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Nataly Aguirre
Marquette University

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Nataly Aguirre

McNair Mentor: Anthony J. Porcelli

Marquette University

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Abstract

Considerable research suggests acute stress influences decision-making. There has, however, been a lack of research examining the possibility that separable components of the stress response may influence decision-making differently: the sympatho-adrenomedullary (SAM) and hypothalamic-pituitary-adrenal (HPA) axes. In the current pilot study, participants engaged in a gambling task where they made choices between decisions of varied probability and magnitude for potential gains of money after being exposed to acute stress (via a variant of the cold pressor task). Further, the timing of the stressor was varied to allow examination of SAM and HPA effects separately. Cortisol and skin conductance were measured. Given the task was in the gain frame only, in support of past research on framing results indicated that individuals made significantly more conservative or risk-averse choices in the gambling. Further, risk-taking scaled to the expected value of a decision. Males made more risk-seeking choices as compared to females. Divergent from the original hypothesis, however, stress of neither type had an effect on individuals' risk-taking overall, nor as a function of probability or magnitude. This suggests that decisions framed as potential gains may not be influenced by stress as readily as decisions framed as potential losses, and that stress may not alter how people perceive the probability or magnitude associated with a decision. Methodological flaws highlighted by the pilot study which may have contributed to the lack of a stress effect will also be discussed.

Stress, Risk, and Reward in Financial Decision-Making: The Roles of Probability and Magnitude

Financial decisions are made daily and there exist many factors that may influence the way they are delineated. Stress is an important factor because it is also encountered daily and it has interesting effects within the body. While information exists about the two separately but a greater understanding of both will develop from studying how they interplay with one another. In this pilot study, the effects of different stress levels on financial decisions will be examined.

Physiological Correlates of Stress

Any stressful situation has the ability to cause physiological and psychological changes within the body. Stress in general prepares the body for excitatory physiological changes away from homeostasis (baseline). There are two pathways involved in the stress response and they are the hypothalamic-pituitary-adrenal axis (HPA) and the sympathoadreno-medullary axis (SAM). The stress response activates both the HPA axis and SAM system, but the duration of the stress response varies. The SAM returns to baseline faster than does the HPA (Ulrich-Lai & Herman, 2009). When the HPA is activated, however, cortisol is released more slowly into the bloodstream – lingering for approximately 30 - 60 minutes.

Activity of the HPA is initiated by the production of corticotrophin-releasing factor (CRF) hormone in the hypothalamus. This hormone binds to the anterior pituitary, releasing adrenocorticotropic hormone (ACTH). The biological function of ATCH is to maintain the body in a state of homeostasis and through the secretion of gluconeogenesis; ACTH is able to supply an abundance of energy ready to be used to resolve threat. These and other enzymatic reactions are important in a stressful situation because they help the body attempt to resolve the stressor and prime the body to response to the source of the threat (Tsigos & Chrousos, 2002). ACTH then travels to the adrenal gland and stimulates the production of adrenal hormones (e.g., corticosteroids). The primary human corticosteroid, cortisol, is released from the adrenal cortex and enables the body to maintain steady supplies of blood sugar. Adequate and steady blood sugar levels help people to cope with prolonged stress, and the body to return to baseline (Matteri, Carroll, & Dyer, 2000). Cortisol has been found to be associated with euphoria and reward, which is related to sensation seeking behavior (Van den Bos, Harteveld, & Stoop, 2009). With prolonged exposure to stress, however, increased cortisol levels can be detrimental. This is not limited to physiological stressors, as a stressor can also be psychological in nature. For example, emotions can have the same effects on the body as an environmental stressor. Damaging effects of corticoids include: high blood pressure, peptic ulcers, heart problems, and nervous disturbances (Selye, 1993). Thus, it is plausible that stress-related increases in cortisol may also influence decision-making.

As mentioned earlier, however, HPA activation and subsequent cortisol release is only one part of the stress response. The autonomic nervous system (ANS) regulates physiological processes within the body during rest or excitatory periods. It can be divided into the sympathetic nervous system (SNS) and the parasympathetic nervous system (PNS). Whereas the SNS primes the body to response to a stressful stimulus via a host of excitatory physiological changes, the PNS calms those functions and returns the body to baseline (Jacobs, 2001). The SNS is a component of the aforementioned SAM, triggered under exposure to acute stress, and it is associated with release of norepinephrine and epinephrine into the bloodstream. These two hormones have an important role in the flight-or-flight response or what is now known as the stress response. The flight-or-fight response prepares an organism to fight off or to run away from stressful stimulus. Norepinephrine and epinephrine help initiate the process under the SAM system by increasing SNS functions which helps mobilize any given organism to take action and thus resolve stressful stimuli (Jacobs, 2001). When a stressful stimulus is no longer present, the PNS helps the body then return to baseline by reversing the excitatory changes associated with SAM activation.

Economic Theories of Decision-making under Risk

People must often make choices under stressful conditions, yet the process of decision-making itself is highly complex. Exactly how and why certain choices are made over others has been studied extensively in recent years. The expected utility (EU) hypothesis is a theory that originated in the field of economics to help explain why people make certain decisions under risk (Kahneman & Tversky, 1984). The theory points out decisions are made through the computation and comparison of *expected values*, which can be represented mathematically as the value of the possible outcome multiplied by the probability of that outcome coming to pass. According to this theory, individuals should always choose the option associated with a higher expected value (i.e., to maximize expected value). It has become evident that the EU hypothesis does, however, not account for *other* factors involved in decision-making.

Many other important variables are actually psychological in nature (i.e., in reality, people make 'irrational' choices that do not maximize expected value all the time). Kahneman and Tversky (1979) developed prospect theory (PT) in order to address these types of failure in EU theory. Rather than focusing on theory, they took a behavioral approach to explore decision-making by conducting a range of studies with actual participants. The way choices are framed is very important because it can manipulate a persons' perception of an upcoming decision. The Asian Disease example, created by Kahneman and Tversy (1983), has been used extensively to demonstrate the impact of framing on decision-making. However, participants had to choose one of the two alternative choices to implement as a solution for an outbreak of a hypothetical Asian flu that would kill 600 people. The Asian Disease Problems were framed as follows:

> Problem 1 (N = 152): Imagine that the U.S. is preparing for the outbreak of an unusual Asian disease, which is expected to kill 600 people. Two different alternative programs to combat the disease have been proposed. Assume that the exact scientific estimates of the consequences of the programs are as follows:
>
> If Program A is adopted, 200 people will be saved. (72%)
> If Program B is adopted, there is a one-third probability that 600 people will be saved and a two-thirds probability that no people will be saved. (28%)
>
> Problem 2 (N = 155):
> If Program C is adopted, 400 people will be die. (22%)
> If Program D is adopted, there is a one-third probability that nobody will die and a two-thirds probability that 600 people will die. (78%)

Note the Asian Disease example posed two choices framed differently (i.e., saved vs. die), yet the choices were equivalent in terms of expected value. For example, in Program A the choice of 200 people * 1 (i.e., 100%) = 200 is mathematically equivalent to choice of Program B 600 * .33 (i.e., 33% or 1/3) = 200 in terms of people saved. Therefore, absent the framing of the problem participants should have chosen equally between each option in both problems.

