in trust. It has been theorized that this decision process consists of three general stages (1) analyzing information in the environment to perceive all available actions (2) the process of placing value on actions, and (3) then choosing the action (Zak, 2004; Zak, Kurzban, & Matzner, 2004). The current study adds specifically to the neurobiological correlates of various steps in the decision-making process to trust.

Due to limited research on trust, the current study focused on outlining available research on neuroeconomics, stress, and risk-taking (as previously discussed risk-taking has been associated with trust behavior). Decisions under risk became a focal point of neuroeconomic research after behavioral economists determined that individuals often make decisions under risk in manners contrary to rational choice theory. For example, Kahneman & Tversky's (1979) Prospect Theory proposes individuals make decisions differently based on whether or not the choice is framed in terms of potential gains or losses and not based on the expected value of the choice (as rational choice theory predicts). In general, individuals have a propensity to be more risk-seeking when decisions are framed in losses and more risk-averse in decisions framed in gains (Kahneman & Tversky, 1979). Additional research conducted by Kahneman and Tversky (1986) examining the framing effect indicated individuals are more sensitive to loss rather than to gain, also known as loss aversion. In general, individuals subjectively weigh the “cost” of losing money as twice as significant as a gain of the same amount of money (Tom, Fox, Trepel, & Poldrack, 2007).

Stress and Risk-Taking

Stress has been linked to alterations in risk-taking and adjustments to previously formed risk preferences. For example, the framing effect may be exacerbated under acute stress (Porcelli & Delgado, 2009). In a financial decision making task with gambles framed in gains and losses, individuals under systemic stress (CPT) increased risk-seeking behavior in the loss domain and risk-averse behavior in the gain domain. However, the opposite effect was observed after a psychosocial stressor similar to the TSST with participants less likely to engage in risk seeking behavior when outcomes are framed in losses (Pabst et al., 2013). On a gambling task, individuals with anticipatory stress elicited poorer decision making abilities with explicit risk parameters by choosing less advantageous options suggesting stress interferes with computation of risk when making decisions (Starke et al., 2008). In addition, exposure to acute stress led to more risky behavior in a similar gambling task and increased the potential for larger punishments (Brand, Heinze, Labudda, & Markowitsch, 2008).

Existing research on risk-taking and stress has yielded varying outcomes (e.g., increased risk aversion in choices framed in gains, increased risk-seeking in choices framed in losses, and increased choices of high-risk gambles) thus far and often observations in decision making under risk is mixed and at times contradictory (Starcke & Brand, 2012). Potential differences observed may be due to methodological differences in task, stress-induction technique, and the timing of the task after induction. Thus, there is evidence to suggest stress modulates decision making under risk; however, research is still limited. The observation that individuals increased risk seeking behavior in choices framed in losses may lead to the supposition that individuals may demonstrate increased trust behavior when social decisions are framed in losses under stress.

Sex, stress, and risk-taking. There are clear sex differences in the physiological response to stress in terms of cortisol reactivity (e.g., Kajantie & Phillips, 2005; Kirschbaum, Wust, & Hellhammer, 1992). For example, males have been observed to exhibit mean cortisol responses approximately 1.5 to 2 times higher than females after a psychological stressor. In addition, males have also been observed to demonstrate increased mean cortisol responses following anticipatory stress, whereas females demonstrated cortisol responses unchanged from baseline or a decrease in mean cortisol response. That sex differences exist in the physiological correlates of stress reactivity implies potential differential effects of stress on cognition generally, specifically decision making in the context of the current study.

Sex differences have been observed on a behavioral risk-taking task after acute stress (Balloon Analogue Risk Task; BART; Lighthall, Mather, & Gorlick, 2009). The BART is a computerized behavioral risk-taking task. Participants are shown a balloon with a button labeled “pump”, a “Collect $” button, and are presented with a running total of earnings accrued throughout the task. Participants were instructed that each click on the “pump” button increased the balloon’s size and lead to a payment of 5 cents; however, each participant was told the balloon could explode at any time. As the amount of times a participant decided to click on the “pump” button increased, the risk of losing money increased. Risk-taking was operationalized as the amount of times the participant decided to click on the “pump” button. In the control condition, males and females exhibited comparable levels of risk-taking. Under acute stress, however, females were observed to be more risk avoidant whereas males were more risk-seeking in BART performance. That said, as little research exists on the topic the potential that stress effects can differentially influence decision making in males and females is explored in the current study.

Trust and Risk-Taking

A relationship between trust behavior and risk-taking has already been suggested, with some theorists arguing that risk is evident in any decision to trust (Josang & Lo Presti, 2004; Das & Teng, 2004). Therefore, a decision to trust can be considered a form of risk-taking. Evidence suggests that individuals are risk averse in terms of placing trust in another individual without certainty of an external benefit; however, replication of that research is needed (Kosfeld et al., 2005). Individuals are more willing to engage in risks when the counterpart was a computer and the probability of trustworthiness or betrayal was due to chance compared to individuals making trust decisions with a social counterpart. Moreover, risk attitudes appear to impact trust behavior in the Trust Game whereas risk attitudes for financial decisions do not (Bohnet & Zeckhauser, 2003).

Delineation between independent risk-taking and social risk-taking (i.e., trust) is necessitated and is illustrated in the current study.

Limited Empirical Studies on Stress and Trust

Only three empirical articles exploring the relationship between stress and trust were located. Smeets, Dziobek, and Wolf (2009) examined the effects of acute stress (TSST) and associated glucocorticoid levels on social cognition. While social cognition does not necessarily equate to trust as defined previously, the ability to infer the mental or emotional state of others is a critical component of trust (Sripada et al., 2009). Two tasks were administered: Reading the Mind in the Eyes Test (RMET) and the Movie for the Assessment of Social Cognition (MASC). RMET required individuals to identify internal affective states of another person based on viewing the eyes (e.g., panicked, angry, or hateful). The MASC consisted of a 15 minute video in which individuals had to assess emotional and cognitive states (e.g., thoughts) of characters shown in a dinner party setting. Thus, the task was designed to reliably measure accuracy in identification of other’s mental states.

Males with elevated cortisol levels post-stress obtained higher scores on the MASC as compared to females, suggesting males exposed to stress were more accurate in the identification of other’s emotions. In contrast, females with lower levels of cortisol elevations post-stress obtained higher scores on the MASC suggesting females with lower levels of cortisol were more accurate in identifying mental states of others (Smeets et al., 2009). While no difference in cortisol levels and performance on the RMET were observed overall between males and females, it appears that sex differences exist in stress’ influence some aspects of social cognition.

Along similar lines, evolutionary psychologists have long postulated that males and females respond to stress differently to maximize genetic fitness (Taylor et al., 2000). For example, it has been suggested that males respond with increasing sympathetic reactivity in preparation for engagement of the “fight or flight” response. On the other hand, females may respond to stress in a “tend and befriend” manner. According to this theory, females’ stress responses evolved to support affiliation with other members of their social group to protect their offspring. Research in non-social contexts (e.g., fear conditioning; von Dawans et al., 2012; and financial decision making, Lighthall et al., 2009) further supports the existence of sex differences in the effects of stress on behavior. That said, additional work is needed to characterize stress-related sex differences in social cognitive processes and trust.

More specific to the topic of trust, one study conducted by von Dawans, Fischbacher, Kirschbaum, Fehr, and Heinrichs (2012) explored the effects of acute stress on prosocial behavior in males only. Participants were exposed to a processive stressor (i.e., TSST) and then engaged in tasks measuring trust, trustworthiness, sharing, punishment, and nonsocial risk-taking (von Dawans et al., 2012). A multi-round Trust Game was employed to measure trust and trustworthiness behavior, while a “sharing game” involved individuals receiving a monetary endowment with the option to share it with a counterpart (or not). A “punishment game” involved a similar endowment, but allowed participants to “punish” their counterpart if a choice to share was not reciprocated. Lastly, a “nonsocial risk game” involved a solitary gambling task with varying levels of risk to establish a non-social baseline of risk-taking.

TSST exposure was associated with increased trust, trustworthiness, and sharing. Stressed males invested more money in the trustee and reciprocated repayment more often than did males in the control condition. Additionally, in the sharing task males under stress were more likely to share larger amounts of money to their social counterpart. However, performance in the punishment and nonsocial gambling tasks remained unaffected by exposure to stress. Thus, the authors concluded that stress specifically facilitated prosocial behavior (i.e., trust, trustworthiness, and sharing) in social exchanges. That said, only males were investigated and (making comparisons between males and females impossible).

A recent study conducted by FeldmanHall, Raio, Kubota, Seiler, and Phelps (2015) examined the effects of stress on social and nonsocial behavior. Participants (males and females included) were exposed to systemic stress (CPT) and then engaged in 36 one-shot interactions of the Trust Game with a social counterpart. The participants were designated “investors” and shown photos of designed “trustees” or their assigned social counterpart for each interaction. The nonsocial lottery game consisted of solitary gambling task with varying levels of risk. Exposure to acute stress was associated with less trust behavior during each one-shot Trust Game interaction and higher levels of risk-taking on the nonsocial lottery task. Control subjects had similar risk-taking and trust behavior. Sex differences were examined and no differences in risk-taking or trust behavior between males and females were found. Research exploring sex differences in trust behavior under acute stress remain limited and only three empirical studies measuring social approach behavior under stress were located, therefore attempting to generalize would be unwise. Research examining trust behavior after exposure to acute stress is necessary to delineate potential sex differences and the current study examined sex differences (males and females) on trust behavior after acute stress.

Present Study

The objective of this project was to examine interactions between prosocial behavior (i.e., trust) and acute stress exposure. The current project incorporated methodological elements from the fields of psychology and economics and added understanding of neuroendocrine function for hypothesis generation. What is the nature of stress-related changes in social decision-making? Does exposure to stress promote a "fight or flight" response in trust behavior or does it lend to more "tend-and-befriend" behavior? Does stress elicit temporal differences in trust behavior and are sex differences evident? This research yielded new and useful insights into the nature of stress and social interactions, and can potentially inform the development of techniques that may be designed to intervene between stress and decision-making so as to promote adaptive choices and prevent maladaptive ones.

Specific Aims

Aim 1. *To examine factors influencing prosocial behavior; specifically the role of stress in the propensity to engage in trust and/or risk-taking.* While evidence suggests that acute stress influences risk-taking, at present, interactions between stress, trust, and risk have been largely unexamined. Research exploring the effects of acute stress on trust has not incorporated the role of risk within trust behavior. Given the significant overlap between risk and trust discussed previously, research addressing stress and trust together may broaden present knowledge on mechanisms underlying the motivation for humans to make social risks. This could yield further insights into the dynamics of social interaction under conditions of stress.

Aim 2. *To investigate the effects of sex on trust decisions after exposure to acute stress.* There is preliminary research suggesting behavioral risk-taking under stress varies by sex. Females have been observed to be risk-averse under stress whereas males are risk-seeking. Further information is necessary to reinforce potential sex differences on prosocial behavior (i.e., trust) under stress. For example, whether exposure to stress activates a "fight or flight" response in trust behavior or lends to more "tend-and-befriend" behavior based on sex.

Aim 3. *To differentiate the roles of separable psychophysiological and neuroendocrine (i.e., cortisol) correlates of acute stress and to examine whether dissociable temporal components of the stress response differentially influenced trust decisions.* SAM-sensitive psychophysiological measures were acquired (e.g., skin conductance) as was HPA-sensitive salivary cortisol to monitor stress reactivity prior to and during the trust game and the risk-taking tasks. While recently much research has turned to the effects of acute stress on decision making research focusing on the potential differential impact of said systems on decision making generally (and trust specifically) remains to be explored. In addition, the temporal components of stress (whether psychosocial or physiological) may yield varying decision making tendencies. Research already suggests immediate response to a psychosocial stressor (TSST) results in less risky decision making on a gambling task compared to more risky decision making thirty minutes later after cortisol activation (Pabst et al., 2013). The current project is the first to investigate the temporal components of the stress response on prosocial behavior (i.e., trust).

Aim 4. *To examine the influence of a socially evaluative stressor (SECPT) compared to a physiological stressor (CPT) on prosocial (i.e., trust) behavior.* An individual's willingness to invest trust in a stranger may at times be motivated by conforming to social norms or conserving a positive self-image. In the presence of a social threat, individuals may increase negative self-evaluations which may lead to variable prosocial behavior compared to an exclusively physiological stressor. The current project is the first to explore the social-evaluative compared to the non-social evaluative stressor on trust behavior.

