

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

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Hello my name is Nataly Aguirre and Anthony Porcelli was my mentor for this summers McNair research project. I will be speaking today about Stress, Risk, and Reward in Financial Decision-Making. Specifically, the role of probability and magnitude.

# Expected Utility Theory

**Expected Utility Theory:** A theory from the field of economics designed to explain how people make decisions.

- One component of the theory is the concept of *expected value*.

$$\text{Expected Value (EV)} = \text{Probability (of the outcome occurring)} * \text{Magnitude (of the potential reward)}$$

- The theory proposes when choosing between options, people always make the decision with the highest expected value.

Within the field of Economics it was purposed that people make decisions based off of the Expected Utility theory

This theory states that decisions are always made in order to maximize gains and it is computed through the concept of expected values

***expected value is defined as the*** Probability of an outcome occurring \*  
Magnitude of the potential reward

The theory proposes when choosing between options, people always make the decision with the highest expected value.

However this is not always the case...

# Probability and Magnitude of an Outcome

▪ Thus, two out of many factors that greatly influence decision-making are:

1. Probability: the probability an outcome occurring
  - E.g., is there a 100% or 50% chance of the chosen decision?
2. Magnitude of reward: amount or extent of the outcome
  - E.g., does one stand to win \$1 or \$100?

▪ There are many factors that greatly influence decision making and two that are essential to this study are:

1. Probability which is again defined as the probability an outcome occurring
  - For example .... is there a 100% or 50% chance of the chosen decision?
2. Magnitude of reward which is defined as the amount or extent of the outcome
  - For example ..... does one stand to win \$1 or \$100?

# Prospect Theory

- **Prospect Theory:** Proposed by Kahneman and Tversky in 1979 took a behavioral approach to research on decision-making. It takes into account other (psychological) factors that can influence choice.
- **Framing Effect:** The framing of a decision as positive or negative can bias decisions.
  1. Gain Domain: Choices are presented as a possible gain
  2. Loss Domain: Choices are presented as a possible loss

Kahneman and Tversky in 1979 took a behavioral approach to explaining decision-making instead of relying heavily on economic theory. They came up with what is now known as Prospect theory which really changed the way we understand decision-making today.

**Prospect Theory** takes into account other (psychological) factors that can influence choice.

They conducted research and noticed that the framing of a decision as positive or negative can bias decisions. This is also known as framing which suggests that a decision can be proposed in one of two domains. Either a gain domain, where choices are presented as possible gain or in a loss domain, where choices are presented as possible loss.

1. Gain Domain: Choices are presented as a possible gain
2. Loss Domain: Choices are presented as a possible

## loss

Within the gain domain they postulated that there exists another effect that comes into play during decision-making: and this is called the Certainty effect: which states that the certainty of gain is more appealing than a gamble of possible greater reward.

To better explain this I will be using one of their examples that helped me understand gain and loss domain

# Asian Flu Example

Problem 1: Gain Domain (Framed in terms of lives saved)

- If Program A: 200 people will be saved. ( $EV = 1.0 \cdot 200 = 200$ )
- If Program B: 1/3 probability that 600 people will be saved and a 2/3 probability that no people will be saved. ( $EV = 0.33 \cdot 600 = 200$ )

Problem 2: Loss Domain (Framed in terms of losing lives)

- If Program C, 400 people will die.
- If Program D, there is a 1/3 probability that nobody will die and a 2/3 probability that 600 people will die.

*Programs A and B are mathematically equivalent in terms of expected value, as are Programs C and D.*

*People should not prefer one over the other – but they DO, and as a function of FRAME.*

Imagine if you will that there is an Asian flu outbreak and an estimated 600 people will die. You are given one of these two problems that contain two choices.

Problem 1 is presented as gain domain because the choices are in terms of saving lives

- If Program A: 200 people will be saved.
- If Program B: 1/3 probability that 600 people will be saved and a 2/3 probability that no people will be saved.

It was observed that there is more risk aversion in the gain frame (72% of the time) as they chose the certain gain over what they perceived as a gamble

Problem 2 is framed as a loss domain because the choices are in terms of losing lives.

- If Program C, 400 people will die.
- If Program D, there is a 1/3 probability that nobody will die and a 2/3 probability that 600 people will die.