The percentage of choices participants made between the two Programs is shown in parentheses. In the first part of the experiment Program A and B were framed in saving lives or framed in the “gain domain”. Participants were more risk-averse in that they more often chose program A, or the sure gain of saving lives, over B. In the second part of the experiment Program C and D were framed in lives lost of framed or in the “loss domain”. Participants were more risk-seeking in that they chose program D over C. Thus, in the gain domain participants were risk-averse but in the loss domain they were more in risk-seeking. This reversal of preference with respect to risk is known as the “reflection effect”. Framing has an important role in the way a question is phrased because two choices can have the same outcome, yet one may appear more attractive solely on the way it is presented. Different conclusions can be drawn from each outcome depending on the readers' interpretation and understanding (Kahneman, & Tversky, 1984).

The reflection effect is predicted by PT and represents a decision-making irregularity that cannot be explained under EU theory. Essentially, the reflection effect represents the fact that on average risk-averse behavior is observed when there is a larger probability of occurrence presented in the gain domain than when there is a smaller probability of occurrence in the loss domain. This pattern is reversed, however, when losses have moderate probabilities and gains have small probabilities – associated with risk-taking. Contrary to the predictions of EU theory, risk-taking tends to be exaggerated when decisions are framed in the loss domain, but risk-aversion tends to be exaggerated when decisions are framed in the gain domain. (Kahneman & Tversky, 1979). The current study takes advantage of this prevalent pattern of behavior by attempting to examine if stress influences this type of risk taking behavior. Another prediction that postulates how people make decision in PT is the certainty effect.

The certainty effect was also proposed by Kahneman and Tversky (1986) and stated that individuals have a preference for sure or certain decisions when decisions are framed as potential gain. This suggests that individuals are more risk-averse in gain domain situations when the other option involves risk. In the pilot study at hand, individuals will be given the option of either a sure gain or a risky choice without certainty of gain. A central goal will be to examine whether or not acute stress modulates participants choices in terms of risk-taking.

Probability and Magnitude in Decision-making under Risk

Two important factors that are evaluated when making decisions are probability and magnitude, and they are perceived differently. Probability can be defined as the possibility of an outcome coming to pass while magnitude refers to the extent of that outcome. Kahneman and Tversky (1979) observed that people overweight small probabilities when making a financial decision under risk (i.e., perceive them as being more likely to occur than they are). This means they are more likely to choose a risk for a possible gain at a low probability, but are more risk-averse at higher probabilities. It follows, then, that the probability of a decision outcome occurring directly influences the decision made. Thus, it is possible that stress might influence decision-making by altering the manner in which people perceive the probability associated with a decision.

The effects of probability and magnitude on decision-making were examined in another study using the Iowa Gambling Task (IGT). In a study conducted by Van den Boss, Houx, and Spruijit (1995), participants were placed into stress or control condition after a relaxation phase of 15 minutes where they listened to music and read magazines. The stress condition consisted of the Trier Social Stress Test (TSST) while the control group did not receive any stress manipulation. The TSST is a well-researched psychological stressor that involves an individual preparing and giving a public speech and completing a difficult mental arithmetic task (Kirschbaum, Pirke, & Hellhammer, 1993). This phase lasted for about 15 minutes and was followed by both conditions completing the IGT. In the IGT, participants were presented with four decks of cards. Two of the decks lead to an overall favorable outcome of winning 100 dollars as compared to the other two which lead to a unfavorable outcome of winning only 50 dollars. Over time, participants had to learn which decks of card lead to the most gain.

Participants were acutely stressed and cortisol levels were recorded (using salvia sample from salivettes) before the experiment, after TSST/No TSST, and after the IGT. Their data suggest that there was a significant difference between cortisol levels after TSST and risk-taking behavior in IGT among gender. Higher levels of cortisol were recoded after TSST and it was observed that males increased in risk-taking in the IGT. However, the inverse was observed for female. Stress was shown not only to affect decision-making in this study, but this also varied by sex of the participant.

How Might Stress Influence Decision-making?

Decision-making can be challenging in and of itself, but in the real world decisions are often made under the influence of other factors (such as stress). Stress may affect cognitive processes involved in decision-making such as financial risk-taking. In a study conducted by Porcelli and Delgado (2009), it was observed that acute stress modulated decision-making as measured by risk-taking. An increase in the reflection effect was observed when participants were exposed to acute stress via the cold pressor task (involving immersion of participants hand in ice-cold water for a period of time). Essentially, participants made more risk-seeking choices in loss domains and risk-aversive choices in gain domains. These findings concur with dual processing approaches, which state that decisions made under stress are impaired and thus choices are made intuitively rather than based on logic. Thus, if the reflection effect is a bias or heuristic (i.e., an automatic process) stress may shift a decision-maker’s focus from logic and deliberative decision-making towards the habitual and automatic. The implications of these findings indicate that there might be a heavy dependence on lower level intuitive processes, which can be subject to increased error.

According to additional research, stress-related sex differences exist in risk-taking. In one study, a stress group or non-stress control group were administered a computerized balloon analogue risk task (BART). The BART measured the risk-taking of participants by counting the number of pumps (i.e., button presses) to blow up a virtual ‘balloon’ a participant was willing to risk before stopping. Each pump was associated with cash winnings for the participant, but they could choose to stop and cash out at any time. The balloon presented on every trial was set to explode at an unknown amount of pumps – at which point participants would lose all of their winnings. Thus, each time the balloon is expanded the participant increased their risk of losing the cash winnings. It was observed that acute stress increased risk-seeking in men but was associated with increased risk-avoidance in women. (Lighthall, Mather, & Gorlick, 2009).

Other research indicates that the effects of stress on decision-making may be mediated by cortisol levels. Though cortisol is produced by both sexes, research suggests that it may influence decision-making differently as a function of sex. In a recent study, participants exhibited elevated cortisol levels after being acutely stressed using the Trier Social Stress Test (TSST). The TSST is a well-researched psychosocial stressor that involves an individual preparing and giving a public speech and completing a difficult mental arithmetic task. In this study, the TSST was used to examine the effects of stress on risk-seeking and cortisol activity when playing the IGT (described earlier). Performance was defined as choosing advantageous or disadvantageous decks of cards strategically to win more money. It was observed that an increase in cortisol levels reduced males’ ability to perform advantageously on the IGT. Women, on the other hand, increased in their ability to perform well when cortisol levels were slightly increased, but their performance decreased if cortisol levels were elevated too high (Van den Bos, Harteveld, & Stoop, 2009). These results indicate that elevated cortisol levels impair financial decision-making in men, but when slightly elevated cortisol levels may actually help women make sound financial decisions.