Method

Participants

Ninety-six participants (47 females, 49 males) participated in the current study. 5 participants withdrew from the study after Day 1 (1 female, 4 males). Participants were young adults recruited from Marquette University (Mean age = 18.75, SD = 0.98; age range 18-22 years) See Appendix A for further information regarding participant demographic characteristics. Exclusion criteria included history of cardiovascular illness, aneurysm, heart attack, congenital heart abnormalities, untreated hypertension, chronic rheumatologic disease, diabetes, Reynaud's disease, cold urticaria, currently being under the care of a psychologist or a psychiatrist, psychotropic medication, and pregnancy. Participants were also screened for frequent cigarette use. With respect to female participants, exclusions also included use of oral contraceptives. In addition, performance of tasks of central interest (i.e., Trust Game and risk-taking) occurred during the midluteal menstrual phase to control for fluctuations in cortisol (Kirschbaum, Kudielka, Gaab, Schommer, & Hellhammer, 1999).

Day 1 Procedures

The study took place over two days, the first approximately 1.5 hours in length. All study procedures were approved by the Marquette University Institutional Review Board (IRB) and all participants gave informed consent. On Day 1 participants completed questionnaires and a neuropsychological measure estimating level of intelligence. A demographic questionnaire was given identifying age, sex, race/ethnicity, and handedness (again see Appendix A for further demographic information).

North American Adult Reading Test (NAART*).* To account for premorbid intellectual ability, the North American Adult Reading Test, a reliable and valid measure of premorbid intellectual ability, was administered (NAART; Pabst et al., 2013; Lejuez et al., 2002; Uttl, 2002).

Childhood Trauma Questionnaire (CTQ). The Childhood Trauma Questionnaire (CTQ) was administered due to studies indicating early childhood trauma has been associated with learning impairments in adulthood based on rat models and has shown to be linked to lower levels of glucocorticoid concentration which may affect stress reactivity (Scher, Stein, Asmundson, McCreary, & Forde, 2001; Lupien, McEwen, Gunnar, & Heim, 2009). The CTQ has been found to have high internal consistency, construct validity, and discriminant validity. Each item is on a Likert scale of “Never True” to “Very Often True” with higher scores indicating higher amounts of maltreatment and trauma (Bernstein et al., 1994). The current study focused on three specific domains: emotional abuse, physical abuse, and sexual abuse (Bernstein et al., 1994).

The General Trust Scale. The General Trust Scale was also administered on Day 1 which measures an individual's general trust in others and/or participants' belief that trusting in others may be risky (Takahashi et al., 2005). The General Trust Scale is a 6-item scale measuring participants' beliefs about honesty and trustworthiness of others. The General Trust Scale is an expansion of the 1-item General Social Survey measure of general trust; "Generally speaking, would you say that most people can be trusted, or that you can't be too careful in dealing with people?" (Glaeser et al., 2000; Reeskens & Hooghe, 2008).

Penny Game. Lastly, the Penny Game, a survey-based task that measures financial risk preferences (i.e., whether an individual tends toward risk aversion, risk seeking, or is risk neutral; Holt & Laury, 2002) was administered. The task presented real and hypothetical lotteries that range from "real" dollar payments to hypothetical larger amount of payments. The first decision task included ten decisions of choosing between a low-payment (risk averse) option and a higher-payment (risk seeking) option. The higher payment option (risk seeking choice) increased in probability as the decisions moved from the first decision to the last decision. Therefore, as participants moved from decision one to decision ten, participants identified a transition point from choosing the "risk averse" option to the "risk seeking" option. The transition point provides an interval estimate of a participants' relative risk aversion. In addition, in the first decision task participants were instructed that a decision will be played out for real money giving incentive that the task is "real". The second decision task was structured similarly to the first decision task except the participant was given larger hypothetical amounts of money instead of small dollar amounts (hypothetical incentive) and the same transition point provided another estimate of a participants' relative risk aversion in a hypothetical situation.

Day 2 Procedures

On the Day 2, individuals were informed that they were interacting with a gender-opposite partner during task performance (in actuality, a confederate). Participants observed the confederate in the waiting room and then subsequently watched study personnel escort them into another testing room at the start of the study. This interaction was intended to create the impression that participants would be performing Trust Game tasks with a real-life partner (necessary to elicit as close as a replication to social interactions in the real world; Johnson & Mislin, 2011). All participants were informed in advance that they would receive monetary compensation for actual performance on the Penny Game (Day 1), a random trial from the Trust Game, and a random trial from the risk-taking task. In economic-derived financial decision making tasks, providing actual monetary incentive to participants lends to more accurate decision making in comparison to hypothetical financial outcomes due to the "real" nature of performance outcome (Ben-Ner, Kramer, & Levy, 2008).

All experimental sessions were conducted during the afternoon to control for regular fluctuations in cortisol over the course of the day (i.e., circadian cortisol release; Chung, Hoon Son, & Kim, 2011). Participants were randomly assigned between-subjects to one of three stress-induction groups (Control, CPT, or SECPT). In addition, each participant was randomly assigned between-subjects to a "short" or "long" group (SG and LG respectively) to methodologically dissociate the potential effects on performance of rapid SAM axis activation versus the slower activating HPA axis. For SG participants, the Trust Game was administered immediately after stress-induction followed by the risk-taking task. In the LG, participants were given a neutral filler task immediately following the stress induction procedure. After a 20-minute filler task (i.e., reading a neutral magazine for 20 minutes) LG participants then performed the Trust Game followed by the behavioral risk-taking task. In both the SG and LG conditions, before the risk-taking task participants were informed that they were no longer playing with a social counterpart (Refer to Appendix B for further details of Day 2 procedures).

After the risk-taking task was completed for all participants, participants were debriefed, given a post-experimental questionnaire, compensated for their participation in the study (e.g., extra credit for Psychology courses offered at Marquette University), and given monetary compensation from each financial decision making task (i.e., Penny Game, Trust Game, BART).

Trust Game Task. During the trust game, participants were assigned either the role of “investor” (note, this terms was never used with the participants themselves). When assigned as the “investor” participants were endowed with an initial $12 on a trial to trial basis. They then decided whether to invest either $0, $4, $8, or $12 in the “trustee” (portrayed as the confederate they met earlier but in actuality a preprogrammed series of responses to their own task responses). Any amount the investor decided to pass to the trustee was tripled in value to maximize potential gains, also providing the potential that the participant would end up with more money than they might have had had they not passed money to the trustee. Participants then received feedback from the trustee informing them as to whether or not the trustee decided to ‘keep’ the money or 'return' 50% to the investor. For example, if investing $4 (then multiplied to $12) participants could ultimately receive winnings of $6 (more than they would have retained had they not trusted the trustee) or none at all. While unknown by participants until debriefing, feedback from the trustee was balanced evenly between "share" and "keep" decisions (Refer to Appendix C for a visual demonstration of the trust game task).

Participants proceeded through 36 trials in the role of the investor, each trial had a 4000ms interval for participants to make their decision on the amount of money to send to the trustee ($0, $4, $8, or $12). A fixation with a duration of 2000ms served as the interval between their choice and receipt of feedback. In a situation in which the investor decided to keep the money, the task confirmed his or her choice (4000ms presentation) and the next trial began. If the investor decided to send an amount of money to the trustee to make a decision (varying between 3000ms, 5000ms, and 7000ms to enhance the impression of a real social interaction) the investor was offered feedback as to whether or not the trustee "shared" or "kept" the money (4000ms presentation) followed by a 5000ms intertrial interval. Total task time varied depending on the frequency of "shared" compared to "keep" decisions made by the participant. The maximum total task time allotted to each participant (if decided to "share" throughout the 36 trials of the task) was 13 minutes and 20 seconds. In the Trust Game, the mean amount of money invested or the percentage of shared decisions was operationalized as the level of "trust." Therefore, the larger the amount passed from the investor to trustee or the higher the percentage of shared decisions the more "trust" present in the social exchange. Each participant was instructed that a random trial from the Trust Game will be selected and a monetary payout will be given to the participant at the end of the study.

Balloon Analogue Risk Task (BART). The Balloon Analogue Risk Task (BART) utilized in the study was adapted from a version designed by Pleskac, Wallsten, Wang, and Lejuez (2008). The BART assesses risk-taking by asking participants to make sequential button presses to "pump" an animated balloon with no information provided as to when the balloon might "explode." Participants accrued 5 cents with each "pump" but if participants continued to "pump" the balloon until it burst, they lost all winnings accrued on the current trial. Further, participants were instructed that they could stop pumping up the balloon at any time and collect the total amount of money accrued from each trial (the total money earned for each trial would not be affected by subsequent explosions). Thus, each button press and "pump" represents operationalization of risk-taking. Adjusted number of pumps (average number of pumps excluding balloons that exploded) and number of explosions was quantified as "riskiness" on the task. BART has been correlated with self-reported risk-related measures and the current study included a risk-related measure to investigate the relationship between self-reported risk preferences (i.e., Penny Game) and behavioral risk-taking with the BART (Lejuez et al., 2002).

Post-Experimental Questionnaire. The post-experimental questionnaire asked participants general questions about the overall experiment as well as self-perceptions of the social context of the trust task, and other general questions to ensure the experiment environment was appropriate for the study. In addition, the post-experimental questionnaire asked participants his or her subjective ratings of stress on a Likert Scaled from "None" to "Very much" and their subjective feelings related to the stress procedure on a Likert Scale from "Bad" to "Good."

Positive and Negative Affect Scale (PANAS). The positive and negative affect scale was administered to measure positive and negative affect before stress, during stress, and immediately following stress. Participants were instructed to indicate how he or she is feeling at the present moment for 10 positive and negative affect items on a Likert scale from 1 (very slightly or not at all) to 5 (extremely). Two scores were computed to determine amount of positive compared to negative affect. The higher the score on the total computation the higher the ratings of affect (positive or negative; Watson, Clark, & Tellegen, 1988).

Psychophysiological Measures

Skin conductance data was acquired throughout Day 2 of the study through a Biopac MP150 system and associated amplifiers. To measure skin conductance, Biopac MP150 electrodes were placed on the pad-side of the pointer and middle finger of the participants' non-dominant hand and were continuously recorded throughout baseline, stress, and post-stress. Skin conductance measures any change in electrical conductivity of the skin due to autonomic nervous system activation (Bach, Friston, & Dolan, 2010). Skin conductance levels (microsiemens [μS]) were measured throughout the entire procedure. Notably, skin conductance levels were monitored during the stress procedure and then analyzed in three 3 minute segments around stress/control exposure (baseline, stress/control, and post-stress/control) to determine SAM reactivity related to stress-induction or control procedures. In addition, skin conductance was measured throughout the two computerized tasks to monitor psychophysiological correlates of trust and risk decision making. Before data analysis, skin conductance was binned into three minute segments (Baseline, Stress, and Post-Stress) throughout each stress group (Control, CPT, and SECPT). The average waveform was computed (microsiemens [μS]) within each 3-minute segment and square-root transformed to reduce skew and normalize data.

Salivary cortisol was acquired to assess cortisol reactivity related to the stress induction (or control) procedures. Salivary cortisol samples were collected using a Salimetrics Oral Swabs (Salimetrics, LLC, State College, PA) and placed in a swab storage tube, after which all samples were placed in freezer storage (-20 degrees Celsius). Saliva samples were assayed by study key personnel at Marquette's Biochemical and Immunoserological Core Laboratory. Saliva samples were collected for all groups at four points over the course of the study: baseline, post-stress, 20-minutes post-stress, and 40-minutes post-stress. Mean intra-assay coefficients of variation (CV) for the total 380 samples assayed was 5.6 percent which is within acceptable limits (Intra-assay % CVs should be less than 10; Schultheiss & Stanton, 2009). Inter-assay CV for both stress conditions (CPT & SECPT) and no-stress control condition was calculated at 8.2 percent which is also within acceptable limits (Inter-assay % CVs of less than 15 are generally acceptable; Schultheiss & Stanton, 2009).

Stress Induction Procedures

Acute stress was administered via the cold pressor test (CPT; Lovallo, 1975) and socially evaluated cold-pressor test (SECPT; Schwabe et al., 2008) before the administration of the trust game. Participants in the control or no stress condition were directed to place their hand into a bowl of room temperature water for the same duration of the CPT/SECPT groups (3 minutes). The CPT involves placing the dominant hand into a bowl of ice cold water (2-4°C) for three minutes and activates physiological stress on the body (Porcelli & Delgado, 2009; McRae et al., 2006). Sympathetic arousal is measured throughout the procedure and sympathetic reactivity has reliably been observed (Lovallo, 1975; Buchanan et al., 2006). The SECPT adds further consent from the participant to be videotaped while their hand is immersed to analyze facial expressions of stress and gender-mismatched experimenters (or one gender-matched experimenter) act in a cold and neutral manner to create an evaluative environment (i.e., white lab coats, clipboards, and stopwatches; Schwabe et al., 2008). The SECPT added a social-evaluative component to the stressor.

Data Analytic Plan

To address aim one, two, and four and examine the role of stress, sex, and timing of stress on trust decisions and risk-taking, multiple 2 (Sex) X 2 (Timing) X 3 (Stress Type) three way between-subjects ANOVAs were completed on Trust Game and BART performance. Additionally, inter-individual variability in cortisol reactivity was incorporated as a variable within stress groups (CPT and SECPT) as an added factor influencing trust decisions and risk-taking. An exploratory 4 (Share Decision) X 2 (Control and Stress) X 2 (Sex) X 2 (Timing) mixed design ANOVA was employed to determine differences in specific trust decisions based on stress, sex, and timing of stress.

To address aim three and differentiate the roles of separable psychophysiological and neuroendocrine (i.e., cortisol) correlates of acute stress, multiple two-way ANOVAs were calculated by stress group and sample (i.e., cortisol or skin conductance). Additional analyses were performed on cortisol levels and stress group taking into consideration AUCg and AUCi. Behavioral analyses were conducted to determine group differences between subjective ratings of affect, estimated premorbid intelligence, trust expectancies, self-reported childhood trauma, and risk preferences.

A multiple hierarchical regression was performed to determine whether trust expectancies measured on the General Trust Scale, level of maltreatment on the Childhood Trauma Questionnaire, sex, and stress predicted performance on the Trust Game. Moreover, to examine whether or not participants' risk-preference (via Penny Game) and risk-seeking behavior (via BART) predicted their decisions to trust in the trust game, a hierarchical linear regression was explored.

Results

All analyses were conducted using SPSS Statistics 22. All data were examined for outliers and issues with skew and kurtosis prior to analysis. Direction of results and statistical significance remained unaltered even after appropriate transformations were applied thus raw scores were used in analysis unless otherwise specified.

Stress Procedure

There were 31 participants in the Control group, 32 participants in the CPT group, and 33 participants in the SECPT group. Only one participant removed their hand from the water before completion of the control procedure, eight participants before completion of the CPT procedure, and six participants prior to completion of the SECPT procedure (out of 3 minutes for all three procedures). A significant difference was noted for average amount of time a participant's hand was submerged in water by stress group ($F(2, 93) = 3.093$, $p = .05$, $\eta_p^2 = .062$). Participants in the control group averaged 2.96 seconds of hand submersion, significantly longer than participants in the CPT group (averaged 2.58 seconds; $t(61) = 2.519$, $p < .05$, $d = 0.64$). Participants in the SECPT group averaged 2.73 seconds which was significantly shorter than the control group

($t(62) = 1.951$, $p = .05$, $d = 0.5$). No significant differences were observed between average time of hand submersion during the stress procedure for participants in the SECPT and CPT group ($t(63) = -.813$, $p > .15$, $d = -0.2$).

Salivary Cortisol Results

To determine HPA axis activation between stress groups (CPT and SECPT) compared to the no-stress control group, salivary cortisol was acquired across four different time points throughout the study (baseline, post-stress, 20-minutes post-stress, and 40-minutes post-stress). Before data analysis, data were screened for normality and outliers. There were no outliers within the data set; however, cortisol data across the four time points were log transformed to address positive skew. Utilizing a trapezoidal formula to simplify salivary cortisol data, the area of the curve for cortisol with respect to increase (AUCi) and the area under the curve with respect to ground (AUCg) were computed (Pruessner, Kirschbaum, Meinlschmid, & Hellhammer, 2003).

A 3 (Stress Group) X 4 (Sample) mixed-design ANOVA was calculated to compare cortisol levels by stress group (Control, CPT, and SECPT) at four different time points (baseline, stress, 20-minutes post-stress, 40-minutes post-stress). A significant main effect of stress group was noted, $F(1, 89) = 4.81$, $p < .05$, $\eta_p^2 = .098$. A significant interaction between time and stress group was observed (Greenhouse-Geisser corrected for sphericity; $F(3.02, 134.37) = 7.324$, $p < .05$, $\eta_p^2 = .141$). Post-hoc independent t-tests were conducted to determine differences in salivary cortisol levels over time by stress group. A significant increase in salivary cortisol levels was observed from baseline to 20-minutes post-stress (when cortisol levels post-stress are expected to increase), in CPT and SECPT groups; $t(31) = -2.838$, $p < .05$, $d = -1.02$; $t(32) = -2.273$, $p = .05$, $d = -0.8$

respectively. A significant decrease was observed in salivary cortisol from baseline to 20-minutes post-stress for participants in the control group, $t(29) = 3.752$, $p < .05$, $d = 1.39$ (see Appendix D). The CPT and SECPT procedures were not associated with significantly different levels of cortisol reactivity 20-minutes after the application of stress procedure. However, both stress groups (CPT and SECPT) elicited significant HPA activation compared to the no-stress group.

When investigating AUCg and AUCi by stress group, a significant difference in AUCg was observed between stress groups ($F(2, 89) = 4.983$, $p < .01$, $\eta_p^2 = .101$) as well as in AUCi ($F(2, 89) = 4.199$, $p <.05$, $\eta_p^2 = .086$). Bonferroni corrected post hoc tests revealed AUCg for stress groups (CPT; *M* = 374.99, *SD* = 367.75; and SECPT; *M* = 392.102, *SD* =177.81) exhibited significantly higher cortisol as compared to the control (*M* = 207.67, *SD* = 131.05). AUCi for participants in the CPT group (*M* = 45.99, *SD* = 190.34) was significantly greater increase in cortisol reactivity from baseline when compared to the control (*M* = -73.37, *SD* = 106.42). See Appendix E and F for more information. Analyses utilizing the AUCg and AUCi calculations similarly demonstrate significant cortisol reactivity in the stress groups (CPT and SECPT) compared to the no stress control group.

Additionally, inter-individual variability in cortisol reactivity to acute stress (i.e., was there a measureable stress-associated secretory episode of cortisol release of at least 15.5% above baseline) necessitates classification of participants as “responders” or “nonresponders” (Miller et al., 2013). After classification criteria was applied, the control group consisted of 9.7 percent responders, the CPT group included 59.4 percent responders, and the SECPT group 51.5 percent responders. Responder type was included as an additional between-subjects factor throughout data analysis.

Skin Conductance Results

A 3 (Stress Group) X 3 (Time) mixed-design ANOVA was calculated to compare the effects of stress group and time (Baseline, Stress, and Post-Stress) on mean skin conductance levels. Confirming stress-related SAM activation, a significant stress group by time interaction was observed, $F(3.664, 170.361) = 10.632$, $p < .05$, $\eta_p^2 = .186$ (Greenhouse-Geisser corrected). Post-hoc paired t-tests indicated a significant increase in mean skin conductance levels from baseline to stress for CPT and SEPCT participants; $t(31) = -6.753$, $p < .01$, $d = -2.43$; $t(33) = -5.694$, $p < .01$, $d = 1.98$; respectively. Significant decreases in mean skin conductance levels for participants in the control group was observed; $t(30) = 4.659$, $p < .01$, $d = 1.7$ (see Appendix G for a visual representation of skin conductance levels baseline to stress). Stress groups (CPT and SECPT) did not produce significantly different SAM activation via skin conductance though both stress groups elicited significantly greater SAM activation from baseline to stress compared to the control group.

Behavioral Analyses

Independent t-tests were performed to determine group differences by stress group in subjective reports of positive or negative affect (PANAS), estimated premorbid intellectual ability (NAART), self-reported generalized trust beliefs (General Trust Scale), self-reported childhood trauma (CTQ), and risk preferences (Penny Game; Refer to Appendix H for descriptive statistics by stress group and sex). On a post-experimental measure, five participants expressed uncertainty over whether or not the social interaction with the confederate was a "real" interaction; however, when these selected participants were excluded from the data analysis results remained unchanged. Therefore, all data analyses conducted included all 96 participants.

Stress Group Differences

Subjective ratings of stress. No significant difference between self-reported ratings of positive and negative affect (as measured by the PANAS) were observed before the assigned stress procedure was administered ($F(2, 88) = 0.177$, $p > .15$, $\eta_p^2 = .004$; $F(2, 88) = 0.635$, $p > .15$, $\eta_p^2 = .014$; respectively). Ratings of positive and negative affect immediately following the assigned stress procedure revealed no significant differences in positive affect, $F(2, 90) = 0.110$, $p > .15$, $\eta_p^2 = .002$, and negative affect, $F(2, 90) = 1.77$, $p > .15$, $\eta_p^2 = .038$, by group. When specifically investigating changes between participant rating of feeling "distressed" before and after an acute stressor, participants exhibited a significant increase of distress in the stress groups (CPT and SECPT; $t(60) = -2.673$, $p < .05$, $d = -0.69$) compared to the control ($t(28) = -.895$, $p > .15$, $d = -0.34$). On the administered post-experimental questionnaire, participants in the stress groups (CPT and SECPT) self-reported experiencing significantly higher levels of stress and negative affect after the water exposure ($F(2, 87) = 53.422$, $p < .01$, $\eta_p^2 = .551$; $F(2, 87) = 69.554$, $p < .01$, $\eta_p^2 = .615$; respectively). Bonferroni corrected post hoc tests demonstrated stress groups (CPT; $M = 2.03$, $SD = 1.02$; and SECPT; $M = 2.16$, $SD = .987$) rated the stress procedure significantly more negative than controls ($M = 5.07$, $SD = 1.3$). Additionally, Bonferroni corrected post hoc tests revealed stress groups (CPT; $M = 4.84$, $SD = 1.66$; and SECPT; $M = 4.75$, $SD = 1.48$) rated feeling significantly more stressed when compared to the control group after the stress procedure (*M* = 1.48, *SD* = 0.85).

Generalized trust. No significant difference in generalized trust by stress group (Control, CPT, and SECPT) was observed on Day 1 prior to undergoing the experimental Trust Game on Day 2 ($F(2, 92) = 2.338$, $p > .10$, $\eta_p^2 = .048$). Therefore, participants from each group (Control, CPT, and SECPT) self-reported similar generalized trust beliefs.

Childhood trauma questionnaire. No significant differences in self-reported early childhood trauma within three specific domains (emotional abuse, physical abuse, and sexual abuse) were observed across groups ($F(2, 92) = 1.654$, $p > .15$, $\eta_p^2 = .035$; $F(2, 92) = 1.098$, $p > .15$, $\eta_p^2 = ..023$; $F(2, 92) = 1.39$, $p > .15$, $\eta_p^2 = .029$; respectively). Based on the scale, a reported “5” on each CTQ domain indicates no report of abuse. Participants across all groups reported a mean of 5.74 (SD = 2.05) and 5.44 (SD = 2.31) on the physical abuse and sexual abuse domain respectively indicating minimal to no report of physical and sexual abuse. Participants across all groups reported a mean of 7.12 (SD = 3.07) or low levels of emotional abuse. All participants in the study reported similar levels of childhood trauma.

NAART. No significant differences were observed in NAART performance by group indicating similar estimated premorbid intellectual ability in participants ($F(2, 93) = 1.02$, $p > .15$, $\eta_p^2 = .021$).

Risk preferences. All participants demonstrated similar risk preferences on a task involving “real” dollar payments and larger, hypothetical amounts of money across group ($F(2, 92) = 0.527$, $p > .15$, $\eta_p^2 = .011$; $F(2, 93) = 0.937$, $p > .15$, $\eta_p^2 = .02$). Participants demonstrated similar risk preferences (slightly risk-averse).