The current pilot study attempts to examine the role of stress on risk-taking in decision-making as a function of the probability and magnitude of the possible reward associated with each decision. All financial decisions are framed in the gain domain only. Probability was parametrically varied while holding magnitude constant in one within-subjects condition. In the second within-subjects condition, probability was held constant while gain magnitude was varied. Further, acute stress was administered at different times in order to maximize SAM or HPA activation in two different within-subjects conditions. The question at hand was to explore the influence acute stress has on choice behavior based on the framing of probabilities or the framing of the magnitude of the reward. The first hypothesis was that people would be more risk-averse and take the sure gain due to the certainty effect (Kahneman & Tversky, 2000). The second hypothesis was that stress will alter risk-taking differently when probability or magnitude is varied. The third hypothesis was that the SAM stress condition will exhibit different patterns of cortisol release as compared to the HPA stress condition. Finally, the last hypothesis was that men would be more risk-seeking when exposed to acute stress as compared to women (Lighthall et al. 2009).

Methods

Participants

The participants of this study consisted of 67 undergraduate college students from Rutgers University within 18 to 22 years of age. In this study, there were 30 males and 37 females surveyed. All procedures conformed to Rutgers University Institutional Review Board guidelines.

Procedure

There were three between-subjects conditions: no stress (n = 27), HPA stress (n =20), and SAM stress (n = 20). There were two within-subjects conditions: decisions framed in magnitude of reward (amount of money) and decisions framed in different probabilities of receiving money. There were fifty magnitude condition and fifty probability condition trials (described below) randomly counterbalanced between block 1 or block 2. Both within-subject condition tasks were created using E-Prime 2.0 software.

Decision-Making Tasks

Risky choices in the magnitude block involved the percentage or 'chance' of winning being held at 50% throughout all trials. The amount of money participants stood to win increased in magnitude by the dollar amounts of 20, 40, 50, 60, and 80. The other option was always a 100% chance of winning 25 dollars (a sure gain). The probability block consisted of varying probabilities of always winning $50. The different possible probabilities were 20, 40, 50, 60, or 80 percent. All possible combinations of both the probability block and magnitude block were computed along with expected value (see Table 1). Notably, the expected value of the center choice in each condition (i.e., 50% of $50 in both conditions) mathematically equivalent to the sure gain option (i.e., 100% of $25).

Participants were instructed to choose one of two pie charts that appeared on the screen. All pictures were presented as pie charts filled with varying amounts of red and green space. The green represented the chance (i.e., probability) that participants would win the dollar amount indicated within the green space if chosen. At the beginning of each trial the participant was presented with two such choices for four seconds. Then a fixation was shown for two seconds. The fixation slide consisted of empty two boxes on the screen separated by a plus sign in the middle. The participant was then presented with the previous two choices and at this time has two seconds to make a decision. Another fixation was shown for approximately ten to twelve seconds and then the next trial began (see Figure 1). The general layout of each trial remained the same for the magnitude and probability conditions and the sides on which the different options were presented were counterbalanced. Participants were not offered feedback on any of their decisions, but were told that at the end of the experiment random trials would be selected, played out through a die roll, and they would be able to keep the resulting winnings if any.

Stress Induction

It has been observed that a state of acute stress can be induced when exposed to extremely cold temperatures; several studies have explored this topic in-depth (Ishizuka & Hillier, 2007; Washington, Gibson, & Helme, 2000). In this study, acute stress was delivered specifically via a 'cold pressor arm wrap task' (CPAW). The CPAW is composed of freezer gelpacs cooled in a freezer to approximately four degrees Celsius. This was a similar temperature to those used in traditional cold pressor tasks where participants immerse their hand in a bowl of ice-cold water (Lovallo, 1975). The arm wrap was placed on the forearm of participants for three minutes or for as long as participants could handle. Participants in the no stress condition did not undergo the CPAW.

Stress Conditions

The between-subject conditions (no stress, SAM stress, and HPA stress) were organized differently to allow investigation of the possible differential effects of the HPA and SAM components of the stress response as they relate to decision-making. The SAM condition was as follows: inducing acute stress (3 minutes) via the cold pressor arm wrap (CPAW) task, Block 1 (16 minutes), stressed again (3 minutes), and finally finished with Block 2 (16 minutes). Thus, acute stress was administered shortly before each task in an attempt to evoke SAM activation prior to HPA related increases in cortisol. The HPA condition was as follows: inducing acute stress (3 minutes) via the CPAW task, the Sternberg Delayed Recognition task that was used as a filler task (15 minutes), Block 1 (16 minutes), and Block 2 (16 minutes). (See Figure 2). By administering the CPAW approximately 15-20 minutes before the financial tasks, it was thought that HPA activation would evoke a robust cortisol response, but SAM activation would have returned to baseline.

Filler Task

The Sternberg Delayed Recognition task was administered in the HPA stress condition as a filler task (Kirschbaum, C., Pirke, K., & Hellhammer, D., 1993). This task occupied participants while their cortisol levels reached peak levels after stress exposure. The Sternberg Delayed Recognition task consisted of a computerized presentation of a string of letters. Three capitalized letters were presented for four seconds. Then there was a fixation for four and a half seconds to act as a delay. After the delay, a probe lowercase letter was presented to the participant for two seconds and the participant had to decide whether or not the probe letter was shown in the first string of letters. The participant pressed the “P” key if the probe letter was not seen in the first string of letters and the participant pressed the “O” key if the probe letter was included in the first string of letters. Another fixation was presented at the end of the trial to designate the end and initiate the next trial.

Physiological Measures

Skin conductance levels, was measured throughout the experiment to explore the physiological differences between stress conditions. Skin conductance was not measured in the no-stress condition. A BIOPAC MP150 module was used to acquire the data, and

AcqKnowledge software to it. Skin conductance levels were computed as the average in microseisms over the totality of the financial decision-making task (as in, Porcelli & Delgado, 2009). Salimetrics oral swabs were also used to acquire salivary measurements of cortisol throughout the experiment: at baseline, after Block 1 and at the end of the experiment or after Block 2. Cortisol was measured at three time points: baseline, after stress, and at the end of the experiment.

Self-report Measures

The participants' personalities and the way participants regulate emotions were examined through several surveys. The Emotion Regulation Questionnaire (ERQ) assessed participants' tendency to regulate their emotions by either using Cognitive Reappraisal or by suppressing emotions (Gross & John, 2003). Participants answered the 10 questions on a 7-point Likert-type scale ranging from 1 (strongly disagree) to 7 (strongly agree). The Behavioral Inhibition System and Behavioral Activation System (BIS BAS) was a 20-question survey on a 4 point Likert-type scale ranging from 1 (strongly disagree) to 4 (strongly agree). BIS has been linked to avoidance and withdrawal behavior and anxiety, while BAS is connected to sensitivity of reward. Post questionnaires were administered after all portions of the study were completed (Carver & White, 1994). The post-experimental questionnaire was used as a manipulation check to ensure participants experienced stress during the study. Each participant was asked if they felt stressed by the arm wrap or not.

Results

Physiological Measures

Cortisol.

A 3 (Sample: Baseline, Post Stress 1, and Post Stress 2) x 2 (Stress Condition: SAM, and HPA) repeated-measures ANOVA was conducted to examine the effect of the timing of the two stress conditions on salivary cortisol levels. One outlier was removed from the dataset before analysis. Cortisol did not significantly change from baseline after stress exposure in either post-stress sample, $F(2, 74) = 2.05$, $p < .15$. A trend, however, was observed between the two different stress conditions (i.e., SAM vs. HPA), $F(1, 37) = 2.95$, $p = .094$. Cortisol levels were higher in the SAM condition than in the HPA condition (See Figure 3). Area under the curve with respect to ground (ACUg; Pruessner et al., 2002) was calculated on cortisol data using the trapezoidal method to examine the changes in cortisol over the three different sample time points. An independent t-test was used to examine the difference in AUCg between the two stress conditions (SAM and HPA). AUCg results revealed a trend towards a difference between the SAM ($M = 0.43$, $SD = 0.38$) and HPA ($M = 0.27$, $SD = 0.12$) conditions, $t(21.46) = 1.71$, $p = .10$.

Skin Conductance.

An independent t-test was conducted to compare skin conductance levels between the SAM and HPA stress conditions. Skin conductance levels (SCL; in microsiemens) were computed as the average across both 2 minute of CPAW exposure in the SAM condition to form an overall mean SCL for the SAM condition, which was then compared to the mean SCL of the single CPAW exposure in the HPA condition. SAM SCL ($M = 16.29$, $SD = 7.22$) was not significantly different from HPA SCL ($M = 14.03$, $SD = 7.18$), $t(43) = 1.05$, $p > .15$.

Risk-taking

A 3 (Stress Conditions: No Stress, SAM, and HPA) x 2 (Decision Task: Magnitude and Probability) x 5 (Expected Value: 10, 20, 25, 30, and 40) repeated-measures ANOVA was performed to examine the influence of stress condition, probability and magnitude manipulation, and expected value on risk-taking data. A main effect of expected value was observed, $F(2.62, 167.91) = 136.52$, $p < .05$, indicating that the higher the expected value of a decision (e.g., expected value 40: $M = 0.77$, $SD = 0.29$) the more likely participants were to take the 'risky' over the certain choice (e.g., expected value 10: $M = 0.03$, $SD = 0.07$) . A two-way interaction between expected value and decision task was also observed, $F(3.11, 199.20) = 5.22$, $p < .05$. Participants took more risks in the probability decision task compared to the magnitude decision task specifically when the expected value was at its highest level, $t(66) = -2.99$, $p < .05$.

A median-split was performed on AUCg data to classify participants in the SAM and HPA conditions who were high or low responders to the stressor in terms of cortisol. A 2 (AUCg: Low Responders and High Responders) x 2 (Stress Conditions: SAM and HPA) x 2 (Decision Task: Magnitude and Probability) x 5 (Expected Value: 10, 20, 25, 30, and 40) repeated-measures ANOVA was calculated to examine whether or not cortisol response was associated with variations in risk-taking. A trend toward a three-way interaction between AUCg, stress condition, and expected value was observed, $F(2.62, 91.83) = 2.20$, $p = .10$. Post-hoc t-tests suggest that low cortisol responders to stress (as measured by AUCg) trended towards being more likely to take 'risks' in the SAM over HPA condition when expected value (i.e., 25) was equivalent across the probability and magnitude conditions, $t(21.46) = 1.71$, $p = .10$ (Greenhouse-Geisser corrected; See Figure 4).

Finally, participants were sorted into high or low responders via a median-split using the aforementioned SCL during stress exposure. High versus low skin conductance response had no significant effect on risk-taking, $F(1,31) = 0.18$, $p > .15$.

Exploratory Analysis: Sex Differences

A 3 (Sample: Baseline, Post Stress 1, and Post Stress 2) x 2 (Stress Condition: SAM and HPA) repeated-measures ANOVA was conducted to determine the relationship between sex and salivary cortisol levels as a function of stress condition. There was no main effect of sex on salivary cortisol, $F(1, 35) = 0.15$, $p > .15$. Further, no significant interaction of sex and any other factor (sample and stress condition) was observed.

Sex was added as a between-subjects variable to the 3 (Stress Conditions: No stress, SAM, and HPA) x 2 (Decision Task: Magnitude and Probability) x 5 (Expected Value: 10, 20, 25, 30, and 40) repeated-measures ANOVA to examine risk-taking data for possible sex differences with respect to task variables. A main effect of sex was observed, $F(1, 61) = 4.62$, $p < .05$. The results indicate that males ($M = 0.84$, $SD = 0.31$) took more risks than did females ($M = 0.63$, $SD = 0.39$).

Discussion

In the current study, participants engaged in a financial decision-making task after being exposed to acute stress via a cold pressor arm wrap (CPAW). In one task condition the probability of participants winning money was varied while the magnitude of that reward was held constant, while the reverse was true in a second condition. Further, CPAW was administered at different time points in an attempt to maximize SAM activation (two CPAW exposures immediately before each block of the task) versus HPA activation (one CPAW exposure 15 minutes before the first task). It was hypothesized that: (1) participants would be risk-averse in their decisions (as the task was in the gain domain only), (2) acute stress would be associated with different patterns of risk-taking in the probability and magnitude conditions, (3) the SAM and HPA stress conditions would differ in terms of cortisol levels, and (4) men would be more risk-seeking than women under stress. Results confirmed the first hypothesis, though not the second. Additionally the SAM and HPA stress conditions were associated with different levels of cortisol, confirming hypothesis three, though the direction of that result was unexpected (HPA was expected to be higher than SAM, not the reverse). Finally partially confirming hypothesis four, men did take more risks than women – but acute stress exposure did not play a role.

Cortisol and Stress Conditions

A trend was observed between the stress conditions (i.e., SAM and HPA) and cortisol levels across time (Baseline, Post Stress 1, and Post Stress 2). However, the trend was not in the expected direction as the SAM condition reported higher cortisol levels than did the HPA stress condition. (See Figure 3). The repetition of the stress-inducing task may have led to higher cortisol levels in the SAM condition. Some studies have investigated the application of multiple stressors on the physiological correlates of stress (Liu et. al., 2007; Sabban & Serova 2007). Converging with those studies, multiple stressors could be attributed to an accumulation of cortisol in the body in this pilot study. Interestingly, one long-standing study explored the physiological response of multiple stressors (Tiechner, 1960) and found a connection to the emotional anticipation of a stressor and an increase in physiological response. It is plausible that in the SAM condition participants understood the preparation of the second stress exposure and subsequent anticipation could have increased overall cortisol production, though no data was acquired that could confirm this here.

In the HPA condition, similar to past studies on stress and cortisol (Lighthall et. al., 2010) experimenters postpone experimental tasks for approximately 30 minutes after stress exposure to allow cortisol to peak. In the current pilot study, however, a filler task was given directly after stress exposure instead of a waiting period, which could have interfered with the cortisol response. Further, cognitive activity and distraction have been found to modify the physiological stress response in the body (Petrovic, Petersson, Ghatan, Stone-Elander, & Ingvar, 2000). The delayed recognition memory task could have distracted participants or preoccupied participant attention, thus impeding the desired stress response.