Reaction Time on Trust Game and BART Behavioral Task

Reaction time on the Trust Game was calculated by averaging the total reaction time by trial. No significant differences were revealed in average reaction time by stress group, $F(2, 93) = 0.08$, $p > .15$, $\eta_p^2 = .002$. A 3 (Stress Group) X 2 (Sex) X 2 (Timing) between subjects ANOVA was computed to compare average reaction time based on stress group, sex, and timing of stress on the Trust Game. A significant interaction between stress group and timing of stress was noted for average reaction time on the Trust Game ($F(2, 84) = 7.167$, $p < .01$, $\eta_p^2 = .146$). Post-hoc independent t-tests indicate for participants in the SECPT group, the SG and LG demonstrated similar levels of average reaction time on the Trust Game task ($t(31) = .058$, $p > .15$, $d = 0.02$). Participants in the CPT group demonstrated significantly longer average reaction time on the Trust Game in the LG when compared to the SG ($t(30) = -2.271$, $p < .05$, $d = -0.83$). Control participants demonstrated significantly shorter average reaction time in the LG compared to the SG on the Trust Game ($t(29) = 2.974$, $p < .01$, $d = 1.1$). No significant differences in reaction time on the Trust Game were observed between CPT and SECPT within the SG ($t(31) = -1.074$, $p > .15$, $d = -0.39$) or LG groups ($t(31) = 1.446$, $p > .15$, $d = 0.52$).

Average reaction time on the BART was not significantly different by stress group ($F(2, 93) = 0.63$, $p > .15$, $\eta_p^2 = .001$). To investigate average BART reaction time further, a 3 (Stress Group) X 2 (Sex) X 2 (Timing) between subjects ANOVA was computed. No significant interaction was observed based on stress group, sex, and timing of stress ($F(2, 84) = .65$, $p > .15$, $\eta_p^2 = .02$). A trend towards a main effect of sex was observed for average reaction time on the BART ($F(1, 84) = 2.97$, $p = .089$, $\eta_p^2 = .034$).

Post-hoc independent t-tests indicated males trended towards significantly faster reaction time as compared to females, $t(94) = -1.784$, $p = .078$, $d = -0.368$.

Trust Decisions

Three-way interactions investigating sex, timing of stress, and stress group on trust decisions. To compare trust decisions (average amount of money invested and overall percentage of shared decisions) for male and female participants exposed to different timings of stressor and stress group, multiple 2 (Sex) X 2 (Timing) X 3 (Stress Group) between-subjects three-way ANOVAs were conducted. Post hoc analyses were then performed to examine the influence of sex, timing, and stress group on trust. A 2 (Sex) X 2 (Timing) X 3 (Stress Group) between subjects three way ANOVA conducted to determine overall percentage of share decisions by stress group, sex, and timing and was not significant ($F(2, 84) = .214$, $p > .15$, $\eta_p^2 = .005$). No significant two-way interactions were noted (Sex by Stress group, $F(2, 84) = 1.129$, $p > .15$, $\eta_p^2 = .026$; Sex by Timing of Stress, $F(1, 84) = 1.908$, $p > .15$, $\eta_p^2 = .022$; and Stress group by Timing of Stress, $F(2, 84) = .239$, $p > .15$, $\eta_p^2 = .006$). No significant main effects were also noted (Sex, $F(1, 84) = 1.25$, $p > .15$, $\eta_p^2 = .015$; Stress group, $F(2, 84) = 1.106$, $p > .15$, $\eta_p^2 = .026$; Timing of Stress, $F(1, 84) = .017$, $p > .15$, $\eta_p^2 = .001$).

In terms of average amount of money invested in their social-counterpart, the three-way interaction between sex, timing, and stress group was not significant ($F(2, 84) = 0.421$, $p > .15$, $\eta_p^2 = .01$). No significant two-way interactions were noted (Sex by Stress group, $F(2, 84) = .425$, $p > .15$, $\eta_p^2 = .01$; Sex by Timing of Stress, $F(1, 84) = .602$, $p > .15$, $\eta_p^2 = .007$; and Stress group by Timing of Stress, $F(2, 84) = .631$, $p > .15$, $\eta_p^2 = .015$). No significant main effect was observed for timing of stress ($F(1, 84) = 1.104$, $p >$

.15, η_p^2 = .013). A significant main effect was revealed for sex ($F(1, 84) = 5.105$, $p < .05$, η_p^2 = .057) and a trend toward significant differences was observed by stress group ($F(2, 84) = 2.484$, $p = .089$, η_p^2 = .056). Post-hoc independent t-tests indicated males significantly invested more money on average (*M* = 5.72, *SD* = 2.49) than females (*M* = 4.58, *SD* = 2.11) in the Trust Game ($t(94) = 2.416$, $p < .05$, $d = 0.498$). A one-way ANOVA exploring amount of money invested by stress group demonstrated a trend toward significant differences ($F(2, 93) = 2.508$, $p = .089$, η_p^2 = .051). Bonferroni corrected post hoc tests revealed money invested on average was not significantly different by stress groups (CPT; *M* = 4.74, *SD* = 2.04; and SECPT; *M* = 4.85, *SD* =2.10) but both significantly differed compared to control (*M* = 5.93, *SD* = 2.81).

Three-way interactions with stress groups (CPT and SECPT) collapsed. Overall, participants invested an average of $5.16 to their counterpart regardless of stress group (see Appendix I for frequency of investment choice by group). Participants in the control group on average invested $5.93 to their counterpart, whereas participants in the stress groups (CPT and SECPT) invested less on average to their counterpart (4.74 and 4.85 respectively). Due to similar investment values between the stress groups, and no significant effects based on ANOVAs calculated separating the CPT and SECPT group, CPT and SECPT groups were collapsed and new ANOVAs performed.

A 2 (Control and Stress) X 2 (Sex) X 2 (Timing) between-subjects ANOVA was conducted to investigate amount of money invested by stress or no stress group, timing of stress, and sex. A main effect of stress was observed ($F(1, 88) = 5.08$, $p < .05$, η_p^2 = .055). Post-hoc independent t-tests indicated stressed participants invested significantly less in their counterpart when compared to controls ($t(94) = 2.242$, $p < .05$, $d = 0.46$). A main effect of sex was also noted (*F*(1, 88) = 4.90, $p < .05$, $\eta_p^2 = .053$). As previously discussed, post-hoc independent t-tests determined males invested significantly more money on average (*M* = 5.72, *SD* = 2.49) than females (*M* = 4.58, *SD* = 2.11) in the Trust Game across all groups (*t*(94) = 2.416, $p < .05$, *d* = 0.498). No significant differences in average amount of money invested were observed by timing of stress (SG or LG; *F*(1, 88) = 1.826, $p > .15$, $\eta_p^2 = .02$). The average amount of money invested throughout the Trust Game immediately after the administration of the stress procedure (SG; *M* = 4.94, *SD* = 2.06) was not significantly different than average amount of money invested 20-minutes post-stress (LG; *M* = 5.40, *SD* = 2.67). No significant interaction was noted for stress group (stress and control), sex, and timing of stress on money invested in the Trust Game (*F*(1, 88) = .537, $p > .15$, $\eta_p^2 = .006$).

A 2 (Control and Stress) X 2 (Sex) X 2 (Timing) between-subjects ANOVA was conducted to investigate percentage of shared decisions in the Trust Game by stress or no stress group, timing of stress, and sex. No significant main effects (Stress, *F*(1, 88) = 1.734, $p > .15$, $\eta_p^2 = .019$; Sex, *F*(1, 88) = 1.129, $p > .15$, $\eta_p^2 = .013$; Timing of Stress, *F*(1, 88) = .002, $p > .15$, $\eta_p^2 = .001$), or two-way interactions (Sex and Stress, *F*(1, 88) = .007, $p > .15$, $\eta_p^2 = .001$; Stress and Timing of Stress, *F*(1, 88) = .074, $p > .15$, $\eta_p^2 = .001$; Sex and Timing of Stress, *F*(1, 88) = 1.87 $p > .15$, $\eta_p^2 = .021$) were observed. No significant three-way interaction manifested (*F*(1, 88) = .039, $p > .15$, $\eta_p^2 = .001$). With respect to timing of stress, no significant differences were revealed (*F*(1, 88) = .002, $p > .15$, $\eta_p^2 = .001$). Participants in the SG and LG had similar overall percentage of shared decisions (*M* = 24.28, *SD* = 6.63; *M* = 24.07, *SD* = 7.54; respectively).

Trust decisions by share decision, stress group, sex, and timing of stress. A 4 (Share Decision) X 2 (Control and Stress) X 2 (Sex) X 2 (Timing) mixed design ANOVA was employed to determine differences in percentage of shared decisions (Percentage of Keep, Share $4, Share $8, or Share $12) based on stress, sex, and timing of stress. A significant two-way interaction was observed between share decision and stress group ($F(2.25, 198.07) = 3.75$, $p < .05$, $\eta_p^2 = .041$). Post-hoc independent t-tests demonstrated participants in the control group significantly invested more percentage of the “full” amount of money ($12) to their counterpart than participants in the stress (CPT and SECP) groups ($t(94) = 2.581$, $p < .05$, $d = 0.053$).

A significant two-way interaction was noted between share decision and sex ($F(2.25, 198.07) = 4.076$, $p < .05$, $\eta_p^2 = .044$). Post-hoc independent t-tests determined males significantly invested less percentage of $4 to their social counterpart ($t(94) = -2.61$, $p < .05$, $d = 0.538$) and significantly greater percentage of the “full” amount or $12 to their social counterparts compared to females ($t(94) = 2.83$, $p < .05$, $d = 0.584$). Additionally, a trend toward a two-way interaction between share decision and timing of stress was observed ($F(2.25, 198.67) = 2.823$, $p = .055$, $\eta_p^2 = .031$). Post-hoc independent t-tests revealed participants in the SG trended toward investing more percentage of $4 to their social counterpart compared to participants in the LG ($t(94) = 2.089$, $p < .05$, $d = 0.43$).

No significant three-way interactions were noted (Sex by Stress group by Share Decision, $F(2.25, 198.07) = .879$, $p > .15$, $\eta_p^2 = .01$; Sex by Timing of Stress by Share Decision, $F(2.25, 198.07) = 1.234$, $p > .15$, $\eta_p^2 = .014$; and Stress group by Timing of Stress by Share Decision, $F(2.25, 198.07) = 1.519$, $p > .15$, $\eta_p^2 = .017$). No significant four-way interaction between share decision, stress, sex, and timing of stress was observed $F(2.25, 198.07) = 1.11$, $p > .15$, $\eta_p^2 = .012$).

Trust decisions by responder type, stress group, sex, and timing of stress. Multiple 2 (Responder Type) X 3 (Stress Group) X 2 (Sex) X 2 (Timing) between-subjects four-way ANOVAs were conducted to compare the role of responder, stress group (CPT and SECPT), sex, and timing of stress on trust decisions. The no stress control group was removed from this analysis due to limited cortisol reactivity (i.e., only 9.7 percent were classified as responders). While a four-way interaction between responder, stress group, sex, and timing was not significant for money invested ($F(1, 48) = 2.13$, p > .15, $\eta_p^2 = .042$), it trended towards significant for percentage of share decisions in the Trust Game ($F(1, 48) = 3.018$, $p = .089$, $\eta_p^2 = .059$).

To follow up on this, a 2 (Responder Type) X 2 (Sex) X 2 (Timing) between-subjects ANOVA was conducted for each stress group independently (CPT compared to SEPCT) on overall percentage of sharing. For participants in the SECPT group a trend toward a three way interaction between responder type, sex, and timing was observed ($F(1, 24) = 3.68$, $p = .067$, $\eta_p^2 = .133$). No such trend was observed for participants in the CPT group ($F(1, 24) = 0.49$, $p > .15$, $\eta_p^2 = .02$). Therefore, a 2 (Responder Type) X 2 (Timing) between-subjects ANOVA was performed on SECPT participants alone. No significant two way interaction between responder type and timing of stress for males was noted in the SECPT group ($F(1, 12) = 2.305$, $p > .15$, $\eta_p^2 = .161$). For females in the SECPT group, a trend towards a main effect of responder type on percentage of shared decisions was observed ($F(1, 12) = 4.267$, $p = .061$, $\eta_p^2 = .262$). A post-hoc independent t-test demonstrated females coded as “nonresponders” in the SECPT group demonstrated significantly lower percentage of shared decisions compared to female “responders” in the SECPT group ($t(14) = -2.179$, $p < .05$, $d = -1.16$). See Appendix J for a visual representation of findings.