Risk Taking Behavior

According to Expected Utility Theory, decision-makers maximize profit by choosing to optimize expected value (Bleichrodt, Pinto, & Wakker, 2001). Kahneman and Tversky (1979) have demonstrated that other factors have to be taken into account because they violate expected utility conventions, such as the influence of framing on risk taking behavior. The results of the current study emphasize both of the importance of expected value in making decisions and how other factors can influence those decisions. Participants took significantly more risks based on the expected value of financial decision options. However, different levels of risk-taking were observed dependent on whether probability or magnitude of the financial decisions was manipulated.

Results suggest that participants were more willing to choose a ‘risky’ option when the expected value was larger through the manipulation of probability, whereas participants were less willing to take a risk when magnitude was manipulated (even when the expected value was mathematically equivalent). As the ‘risky’ option was presented in varying probabilities between 20% and 80% of gaining $50, and research indicates that people overweight small probabilities but not large ones, this may represent a divergence in choice based on expected value alone. The certain or "conservative" option remained 100% probability of gaining $25 dollars, so it is plausible that as the probabilities approached equal (i.e. 80% and 100%) the amount of money (i.e. $50 and $25) became a more salient reference point for participants.

Stress and Risk Taking Behavior

Results revealed a statistical trend towards a difference in risk-taking between low and high responders to stress (in terms of AUCg) as a function of stress condition (i.e. SAM and HPA) and expected value (i.e. 10, 20, 25, 30, and 40). When the two decisions were of equivalent expected value in the SAM condition, low responders made more 'risky' choices compared to low responders in the HPA condition. It appears that when presented in equal weights of expected value, low responders in the two stress conditions had different risk behavior. High responders to stress, however, performed similarly to all decisions based on stress condition. Research has confirmed negative affect narrows attention and limits an individual's ability to calculate optimal decisions (Mellers, Schwartz, & Cooke, 1998). It is plausible that high responders to stress performed in a similar manner due to the physiological consequences of stress limiting choice accuracy and compelling high responders to depend on lower-level intuitive processes (Mellers, Schwartz, & Cooke, 1998; Porcelli & Delgado, 2009). In addition, stress affects an individual's ability to abide by rational choice models when weighing probabilities and utilities (e.g., magnitude) of decisions (Keinan, 1987). In contrast to previous research, the high responders in this pilot study made similar decisions linearly scaled to expected value. Thus, cortisol increases related to stress may actually have been a protective factor against choices divergent from optimal expected value.

Research indicates that stress can serve as a protective factor on easy decisions, however, in more difficult tasks stress impairs accurate choice behavior (Mellers, Schwartz, & Cooke, 1998). In this study, when expected values were quite different (i.e. 50% of $80 vs. 100% of $25) the choices were easier. When expected values were similar (i.e. 50% of $50 vs. 100% of $25) the choices may have become more difficult. This could explain the narrow choice behavior between stress condition in high responders, this pilot study observed differences in risk-taking between stress conditions only when expected value was equivalent or nearly equivalent. Future studies should explore risk-taking between low and high cortisol responders with smaller incremental differences between expected values of the choices in each trial.

Risk Taking, Stress, and Sex

The pilot study observed sex differences in risk-taking that were consistent with past research (Powell & Ansic, 1996; Schubert, Brown, Gysler, & Brachinger, 1999). Men were more risk-seeking on all decision-making tasks as compared to women. Notably, in this pilot study participants were not offered feedback on the outcome of their choices after they made a decision. This could have fostered more risk-taking in general (Mellers, Schwartz, & Cooke, 1998). Research also suggests males and females may use different strategies to make a financial decision, but that this does not impair either sex in their ability to make financial decisions under stress (Powell & Ansic, 1997). Overall, throughout the study women made more risk-averse or conservative choices compared to men. That said, stress did not significantly influence risk-taking in most trials.

These findings do not converge with past research demonstrating that women increase in risk-aversion when cortisol levels are slightly elevated and men increase in risk-seeking when cortisol levels peak (Lighthall et. al., 2009). This could be due to ineffective stress induction or the possibility that decisions made in the gain domain are not as strongly influenced by stress as compared to decisions made in the loss domain (Kahnemann & Tversky, 1979). The experiment did not involve decisions in the loss domain, and this should be explored further. The exception would be in trials where the expected values of the risky and conservative decisions were equivalent. There, low cortisol responders in the SAM condition took more risks than low cortisol responders in the HPA condition. Additional research is needed to examine how cortisol levels, and other physiological correlates of stress, might bias ambiguous decisions like these.

Cortisol Levels and Sex

There exist conflicting research findings about sex and cortisol. Some researchers suggest that men produce higher levels of cortisol in comparison to women under stress (Kudielka, 1993; Kirschbaum & Kudielka, 2005). On the contrary, other researchers suggest that women have a greater cortisol response when stressed (Lighthall et al., 2009). In this pilot study, results would suggest that there was no significant difference observed between sex and cortisol levels when stressed and thus we cannot infer that the overall conservative behavior observed in this study was influenced by cortisol. Further research should be conducted that closely regulates the CPAW to ensure that participants are consistently stressed for the full duration of stress task. Further, it is possible that the CPAW gelpacs were not uniformly kept at the same temperature. At times they could have been warmer than necessary to produce a physiological stress response. Another methodological limitation to the current study is the lack of salivary cortisol sampling and skin conductance in the no stress condition, resulting in lack of a comparison of sex and cortisol levels outside of stress. Previous research has revealed that men can demonstrate increases in salivary cortisol two to four times higher than females when exposed to stress

(Kirschbaum, Wust, & Helhammer, 1992). Future research based on this pilot should acquire both of these measures for no stress participants.

Conclusion

The current pilot study attempted to manipulate two different stress pathways in the body (i.e. SAM and HPA) on decision-making as a beginning step in understanding a larger picture of the influence of separable components of stress on behavior. Overall financial decision-making in this pilot study has been consistent with prior research in the behavioral psychology field. Men were observed to be more risk-taking than women. Individuals employed utility theory and made decisions based on the optimal expected value. However, this pilot study did not observe a clear influence of stress on decision-making, let alone the difference of SAM and HPA on decision-making. One distinctive finding, however, was the contrast between high and low cortisol responders to stress on decisions of equivalent expected value. Different types of stress appear to be a factor in the perception and interpretation of decisions that are more ambiguous, rather than decisions that are straightforward. The knowledge gained in this pilot study will contribute to future research designed to examine the influence of stress on decision-making.

References

Bleichrodt, H., Pinto, J. L., & Wakker, P. P. (2001). Descriptive prospect theory for prescriptive expected utility. *Management Science, 47*, 1498-1514.

Bremner, F. & Trowill, J., (1962). A combined manipulandum-reinforcement arrangement. *Journal Exp. Anal. Behav*., *5(3*), 339–340. doi: 10.1901/jeab.1962.5-339.

Carver, C., & White, T., (1994). Behavioral inhibition, behavioral activation, and affective responses to impeding reward and punishment: The BIS/BAS Scales. Journal of Personality and Social *Psychology, 67*, 319-333. doi: 10.1037/0022-3514.67.2.319

Eckel, C., & Grossman, P., (2008). Forecasting risk attitudes: An experimental study using actual and forecast gamble choices. *Journal of Economic Behavior & Organization 68*, 1-17. doi: 10.1016/j.jebo.2008.04.006

Gross, J. (2002). Emotion regulation: Affective, cognitive, and social consequences. *Psychophysiology, 39*(3), 281-291, doi: 10.1217.S0048577201393198

Gross, J. & John, O., (2003). Individual differences in two emotion regulation processes: Implications for affect, relationships, and well-being. *Journal of Personality and Social Psychology*, 85, 348-362.

Hinshaw, S. (2003). Impulsivity, emotion regulate on, and developmental psychopathology: Specificity versus generality of linkages. *Annals of the. New York Academy of Sciences, 1008*, 149-159. doi:10.1196/annals.1301.016

Ishizuka, K., Hillier, A., (2007). Effect of the cold pressor test on memory and cognitive flexibility. *Neurocase, 13*(3), 154-157. doi: 10.1080/13554790701441403

Jacobs. G., (2001) The Physiology of Mind–Body Interactions: The Stress Response and the

Relaxation Response. *The Journal of Alternative and Complementary Medicine, 7*, 83-92. doi:10.1089/107555301753393841.

Kahneman D., & Tversky, A., (1979). Prospect theory: An analysis of decision under risk. *Econometrica, 47*(20), 263-291

Kahneman D., & Tversky, A., (1984). Choices, values, and frames. *American Psychological Association, 39*(4), 341-350. doi: 10.1037/0003-066X.39.4.341

Keinan, G. (1987). Decision making under stress: Scanning of alternatives under controllable and uncontrollable threats. *Journal of Personality and Social Psychology, 52*, 639-644.

Kirschbaum, C., Pirke, K., & Hellhammer, D., (1993). The 'Trier Social Stress Test'--a tool for investigating psychobiological stress responses in a laboratory setting. *Neuropsychobiology 28*(1-2), 76-81.

Kirschbaum, C., Wüst S., & Hellhammer D., (1992). Consistent sex differences in cortisol responses to psychological stress. *Psychosom Med, 54*(6), 648-57.

Kudielkaa, B. & Kirschbaumb , C., (2005). Sex differences in HPA axis responses to stress: A review. *Biological Psychology, 69,* 113–132.

Lighthall, N., Mather, M., & Gorlick, M., (2009). Acute stress increases sex differences in risk seeking in the balloon analogue risk task. *PLoS ONE, 4*(7), e6002. doi:10.1371/journal.pone.0006002

Lovallo, W., (1975). The cold pressor test and autonomic function: a review and integration. *Psychophysiology, 12(*3), 268-282

Liu, J., et al. (2007). Complexity of Coupled Human and Natural Systems. *Science, 317,* 1513-1516. doi: 10.1126/science.1144004

Mather, M., Gorlick, M., & Lighthall, N., (2009). To brake or accelerate when the light turns yellow?: Stress reduces older adults' risk taking in a driving game. Psychological Science (20), 174-176. doi: 10.1111/j.1467-9280.2009.02275.x

Matteri, R., Carroll, J., & Dyer, C., (2000). *Neuroendocrine Response to Stress. In Biology of Animal stress: Basic principles and implications for animal welfare*, ed. G.P. Morberg and J. A. Mench, 43-76. Wallingford, UK: CABI Publishing

Mellers, B. A., Schwartz, A., & Cooke, D. J. (1998). Judgement and decision making. *Annual Review of Psychology, 49,* 447-477.

Porcelli, A., and Delgado, M., (2009). Acute stress modulates risk taking in financial decision making. *Psychological* Science*, 20,* 278-83, doi: 10.1111/j.1467-9280.2009.02288.x

Petrovic P., Petersson K., Ghatan P., Stone-Elander S., & Ingvar M., (2000). Pain-related cerebral activation is altered by a distracting cognitive task. *Pain, 85*(1-2), 19-30.

Powell, M. & Ansic, D., (1997). Gender differences in risk behavior in financial decision-making: An experimental analysis. *Journal of Economic Psychology 18,* 605-628.

Preston, S., Buchanan. T., Stansfield, R., & Bechara, A., (2007). Effects of Anticipatory stress on Decision-making in a gambling task. *Behavioral Neuroscience, 121*(2), 257-263. doi: 10.1037/0735-7044.121.2.257

Pruessner, J., Kirschbaum, C., Meinlschmid, G., & Hellhammer, D., (2002). Two formulas for computation of the area under the curve represent measures of total hormone concentration versus time-dependent change. *Psychoneuroendocrinology, 28,* 916–931. doi:10.1016/S0306-4530(02)00108-7

Quatermain, D., & Stone, E., Charbonnea, G., (1996). Acute stress disrupts risk assessment behavior in mice. *Physiology & Behavior, 59*(4/5), 937-940. doi: 10.1016/0031-9384(95)02140-X

Sabban E. & Serova L., Influence of prior experience with homotypic or heterotypic stressor on stress reactivity in catecholaminergic systems. *Stress, 10*(2), 137-43.

Schubert, R., Brown, M., Gysler, M., & Brachinger, H. W. (1999). Financial decision-making: Are women really more risk averse? *The American Economic Review, 89,* 381-385.

Selye, H. (1993). History of the stress concept. In L. Goldberger & S. Breznitz (Eds.), *Handbook of Stress: Theoretical and clinical aspects*. New York, NY: Free Press.

Tsigos, C., & hrousos, G., (2002). Hypothalamic-pituitary-adrenal axis, neuroendocrine factors and stress. *Journal of Psychosomatic Research, 53,* 865-871. doi:10.1016/S0022-3999(02)00429-4

Ulrich-Lai, Y. & Herman, J. (2009). Neural regulation of endocrine and autonomic stress responses*. Nature Reviews Neuroscience 10,* 397-409. doi:10.1038/nrn2647

Van den Bos, R., Harteveld, M., & Stoop, H., (2009). Stress and decision-making in humans: Performance is related to cortisol reactivity, albeit differently in men and women. *Psychoneuroendocrinology, 34*(10*),* 1449-1458, doi:10.1016/j.psyneuen.2009.04.016

Van den Bos, R., Houx, B., Spruijt, M., (1995). The effect of reward magnitude differences on choosing disadvantageous decks in the Iowa Gambling Task. *Biological Psychology, 71*(2)*,* 1873-6246. doi: 10.1016/j.biopsycho.2005.05.003

Washington, L., Gibson, S., Helme, R., (2000). Age-related differences in the endogenous analgesic response to repeated cold water immersion in human volunteers. *Pain 89* (15), 89–96. doi: 10.1016/S0304-3959(00)00352-3

Table 1

The Expected Value and Possible Amount of Risk Taking Choices Presented Throughout the Experiment Separated by Domain (Magnitude of Reward and Probability)

Magnitude of Reward		**Expected Value**		**Probability**
$25	50% chance of $20	10	$25	20% chance of $50
$25	50% chance of $40	20	$25	40% chance of $50
$25	50% chance of $50	25	$25	50% chance of $50
$25	50% chance of $60	30	$25	60% chance of $50
$25	50% chance of $80	40	$25	80% chance of $50

Note. All trials were counterbalanced to be shown an equal amount of times on either side of the screen. The magnitude of reward block consisted of a consistent sure gain of $25 as one of the options and a random presentation of reward amount (20,40,50,60,80) each with a probability of 50% held constant as the second option. The probability block consisted of a consistent sure gain of $25 as one of the options and a random presentation of differing probabilities of attaining a reward of $50 as the second option. Expected value is the weighted value of the ‘risky’ option in either the probability or the magnitude block.