BART Performance by Stress Group

Participants in all groups regardless of stress performed similarly on the BART task. They engaged in similar stop behavior per trial over the course of the task ($F(2, 93) = .143$, $p > .15$, $\eta_p^2 = .003$). Participants had exhibited a similar number of explosions throughout the task which was quantified as “risk-taking” on the task ($F(2, 93) = 0.163$, $p > .15$, $\eta_p^2 = .003$). Additionally, participants’ decisions to “pump” the balloon to accrue greater winners (also a measure of risk-taking) were similar between groups ($F(2, 93) = 0.685$, $p > .15$, $\eta_p^2 = .506$). Therefore, risk-taking on the BART task was similar between stress groups.

BART performance by stress group, sex, and timing. Multiple 3 (Stress Group) X 2 (Sex) X 2 (Timing) between subjects ANOVAs were conducted to examine BART performance (adjusted number of balloon pumps, number of explosions, and number of stops) based on stress group, timing of stress, and sex. No significant interaction was observed between stress group, timing of stress, and sex on number of explosions ($F(2, 84) = .496$, $p >.15$, $\eta_p^2 = .012$). No significant two-way interactions were indicated (Sex by Stress group, $F(2, 84) = 1.002$, $p > .15$, $\eta_p^2 = .023$; Sex by Timing of Stress, $F(1, 84) = .004$, $p > .15$, $\eta_p^2 = .001$; and Stress group by Timing of Stress, $F(2, 84) = .904$, $p > .10$, $\eta_p^2 = .021$). There was no significant main effect was of stress group ($F(2, 84) = .222$, $p > .15$, $\eta_p^2 = .005$) and timing of stress ($F(1, 84) = 1.428$, $p > .15$, $\eta_p^2 = .017$). A significant main effect of sex was noted trending towards significant male and female differences in number of explosions (F(1, 84) = 3.043, p = .085, η_p^2 = .035). Post-hoc independent t-tests indicates males trended toward a significantly higher occurrence of balloon explosions during the BART as compared to females (t(94) = 1.74, p = .085, d = 0.359).

No significant interaction between stress group, timing of stress, and sex was indicated on adjusted number of balloon pumps (F(2, 84) = .357, p > .15, η_p^2 = .008). No significant two-way interactions were observed (Sex by Stress group, F(2, 84) = .796, p > .15, η_p^2 = .019; Sex by Timing of Stress, F(1, 84) = .007, p > .15, η_p^2 = .001; and Stress group by Timing of Stress, F(2, 84) = 2.361, p > .10, η_p^2 = .053). No significant main effects were also noted (Sex, F(1, 84) = .447, p > .15, η_p^2 = .006; Stress group, F(2, 84) = .739, p > .15, η_p^2 = .017; Timing of Stress, F(1, 84) = .633, p > .15, η_p^2 = .007).

No significant interaction was observed for number of stops on the BART task between stress group, timing of stress, and sex (F(2, 84) = .529, p > .15, η_p^2 = .012). No significant two-way interactions were noted (Sex by Stress group, F(2, 84) = .969, p > .15, η_p^2 = .023; Sex by Timing of Stress, F(1, 84) = .001, p > .15, η_p^2 = .001; and Stress group by Timing of Stress, F(2, 84) = .903, p > .15, η_p^2 = .021). No significant main effects were also noted for stress group (F(2, 84) = .198, p > .15, η_p^2 = .005 and timing of stress (F(1, 84) = 1.356, p > .15, η_p^2 = .016). A significant main effect of sex was noted trending towards significant differences between males and females for number of stops (F(1, 84) = 3.119, p = .081, η_p^2 = .036). A post-hoc independent t-test suggests a trend toward female participants engaging in more “stops” during the BART task as compared to males (t(94) = -1.763, p = .081, d = -0.364). Thus, qualitatively females engaging in more “stops” throughout the task would lead to less occurrence of balloon explosions in the task.

BART performance by responder type, stress group, timing, and sex. Multiple 2 (Responder Type) X 3 (Stress Group) X 2 (Sex) X 2 (Timing) between-subjects four-way ANOVAs were explored to compare the role of responder, stress group (CPT and SECPT), sex, and timing of stress on BART performance (adjusted number of balloon pumps, number of explosions, and number of stops). The no stress control group was also removed from this analysis due to limited cortisol reactivity. No significant interaction was observed for adjusted number of balloon pumps by responder type, stress group, sex, and timing of stress ($F(1, 48) = .154$, $p > .15$, $\eta_p^2 = .003$), number of explosions ($F(1, 48) = .536$, $p > .15$, $\eta_p^2 = .011$) and stops ($F(1, 48) = .536$, $p > .15$, $\eta_p^2 = .011$).

A trend toward a significant interaction was revealed for stress group (CPT versus SECPT) and responder type for adjusted number of balloon pumps ($F(1, 48) = 3.425$, $p = .07$, $\eta_p^2 = .067$). SECPT group nonresponders trended toward engaging in a higher number of adjusted balloon pumps when compared to CPT nonresponders ($t(26) = -1.787$, $p = .08$, $d = -0.701$). No significant differences were noted for responders in the SECPT and CPT group on adjusted number of balloon pumps ($t(34) = 1.13$, $p > .15$, $d = 0.39$). A significant interaction was observed for stress group (CPT versus SECPT) and responder type for number of explosions and stops ($F(1, 48) = 5.317$, $p < .05$, $\eta_p^2 = .1$; $F(1, 48) = 5.317$, $p < .05$, $\eta_p^2 = .1$; respectively). Post-hoc independent t-tests demonstrated no significant differences in number of explosions ($t(26) = -1.544$, $p > .10$, $d = 0.606$) and number of stops ($t(26) = 1.544$, $p > .10$, $d = 0.606$) by nonresponders in either stress group (CPT versus SECPT). However, participants coded as responders in the CPT group exhibited significantly higher occurrence of balloon explosions compared to the SECPT group ($t(34) = 2.086$, $p < .05$, $d = 0.715$). Additionally, participants coded as responders in the SECPT group exhibited significantly higher number of "stops" when compared to the CPT group ($t(34) = -2.086$, $p < .05$, $d = -0.715$).

A trend toward significant differences between nonresponder and responder in the SECPT group was noted for number of balloon explosions ($t(30) = 1.861$, $p = .073$, $d = 0.68$; and stops (t(30) = -1.861, p = .073, $d = -0.68$). Nonresponders in the SECPT group engaged in fewer "stops" ($M = 20.4$, $SD = 5.3$) and had a higher number of balloon explosions ($M = 8.6$, $SD = 5.3$) than responders. Responders in the SECPT group exhibited a trend toward a higher amount of "stops" on the task ($M = 23.24$, $SD = 3.17$) and lower amount of balloon explosions ($M = 5.74$, $SD = 3.17$).

Regression Analyses

Prior to completing regression analyses, preliminary analyses were conducted to ensure there were no violation of assumptions of normality, linearity, multicollinearity, and homoscedasticity.

Trust decisions predicted by risk-taking behavior. A hierarchical linear regression was calculated to predict average amount of money invested based on risk seeking preference (via Penny Game; interval estimate of risk aversion based on pennies and based on hypothetical incentive) and (via BART; adjusted number of pumps, number of explosions, and number of stops), and stress group (dummy coded in two separate variables; See Table J for issues of multicollinearity and correlation matrix of variables of interest). Due to an issue of multicollinearity between two independent variables (BART number of stops and BART number of explosions), the variable BART number of stops was removed from the overall regression analysis.

Sex was entered at step one, explaining six percent of the variance in average amount of money invested. After entry of stress (SECPT stress and CPT stress) at step two, the total variance explained by the model significantly added 10 percent variance $F(3, 91) = 3.53$, $p < .05$ with an R^2 of .104. In the final model, after inclusion of risk-seeking variables of interest (adjusted number of pumps, number of explosions, risk aversion based on pennies, and risk aversion based on hypothetical incentive), the model explained 15 percent added variance $F(7, 87) = 2.202$, $p < .05$ with an R^2 of .15. In the final model, only two control measures were statistically significant, with sex making the strongest contribution in explaining money invested in the Trust Game and CPT stress group making the next strongest contribution in money invested. Risk-taking behavior based on the Penny Game and "riskiness" measured by the BART task were not significantly predictive of trust decisions (See Table K for regression model).

Trust decisions predicted by trust expectancies and self-reported childhood trauma. A hierarchical linear regression was calculated to predict average amount of money invested in the Trust Game based on trust expectancies (measured by General Trust Scale), stress group (dummy coded into two separate variables), self-reported level of childhood abuse (i.e., emotional, sexual, physical) as measured by the CTQ, and sex. Due to multiple regression analyses' sensitivity to outliers, one General Trust Scale outlier in was Winsorized (See Table L for correlation matrix of variables of interest).

Sex was entered at step one, explaining six percent of the variance in average amount of money invested. After entry of stress (CPT and SECPT stress) at step two, the total variance explained by the model added 10 percent $F(3, 91) = 3.534$, $p < .05$ with an R^2 of .104. In the final model, after inclusion of generalized trust beliefs and self-reported childhood trauma (physical, sexual, and emotional abuse), the model explained 15 percent which was significant ($F(7, 87) = 2.163$, $p < .05$ with an R^2 of .148). In the final model, only three control measures were statistically significant, with sex making the strongest contribution in explaining money invested in the Trust Game, followed by CPT stress making the next strongest contribution in money invested, and then SECPT stress (See Appendix M for regression model).

A hierarchical linear regression was computed to predict percent of shared decisions. Sex was entered at step one, explaining one percent of the variance in percent of decisions shared. After entry of stress (CPT and SECPT stress) at step two, the total variance explained by the model added three percent $F(3, 91) = 1.201$, $p > .15$ with an R^2 of .038. In the final model, after inclusion of generalized trust beliefs and self-reported childhood trauma (physical, sexual, and emotional abuse), the model explained eight percent and no significant regression model was observed ($F(7, 87) = 1.081$, $p > .15$ with an R^2 of .080).

Discussion

The primary aims of the current study were to investigate 1) the influence of stress on trust decisions and risk-taking 2) potential sex differences on trust decisions after exposure to acute stress, 3) to delineate potential separable psychophysiological and neuroendocrine (i.e., cortisol) correlates of acute stress and determine whether or not temporal components of the stress response differentially influence trust decisions, and 4) to specifically explore the differences of a social-evaluative stressor (SECPT) and physiological stress (CPT) on prosocial behavior (i.e., trust).

Neuroendocrine and Psychophysiological Profiles by Stress Group

Both the CPT and the SECPT group were associated with significant salivary cortisol increases from baseline to 20-minutes post-stress. The control group was associated with significant salivary cortisol decreases from baseline to 20-minutes post-stress. Thus, both stressors (CPT and SECPT) elicited effective HPA activation. Both CPT and SECPT groups produced a significant increase in mean skin conductance levels from baseline to stress compared to the control group demonstrating significant SAM activation. No significant differences in HPA activation and SAM activation were observed between stress group. Additionally, subjective ratings of stress and emotional response to the stressor confirmed effective stress manipulation. Participants rated the stressor as significantly more stressful and "bad" in the stress groups compared to the control.

Research comparing these different classes of stressors specific to the current study (i.e., CPT versus SECPT) is limited. One study delineating between these two types of stressors suggests the SECPT with a social-evaluative component is associated with significantly higher levels of cortisol elevations when compared to the CPT and control group (Schwabe et al., 2008). In the same study, the CPT was associated with higher levels of cortisol than the control group though this was not significant. In the current study both SECPT and CPT groups elicited significantly higher levels of cortisol elevations compared to the control group though no significant differences were observed between stress groups. Further studies utilizing the CPT and SECPT independently provide evidence that both stress-induction techniques elicit both HPA activation and sympathetic arousal (Lovallo, 1975; Porcelli, 2012).

Temporal Components of Stress

The current study revealed exploratory results differentiating between the temporal components (SAM activation versus HPA activation) of the stress response on trust decisions. No significant differences in average amount of money invested and overall percentage of shared decisions were revealed by timing of stress response. A trend was observed for participants engaging in the Trust Game immediately post-stressor for greater percentage of investment of the $4 choice in the game compared to participants who engaged in the Trust Game after a delay. The observed trend for participants to engage in “less risky” decisions by choosing to invest a greater percentage of $4 choice compared to “more risky” decisions ($8 or $12) to their social counterpart may be reflective of the influence of emotional states on risk-taking decisions. When individuals are in a negative mood compared to a neutral or a positive mood, individuals are more likely to engage in risk-averse behavior (Yuen & Lee, 2003). The stress procedure (CPT or SECPT) and the control procedure may have induced a lower mood at the end of the duration of the procedure compared to the beginning of the study.

Participants in the CPT group demonstrated significantly longer average reaction time on the Trust Game in the LG compared to the SG suggesting variance of reaction time by timing of stress. Slower reaction time has been linked to elevations in cortisol following stress (Schoofs, Preub, & Wolf, 2008). Participants in the CPT group who were assigned to the LG had significantly slower reaction time to the SG. Potentially, the immediate effects of systemic stress (e.g., norepinephrine, epinephrine, and dopamine) may be leading to faster reaction times by participants before HPA activation 20-minutes post-stress (Pabst et al., 2013). Regarding lack of significant differences observed in timing of stress on trust decisions in the present study, a meta-analysis on stress and decisions under uncertainty conducted by Starcke and Brand (2016) hypothesized that the timing of stress onset and the administration of decision making task may influence the effect of stress on decisions. However, the meta-analysis concluded time of stress onset and decision making did not predict effect sizes or differential effects of stress on decision making under uncertainty (Starke & Brand, 2016). The studies reviewed within this highlighted meta-analysis may not have methodologically considered timing of stress onset to decision making task and may be difficult to generalize. The current study is the first study to methodologically account for the dissociable temporal components of the stress response and thus replication of findings is necessary.

Sex Differences in Trust after Exposure to Acute Stress

In the present study, sex differences were observed with respect to the amount of money invested in the Trust Game. Males exhibited significantly higher amounts of money invested to their counterpart than females. On closer analysis, males significantly invested less percentage of $4 and greater percentage of the “full” amount or $12 to their social counterpart when compared to females. When the role of stress was included in the analysis sex differences were not observed. Further analysis exploring sex differences in trust decisions based on cortisol reactivity to the stressor indicated that female responders within the SECPT stress group demonstrated a higher percentage of shared decisions than did females who were classified as nonresponders, suggesting modulation of trust behavior in females based on cortisol reactivity within the social-evaluative acute stressor.

Outside the context of stress, past modifications of the Trust Game exploring sex differences in trust decisions demonstrate males engage in more trust (i.e., invest more money to a counterpart; Buchan, Croson, & Solnick, 2008) than females. It has been postulated males engage the Trust Game from an “agentic” or “instrumental” approach consistent with social role theory (Bakan, 1966). Each player in the modified Trust Game paradigm in the current study could only increase their monetary endowment by investing larger amounts of money to their counterpart thus choosing to invest more money on average would lead to the largest accumulation of monetary outcome. Females are more likely to engage in risk-averse decision making than males which may be consistent with results outlined in the present study (Croson & Gneezy, 2009).

In the context of stress, evolutionary psychologists have long postulated that males and females respond to stress differently to maximize genetic fitness (Taylor et al., 2007). For example, it has been suggested that males respond with increasing sympathetic reactivity in preparation for engagement of the “fight or flight” response. On the other hand, females may respond to stress in a “tend and befriend” manner. No sex differences were noted when stress group was included in analysis suggesting similar engagement of amount of money invested and percentage of money shared in the Trust Game. A previous study conducted by von Dawans et al. (2012) observed increased trust behavior in males after an acute psychosocial stressor (i.e., TSST). This finding was not observed in the present study. Notably, the stress-induction techniques employed in the current study differed and thus methodological differences in stress-induction may lead to varying decision making tendencies. A recent study conducted by FeldmanHall et al. (2015), investigated trust after exposure to a physiological stressor (CPT) and observed no sex differences. The absence of sex differences in the Trust Game in the context of physiological stress in the current study replicates this most recent study, sex differences in trust following a social-evaluative stressor (SECPT) do not.

Females who were classified as responders or had higher levels of cortisol reactivity in the social-evaluative stress group were observed to engage in higher percentage of shared decisions on the Trust Game when compared to female nonresponders in the same group, though this observation was noted as a trend. Specific to the social-evaluative component of stress, females who responded to stress with higher cortisol reactivity may be demonstrating an increase in “tend and befriend” behavior by choosing to engage in more “share” decisions with their social counterpart (Taylor et al., 2007). Additionally, elevated cortisol levels have been previously linked to sensation-seeking behavior and reward (van den Bos, Harteveld, & Stoop, 2009). Thus, female cortisol responders within the social evaluative stress may be more inclined to engage in risk-seeking behavior for the immediate reward of the exchange compared to nonresponders within the same group. Females have been noted to be more sensitive to social rejection and “physiologically reactive” to negative interpersonal events when compared to males therefore this adjustment in decision making in females may be specific to stress with a social-evaluative component (van den Bos et al., 2009; Stroud, Salovey, & Epel, 2002).

Sex Differences in Risk-taking on the BART Task

Risk-taking was explored utilizing the BART task and sex differences in performance were investigated. Males demonstrated a trend in faster average reaction time than females. Males also exhibited a trend toward a higher occurrence of balloon explosions than females and a lower number of engagement in “stops” on the BART task. No sex differences were noted on a measure of adjusted number of balloon pumps. Sex differences have been observed in some risk-taking tasks (e.g., Charness & Gneezy, 2012). Males appear to engage in more risk-seeking behavior whereas females engage in more “risk averse” decisions (Borghans, Golsteyn, Heckman, & Meijers, 2009). Consistent with the literature, the current study suggests males engaged in more “risk-taking” decisions as measured by the higher occurrence of balloon explosions on the task compared to females. Similarly, females were observed to engage in more “stops” or decisions to end the trial before the balloon exploded suggesting more “risk averse” behavior and stopping the trial before necessary.

However, recent research suggests sex differences in risk-taking may be less clear than previously outlined (Sarin & Wieland, 2016; Nelson, 2015). A recent study conducted by Sarin and Wieland (2016) suggests females engage in more risk averse behavior when the task includes gambles with explicit probabilities making the subjective computation of expected outcome clearer. Females do not necessarily engage in risk averse behavior when a task consists of decisions under uncertain circumstances (i.e., decisions under uncertainty). The BART task is designed under uncertainty, thus, sex differences on the BART may provide supplemental evidence that females engage in more “risk averse” behavior as compared to males on tasks under uncertainty.

Stress and Trust

After acute stress (across stress group), participants invested a significantly lower amount of money in their counterpart as compared to participants in the no stress control group. Research exploring the effects of acute stress on decision making only recently began incorporating trust decisions, thus the literature is undeveloped. As hypothesized, differences in trust (i.e., money invested) were observed after acute stress. A recent study by FeldmanHall et al. (2015) examined trust based on a similar modification of the Trust Game (Berg et al., 1995) and noted exposure to acute stress (CPT) led to lower levels of trust compared to no stress control participants. The current study demonstrated similar findings when a social-evaluative stressor was introduced as well as the CPT. That said, contrary findings were reported in another study which observed increased trust in males following exposure to a psychosocial stressor (TSST; von Dawans et al., 2012). Notably, that study only included males and a different type of stressor whereas the present study and FeldmanHall et al. (2015) included both males and females (and utilized the CPT as an acute stressor). These investigations suggest exposure to acute stress may lead to lower levels of trust independent of stress-induction technique, though additional research is required as the limited amount of research exploring the relationship between stress and trust yields mixed findings.

In the present study, investment of monetary units to a counterpart during the Trust Game was operationalized as level of trust. Under the postulation that an individual's level of trust is related to risk, the amount of money invested to a counterpart may be regarded as level of "social" risk invested in the game. In general, investors tend to invest approximately half of the monetary endowment to their counterpart (Camerer, 2003). In the present study, participants in the control group invested significant more percentage of the “full” amount of money or largest level of “social” risk in the game. Individuals within the Trust Game invested less trust, potentially representing increased “social” risk averse decisions after acute stress (regardless of stress group) than individuals not exposed to an acute stressor. Under a “social” risk framework, Trust Game decisions made by stressed participants more closely resembled a trend toward trust behavior consistent with its Nash Equilibrium (i.e., as the investor should strategically never trust the trustee to yield the most expected utility from the interaction; Buskens, 2002).

In the Trust Game, after acute stress exposure individuals were less likely to invest trust in a counterpart. Controls, however, engaged in higher levels of trust. Stress has been linked to increased reward salience (Mather & Lighthall, 2012; Abercrombie, Keefe, Difrischia, & Zigmond, 1989). Additionally, acute stress has been associated with improved learning of positive outcomes in a decision whereas the inverse is indicated for learning of negative outcomes in a decision (Mather & Lighthall, 2012). Potentially, after exposure to acute stress participants may respond to the initial monetary endowment as an immediate reward and learn over time that the “sure” gain may outweigh the risk of investing money to their social counterpart. Moreover, stress appears to affect performance on decision making tasks and lead to more risk avoidance behavior (Mather at al., 2009). Stress may modulate investors computations of decision making strategies and leading to more “risk averse” behavior. Consequently, decisions with “social” risk may potentially negatively impact a person’s self-esteem and stress may modulate a person’s risk decisions in the context of a negative outcome (Rector & Roger, 1997).

From an economic framework, the utility function may be a factor influencing trust decisions based on the social nature of the interaction outside the context of stress (Lee, 2008). The utility function in economics states the decision maker considers the other individual's well-being in the social interaction and prefers fairness between each player (Lee, 2008). Therefore, the player in the Trust Game may be engaging in more "social" risk to attain mutual cooperation on the task rather than focusing on their own self-interest. Stress may be associated with reduced focus on fairness between players in the Trust Game, and may enhance a player's attention to their own personal advancement.

Stress and Risk-taking

Participants in the stress groups (CPT and SECPT) who exhibited elevations in cortisol reactivity and coded as "responders" demonstrated differences in BART performance. Participants with higher levels of cortisol reactivity in the SECPT group trended towards a higher number of "stops" on the BART task while participants in the CPT group with higher levels of cortisol reactivity a higher occurrence of explosions on the task. Participants with significant cortisol elevations in the social-evaluative acute stress exposure engaged in more "risk averse" decisions on the BART task than the physiological stressor. Contrary to this finding, participants in the SECPT group who did not demonstrate significant cortisol reactivity to the stress exposure engaged in a higher number of balloon pumps when compared to similar cortisol responders in the CPT group.

The social-evaluative component of stress in the SECPT group is a combination of systemic (physiological stress) and processive stress (psychological stress). The hybrid combination of different elements of stress may set apart stress effects on decision making within the SECPT group who responded with significant cortisol reactivity (Herman & Cullinan, 1997). Processive stressors may lead to higher order interpretation from specific brain structures (i.e., frontal lobe and limbic brain regions) whereas systemic stressors demand urgent response from the body's respiratory and cardiovascular systems to respond to the immediate threat. Participants in the SECPT group who demonstrated cortisol reactivity may be recruiting higher order interpretation of the situation leading to more "risk averse" decisions or safer decisions in the social exchange compared to participants who did not exhibit cortisol reactivity in the same group (Starke & Brand, 2008). For example, after processive stress induction (i.e., TSST), participants were less likely to engage in risk seeking behavior when outcomes are framed in losses (Pabst et al., 2013). Social-evaluative stress may lead to a similar alteration in decision making strategy in the Trust Game for participants with significant cortisol reactivity.

Social-evaluative Stressor Compared to Physiological Stressor on Trust Decisions

No significant differences in trust decisions were observed between the social-evaluative component (SECPT) and the physiological stressor (CPT). Yet, a trend toward differences were observed for females in the SECPT group between cortisol responders and nonresponders. Females with higher cortisol reactivity in the SECPT group had a higher percentage of shared decisions in the Trust Game. As emphasized previously, females who responded to stress with higher cortisol reactivity may be demonstrating an increase in "tend and befriend" behavior by choosing to engage in more "shared" decisions with their social counterpart (Taylor et al., 2007). As mentioned in a study conducted by von Dawans et al. (2012) few studies are targeting prosocial response to social stress and the current study is the first utilizing the SECPT and the CPT to differentiate between social-evaluative and physiological stress together.

Limitations and Future Directions

Due to the exploratory nature of the present study and the limited research on stress and prosocial behavior, limitations to the study will be outlined. The demographic characteristics of the sample consisted of predominantly White/Caucasian (74 percent), 18 to 22-year-old, college-educated adults from a private, Catholic, Jesuit University. Sample demographics may not be generalizable to other age-groups, race, education level, and religion. Trust observed in the study occurred within a staged environment and the social transaction occurred with a stranger, gender-opposite counterpart rather than within a more familiar environment (i.e., work) and familiar individuals (i.e., peers or family members). For example, localized trust is operationalized as an individual's computation of an estimate of general levels of trust dependent on specific situations and then makes use of that computation to inform future decisions (Glanville & Paxton, 2007). As the context of the social exchange influences trust and trust decisions, "trust" operationalized in the current study may not be fully generalizable to real-world social interactions and may only reflect trust in a novel environment.