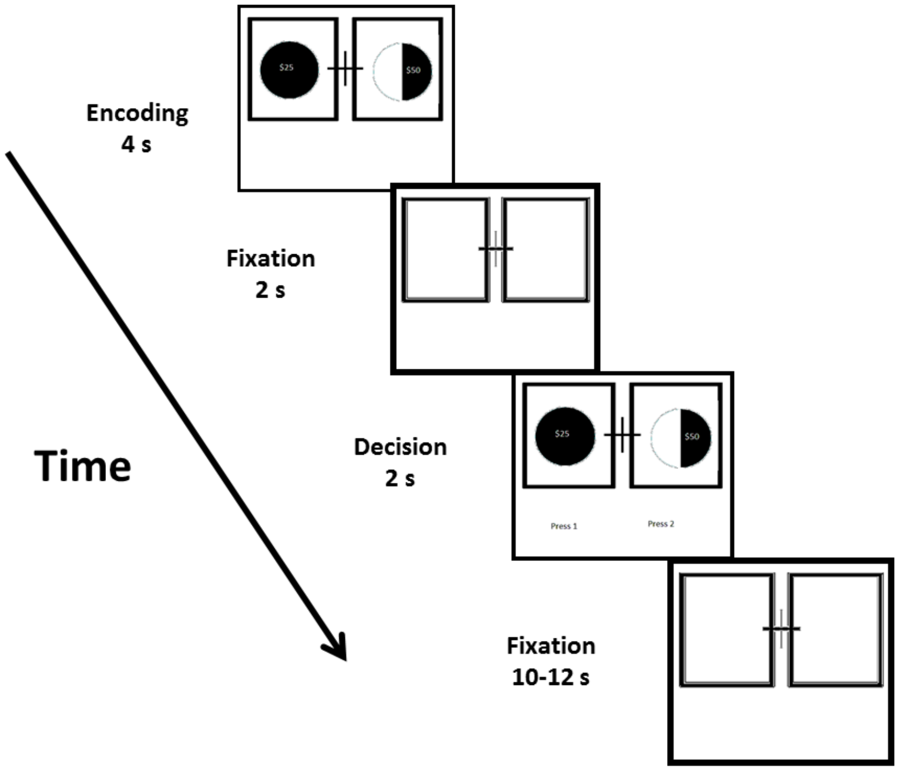

Figure 1. The sequential trial order of the computerized gambling game. The computerized gambling game displayed 100 trials that were counterbalanced between 50 trials of Block 1: Probability and 50 trials of Block 2: Magnitude. The slides above were displayed on a computer screen and their sequential order for each trial was as follows: Encoding (4 seconds), fixation (2 seconds), decision (2 seconds), and fixation again (10-12 seconds).

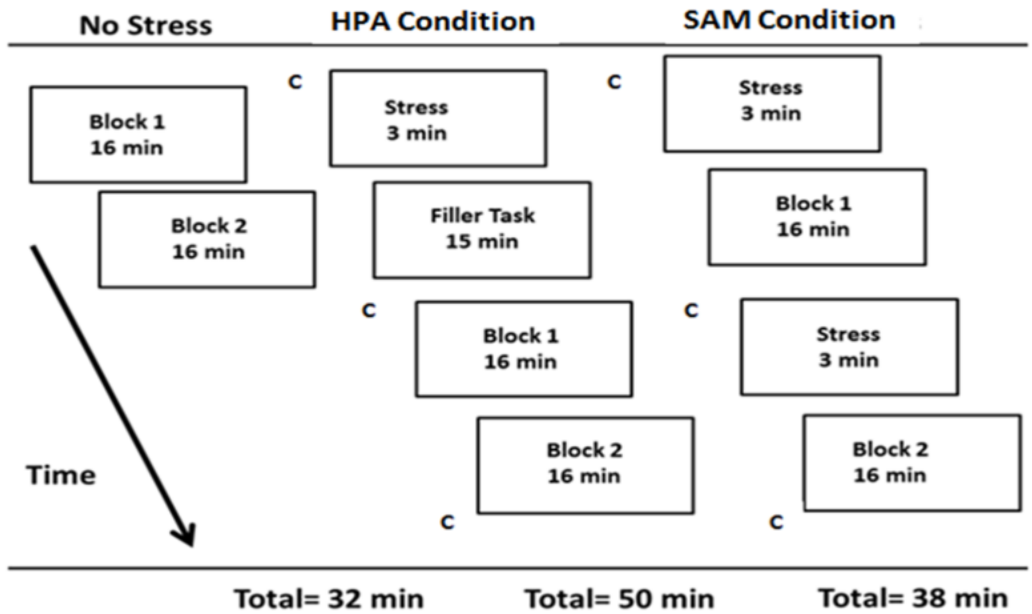

Figure 2. Timeline and overview of all between subject stress conditions (No stress, HPA stress, and SAM stress). Participants were placed at random in one of three stress conditions. The stress conditions were no stress, HPA stress, and SMA Stress. The no stress condition did not receive a stress task and proceeded through Block 1: Magnitude and Block 2: Possibility (16 minutes respectively). The sequential order of the HPA stress condition was as follows: Acute stress induced via cold pressor task (3 minutes), the Sternberg Delayed Recognition task (1993) that was used as a filler task (15 minutes), Block 1: Magnitude (16 minutes), and Block 2: Probability (16 minutes). The sequential order of the SAM stress condition was as follows: acute stress induced via cold pressor task (3 minutes), Block 1: Magnitude (16 minutes), stress task again (3 minutes), and Block 2 (16 minutes). The total times for stress conditions were as follows: no stress was 32 minutes, HPA stress was 50 minutes, and SAM stress was 38 minutes.