There may be other individual differences which can influence an individual's trust decisions. For example, social support has been suggested to attenuate the physiological response associated with stress (Zimet, Dahlem, Zimet, and Farley, 1988). The current study did not incorporate a measure of social support to separate potential individual differences. Working memory and executive functioning have been linked to making decisions under risk (Starke & Brand, 2012). Acute stress exposure has also been associated with impairment in working memory (Schoofs et al., 2008) and individual differences in executive functioning are associated with differential effects of stress (Williams, Suchy, & Rau, 2009). The present study did not account for individual differences in executive functioning or working memory and future studies should account for this potential relationship in the context of trust decisions and risk-taking.

As previously outlined, the different types of stress induction consisted of the SECPT which an added social-evaluative component to the physiological stress of the cold pressor test. Physiological and social-evaluative stress may have differential effects on prosocial behavior (e.g., trust) and the present study is the first utilizing the SECPT and CPT. A psychosocial stressor without a physiological component, such as the classic Trier Social Stress Test (TSST), was not included in the structure of the study. Administration of the TSST has been linked to increased trust, trustworthiness, and sharing in males and some theorists postulate increased prosocial behavior in males reflect a “tend and befriend” coping style after exposure to psychosocial stress (von Dawans, et al., 2012). The current study demonstrated males were significantly more likely to invest greater amounts of money to their social counterpart than females, although when stress was included the pattern was not observed. The type of stress (physiological, social-evaluative with a physiological component, or psychosocial stress) may yield varying trust decisions. Consequently, females are noted to be more sensitive to social rejection and “physiologically reactive” to negative interpersonal events when compared to men, therefore, the administration of a solitary psychosocial stressor without a physiological stressor may alter trust decisions for females beyond the observations of the present study (van den Bos et al., 2009; Stroud, Salovey, & Epel, 2002).

There may be methodological limitations to the present study. Generalized trust or trust beliefs were hypothesized to predict experiential trust decisions, though in the current study this prediction was not supported. A potential confound could be the lack of reliability and validity of the generalized trust measure utilized (General Trust Scale; Yamagishi & Yamagishi, 1994). Additionally, risk attitudes were hypothesized to influence trust decisions on the trust game (Bohnet & Zeckhauser, 2003) though this relationship was not observed. The present study included a financial risk preferences survey-based task (i.e., Penny Game), but inclusion of a self-report measure that captures risk attitudes more directly such as the domain-specific risk-attitude scale may lead to further comprehension of the relationship between risk and trust (Weber, Blais, & Betz, 2002).

Existing studies on risk-taking and stress have yielded varying outcomes and research on trust and stress is even further limited. Potential differences observed between studies may be due to specific methodological differences in task administration (one shot transaction, repeated transactions), stress-induction technique (social stressor, social-evaluative stressor, or physiological stressor), and the timing of the task after induction (immediately following stress or after a delay). Additional research differentiating between these factors and documenting clear methodological guidelines consistent with the current study will aid in developing the relationship between stress and trust.

Clinical Implications

Prolonged stress threatens the body's ability to survive and leads to a greater propensity for individuals to develop psychological disorders and physical conditions (e.g. depression and heart disease). According to the stress-diathesis model, every individual is comprised of predisposing factors for any given psychological disorder (Monroe & Simons, 1991). The predisposing factors in each individual are referred to as diatheses. Any individual is exposed to varying amounts of stress in their environment. There appears to be a relationship between amount of stress and a person's diatheses and at a particular threshold this interaction may lead to the development of any given psychological disorder (Ingram & Luxton, 2005). For example, individuals who experience adverse life events (i.e. stressors) are more likely to suffer from depression (Bogdan & Pizzagalli, 2006). Social support has been suggested to attenuate the physiological response associated with stress (Cohen & Wills, 1985; Zimet, Dahlem, Zimet, and Farley, 1988). Since trust has been defined as a "social lubricant" within social systems and promotes social bonding, understanding motivational factors lending to trust behavior may lead to further protection from disease and provide insight in potential interventions for stress-related disorders (e.g. posttraumatic stress disorder and minority stress; Evans & Kruegar, 2011). Furthermore, presence of a chronic stressor leads to varying amounts of allostatic load or the body's ability to determine an adaptive response to stress (Danese & McEwan, 1998). The body may be unable to effectively cope with chronic stress which can lead to negative health outcomes (e.g., chronic pain and fatigue; Danese & McEwen, 2012). There is overwhelming value to extend research on the effects of acute and chronic stress on trust behavior.

Conclusion

Stress is inescapable in modern society and can negatively impact mental and physical health outcomes (DeLongis, Folkman, & Lazarus, 1988; Monroe & Simons, 1991; Broadhead et al., 1983). While there is preliminary research exploring the effects of acute stress on risk-taking, and potential sex differences in risk-taking, acute stress effects on prosocial behavior has been less examined. The current study attempted to explore trust decisions in the context of stress and reveal potential sex differences on response to stress. The main findings in the current study reveal stress leads to modulation of trust behavior in a modified adaptation of the Trust Game (Berg et al., 1995). Acute stress exposure led to lower levels of investment of trust to a social counterpart within a repeated transaction social exchange. Multiple factors may be associated with lower levels of trust after acute stress (e.g., self-esteem, risk aversion, enhanced reward salience).

Additionally, sex differences were observed in the current study. Males were more likely to invest money to a social counterpart in the Trust Game overall, consistent with previous Trust Game studies (Camerer, 2003). When accounting for cortisol reactivity a trend was noted for females following a social-evaluative stressor. Following a social-evaluative stressor female cortisol responders engaged in more trust. It is plausible that females who responded with significant cortisol reactivity may be responding to the Trust Game interaction from a “tend and befriend” approach and engaging in more trust to build social support in the context of stress.

While acute stress exposure has been associated with alterations in risk-taking and financial decision making (e.g., Porcelli & Delgado, 2009; Starcke et al., 2008, Pabst, 2013), the influence of stress on social decision making and trust behavior has not been well-researched (i.e., only three studies could be located; FeldmanHall, Raio, Kubota, Seiler, & Phelps, 2015; Smeets, Dziobek, & Wolf, 2009; von Dawans, Fischbacher, Kirschbaum, Fehr, & Heinrichs, 2012). Specifically, the topic of sex differences in stress and trust remains an important one and the role of individual cortisol reactivity may lend to differences in decision making behavior (e.g., risk-taking and trust decisions). Presently, experiments attending to these factors are difficult to synthesize without replication and future studies.

There are important implications to extending future research to investigate the relationship between stress, sex, and cortisol reactivity as outlined within the current study. Trust has been defined as a “social lubricant” within social systems and promotes social bonding, understanding motivational factors lending to trust behavior may lead to further protection from disease and provide insight in potential interventions (Evans & Kruegar, 2011). Furthermore, stress is pervasive and prevalent in every day interactions which accentuates the importance of understanding trust in the context of stress. Investigating individual differences in stress responsiveness and subsequent trust behavior will help guide modality of psychotherapy and lead to more knowledge about protective social coping skills in the presence of stress. The current study provides a foundational stepping stone in outlining the potential influencing factors in trust.

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Appendix A

Table A1. *Participant Demographic Characteristics in the Overall Sample*

Variable	N	Range	Mean	SD
Age	96	18-22	18.75	0.98

Variable	*n*	Percentage
1. Male	49	52.1
2. Female	47	47.9
Race/Ethnicity		
1. White/Caucasian	71	74
2. Asian	8	8.3
3. Hispanic	8	8.3
4. African American/Black	4	4.2
5. Multi-Racial	2	2.1
6. Arab	2	2.1
Handedness		
1. Right	88	91.7
2. Left	4	4.2
3. Ambidextrous	3	3.1

Note. Mean and standard deviation is presented for age; percentage is presented for all other variables

Appendix B

General Overview of Day 2 Procedures

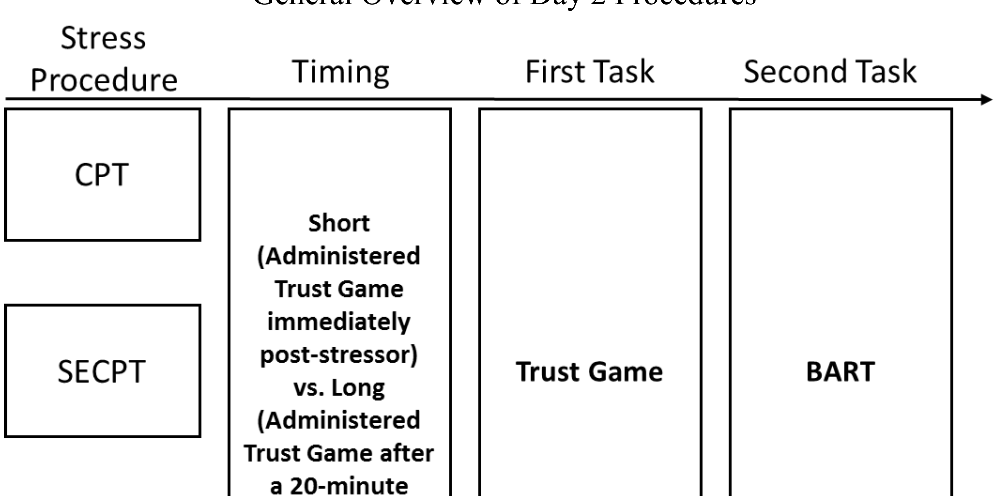


Figure B1. The experiment took place over two separate days. This figure represents the timeline of events during the second day. Individuals arrived and were assigned to either the Control, CPT, or SECPT condition. Then half of the participants (randomly assigned) were administered the Trust Game immediately after the corresponding stress procedure and the other half engaged in a 20-minute delay before the Trust Game. For all participants, the BART (risk-seeking behavioral task) was administered after the Trust Game.

Appendix C

Demonstration of the Modified Trust Game Paradigm (Berg et al., 1995)

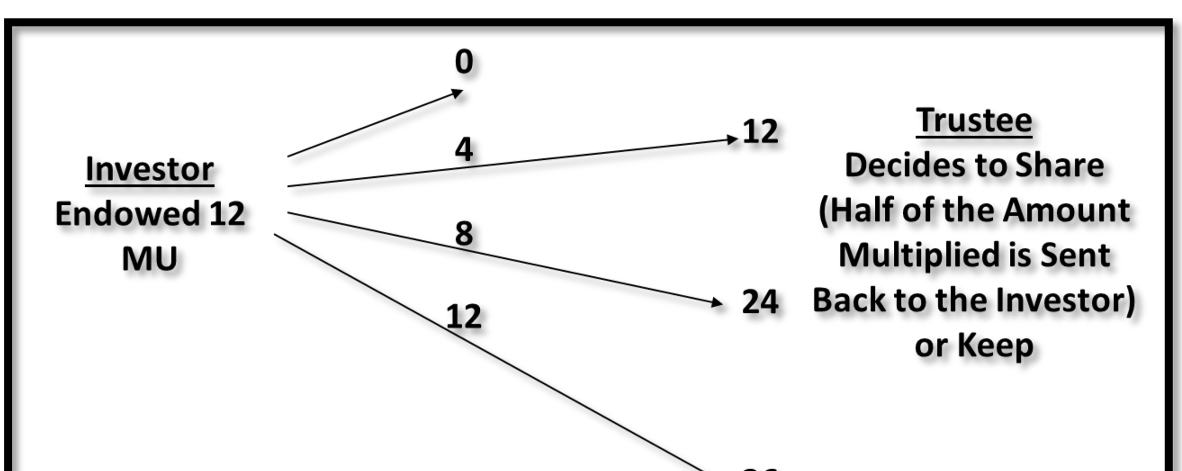


Figure C2. Participants were assigned the "investor" role first and then assigned the "trustee" role. When assigned the "investor" role, participants were endowed with an initial 12 Monetary Units (MU) and then instructed to pass either $0, $4, $8, or $12 to the "trustee". Any amount sent to the trustee was tripled in value. Then the trustee decided to either keep the money sent or return 50% of the money back to the investor. This Trust Game paradigm was modified from Berg, J., Dickhaut, J., & McCabe, K. (1995). Trust, reciprocity, and social history. *Games and Economic Behavior, 10*, 233-142. doi:10.1006/game.1995.1027

Appendix D

Mean Salivary Cortisol Levels by Stress Group and Time

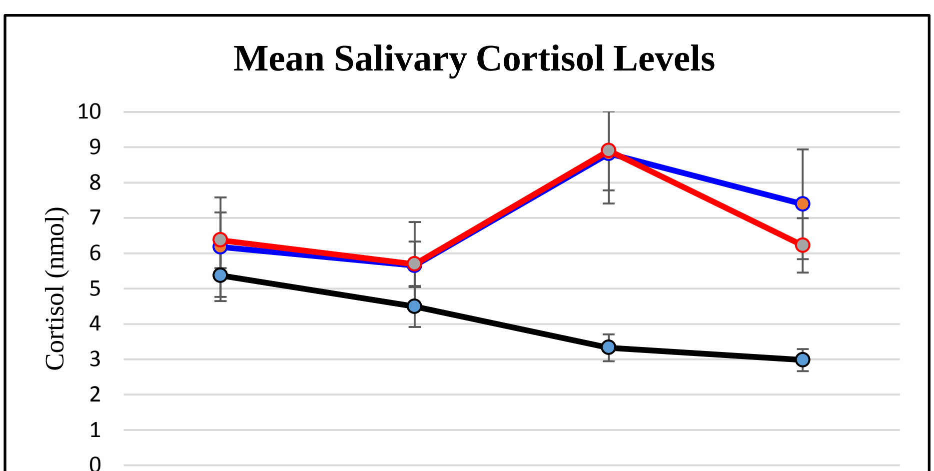


Figure D3. Cortisol raw values were log transformed before data analysis, however, the values presented in this figure represent untransformed cortisol values. Mean salivary cortisol levels (nmol) for each stress group are displayed across four times points throughout the study. Errors bars represent standard errors.

Appendix E

Cortisol Computations of Area Under the Curve with respect to Ground (AUCg) by Stress Group

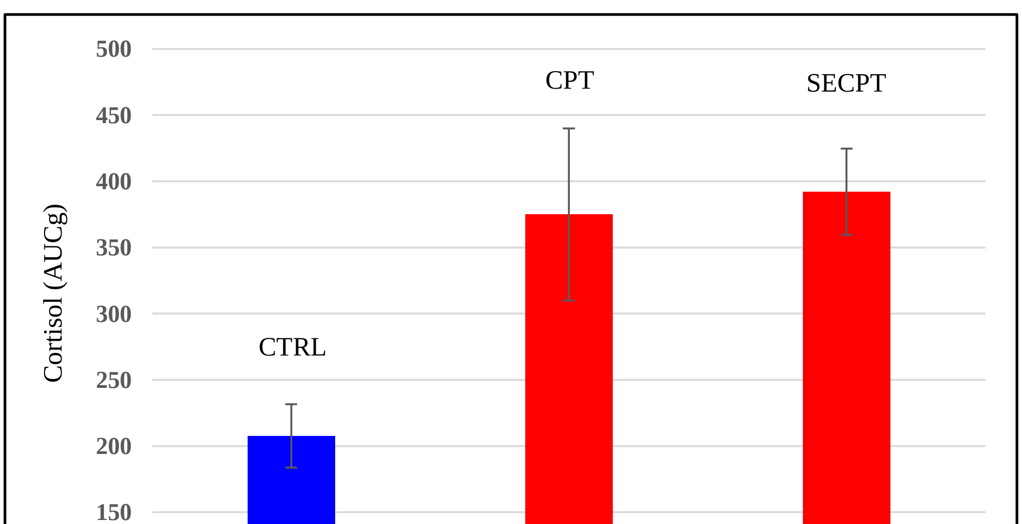
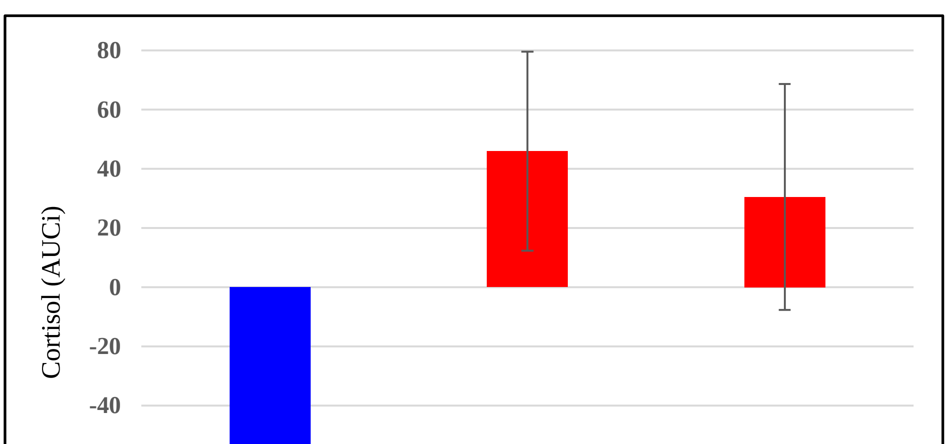


Figure E4. Utilizing a trapezoidal formula to compute the area of the curve with respect to ground (AUCg) was computed for each stress group taking into consideration individual variations in salivary cortisol sampling. Error bars represent standard errors.

Appendix F

Cortisol Computations of Area Under the Curve with respect to Increase (AUCi) by Stress Group



CTRL

CPT

SECPT

Figure F5. Utilizing a trapezoidal formula to compute the area of the curve with respect to increase (AUCi) was computed for each stress group taking into consideration individual variations in salivary cortisol sampling. Error bars represent standard errors.

Appendix G

Mean Skin Conductance Levels by Stress Group from Baseline to Stress

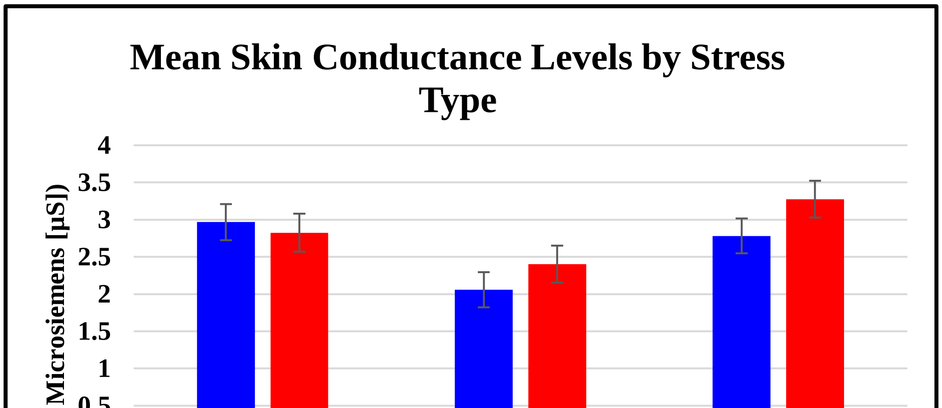


Figure G6. Skin conductance level raw values were square-root transformed before data analysis, however, the values presented in this figure represent untransformed skin conductance level values. Mean Skin Conductance Levels (microsiemens) for each stress group between a three-minute baseline recording compared to a three-minute stress recording are displayed. Error bars represent standard errors.

Appendix H

Table H1. *Means and standard deviations for all behavioral measures administered by stress group*

Behavioral Measures	**Control (*n* = 30)**	**CPT (*n* = 31)**	**SECPT (*n* = 34)**	***F*-test/ *p*-value**
NAART *(Raw Scores)*	36.77 (7.21)	34.16 (10.48)	36.55 (6.01)	*p* > .15
Penny Game *(Penny Transition)*	5.97 (1.30)	5.77 (1.36)	5.64 (1.22)	*p* > .15

Penny Game *(Dollar Transition)*	6.29 (1.44)	6.34 (1.38)	5.88 (1.65)	*p* > .15
Emotional Abuse	6.35 (2.29)	7.23 (3.64)	7.73 (3.05)	*p* > .15
Sexual Abuse	6.00 (3.87)	5.26 (1.00)	5.09 (0.52)	*p* > .15
Physical Abuse	5.29 (0.97)	5.94 (3.10)	5.97 (1.47)	*p* > .15
Generalized Trust Scale	21.32 (2.99)	22.65 (3.41)	20.94 (3.43)	*p* > .10

Note. NAART = North American Adult Reading Test; Childhood Trauma Questionnaire split by Emotional, Sexual, and Physical Abuse

Appendix I

Table I1. *Frequency of amount of money chosen to invest ($0, $4, $8, $12) across conditions*

Condition (N = 96)	**$0**	**$4**	**$8**	**$12**
Control (*n* = 31)	8	9	5	9
CPT (*n* = 32)	9	12	6	5
SECPT (*n* = 33)	11	16	3	3

Note. Frequency is determined by mode of investment choice.

Appendix J

Table J1. *Correlations between Risk-seeking Variables (via BART and Penny Game), Stress, Sex, and Average Amount of Money*

Variables of Interest	**$**	**Sex**	**CPT Stress**	**SECPT Stress**	**Adjusted Balloon Pumps**	**Explosions**
Average Amount of Money ($)	-					
Sex	-.24**	-				
CPT Stress	-.128	.015	-			
SECPT Stress	.095	.037	-.512	-		
Adjusted Balloon Pumps	.015	-.067	-.020	.112	-	
Explosions	-.007	-.18*	.049	.003	.875**	-
Stops	.000	.179*	-.047	-.001	-.874**	-1.00*
Dollars	-.065	-.005	-.008	-.087	-.034	.061
Hypothetical	.099	.016	.084	-.140	.055	.081

Note. $ = Average amount of money invested. *Denotes significance level of $p < .05$. ** Denotes significance level of $p < .01$.

Appendix K

Table K1: *Summary of Regression Analysis for Variables predicting money invested in the Trust Game*

	Model 1			Model 2			Model 3		
Variable	*B*	*SE B*	β	*B*	*SE B*	β	*B*	*SE B*	β
Sex	-1.141	.746	-.242*	-1.089	.469	-.231*	-1.213	.483	-.257*
CPT				-1.142	.578	-.228	-1.201	.580	-.240*
SECPT				-1.011	.574	-.204	-1.061	.586	-.214
Pumps							.027	.037	.164
Exp.							-.119	.139	-.188
Dollars							-.357	.230	-.194
Hypo.							.337	.196	.213
R^2			.058			.104			.150

Note. Pumps is adjusted balloon pumps on the BART task. Dollars represent estimated risk aversion based on pennies and Hypothetical represents estimated risk aversion based on hypothetical incentive. Exp. = Explosions. Hypo. = Hypothetical. *Denotes significance level of $p < .05$.

Appendix L

Table L1. *Correlations between General Trust Scale, Self-reported Childhood Trauma, Stress, and Sex on Average Amount of Money*

Variables of Interest	**$**	**Sex**	**CPT Stress**	**SECPT Stress**	**General Trust**	**Physical Abuse**
Average Amount of Money ($)	-					
Sex	-.24**	-				
CPT Stress	-.128	.015	-			
SECPT Stress	-.095	.037	-.512**	-		
General Trust	-.053	.015	.215*	-.150	-	
Physical Abuse	.128	.115	.068	.083	-.254**	-
Sexual Abuse	-.084	.198*	-.056	-.111	.041	.018
Emotional Abuse	.023	.143	.025	.146	-.371**	.611*

Note. $ = Average amount of money invested. *Denotes significance level of $p < .05$. ** Denotes significance level of $p < .01$.

Appendix M

Table M1: *Summary of Regression Analysis for Variables predicting money invested in the Trust Game*

	Model 1			**Mode l 2**			**Mode l 3**		
VOI	*B*	*SE B*	β	*B*	*SE B*	β	*B*	*SE B*	β
Sex	-1.141	.475	-.242*	-1.089	.469	-.231*	-1.095	.484	-.232*
CPT				-1.142	.578	-.228	-1.369	.603	-.274*
SECPT				-1.011	.574	-.204	-1.226	.591	-.247*
Trust Scale							.014	.078	.019
CTQ Physical							.255	.146	.220
Sexual							-.089	.106	-.087
Emotion							-.026	.103	-.034
R^2			.058			.104			.148

Note. VOI = Variables of Interest. CTQ is Childhood Trauma Questionnaire. *Denotes significance level of $p < .05$