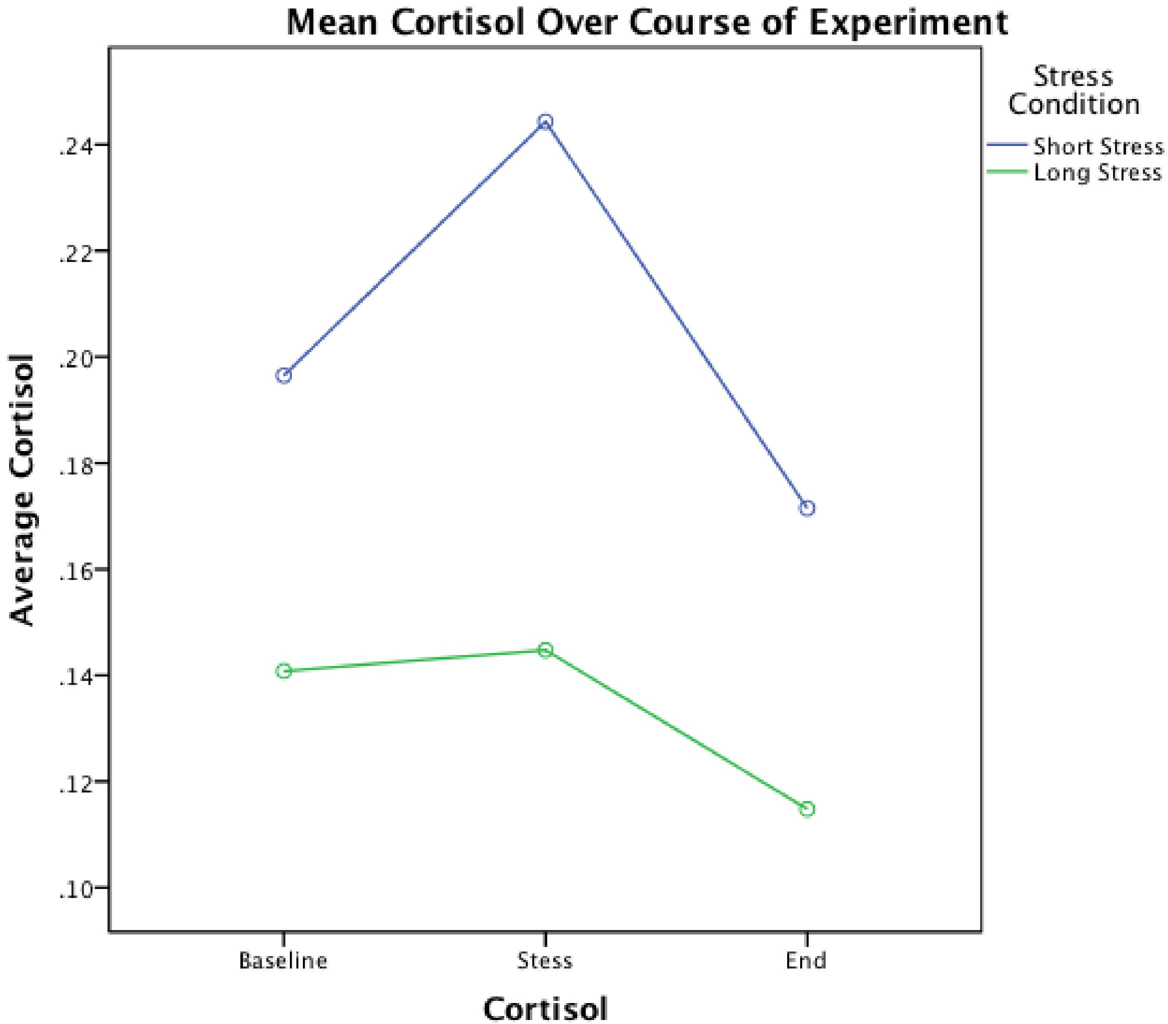

Figure 3. The mean cortisol levels between stress conditions (SAM and HPA) over the course of the experiment. The average cortisol was measured over three specific time points. They were measured at baseline, after participant was stress and at the end of the experiment. Levels of SAM (short stress) and HPA (long stress) conditions were measured. There is a statistical trend that the SAM condition is exhibiting higher cortisol means compared to the HPA condition.

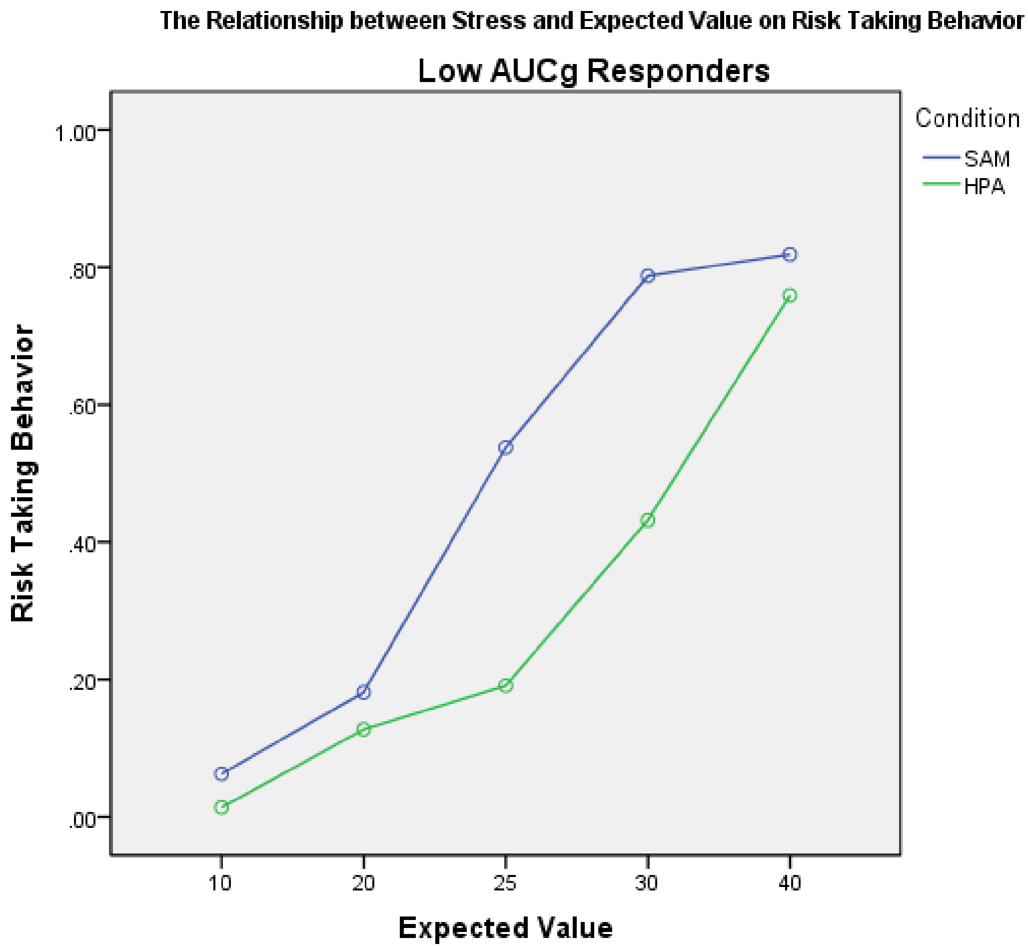

Figure 4. Low responders to stress (in terms of AUCg) and risk taking based on expected value of choice and stress condition (SAM and HPA). Risk taking is scaled from 0 to 1.0; 0 is less risk taking and 1.0 is more risk taking. Overall, the lower expected value resulted in less risk taking while the higher the expected value the more risk taking was observed. Low cortisol responders were more likely to take 'risks' in the SAM condition compared to the HPA condition when expected value of choices presented were equivalent or similar.