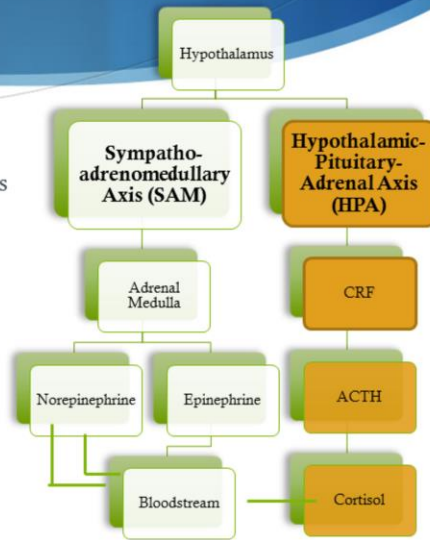
It was observed that there is more risk seeking in the loss frame (78% of the time) as they chose the gamble over the certainty

*Programs A and B are mathematically equivalent in terms of expected value, as are Programs C and D. yet one is chosen more often than the other and this contradicts the expected utilities which states that People should not prefer one over the other – but they DO, and as a function of FRAME.*

As can be seen from this example, Framing has an important role in the way decisions are made because two choices can have the same outcome yet may be perceived differently based on the readers' interpretation and understanding.

# The Physiology of Stress

- Another factor that may influence decisions and is common in daily life: *stress*
- Under stress, many physiological changes occur.
- Some research indicates that stress can increase the presence of framing effects (Porcelli & Delgado, 2009).



Another factor that may influence decisions and is common in daily life is *stress*

The stress response begins in the hypothalamus and continues simultaneously down the sympatho-adrenal medullary axis (SAM) and the hypo-thalamic pituitary adrenal axis (HPA)

The HPA is highlighted in orange and It is initiated by the production hormone. Cortisol, is released from the adrenal cortex and it enables the body to maintain steady supplies of blood sugar. Which is important in helping people to cope with prolonged stress, and also helps the body return to baseline.

The SAM is a part of the Sympathetic nervous system and is highlighted in green. The adrenal medulla is then activated to release norepinephrine and epinephrine into the bloodstream. These hormones resemble those of adrenaline.

Thus the body reacts accordingly and is prepared to either fight or to take flight.

It is also important to note that the SAM releases its hormones instantly while the HPA releases cortisol for an approximate 30 to 60 minutes.



# Sex and Stress

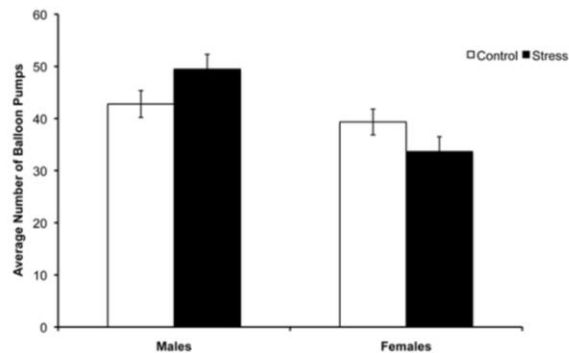
RESEARCH ARTICLE

## Acute Stress Increases Sex Differences in Risk Seeking in the Balloon Analogue Risk Task

Nichole R. Lighthall, Mara Mather, Marissa A. Gorlick

### Balloon Analogue Risk Task (BART):

Subject is shown a computer screen with a balloon; added 5 cents each time you pumped it up; randomly exploded at different times throughout the trial



The balloon analogues risk task (BART) by light hall

In this study the sex differences in how that are affected by stress was explored

BART which involves making a button press to expand a virtual balloon for momentary reward. Which each button press, more money is gained – but at a certain point the balloon will explode. Thus, participants risk losing all winnings if they continue to expand the balloon to gain additional rewards. It was observed that under acute stress males take more risk, whereas females show the reverse pattern

It was found that there was a difference between males and females in the average number of balloon pumps.

Research would suggest that females had a higher cortisol level in comparison to their stress level but were overall more risk conservative.

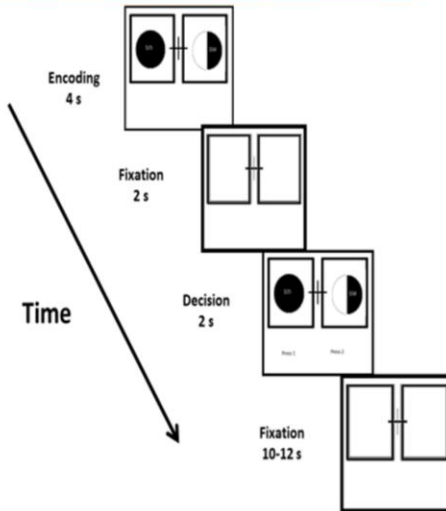
Males had a higher stress level in comparison to their cortisol level but were overall more risk taking.

# Research Questions

- Does stress influence how people perceive the probability or magnitude inherent in a decision?
- Do different components of the stress response (i.e., SAM vs. HPA) influence risk-taking differently?
- Do men and women take risks differently under stress?

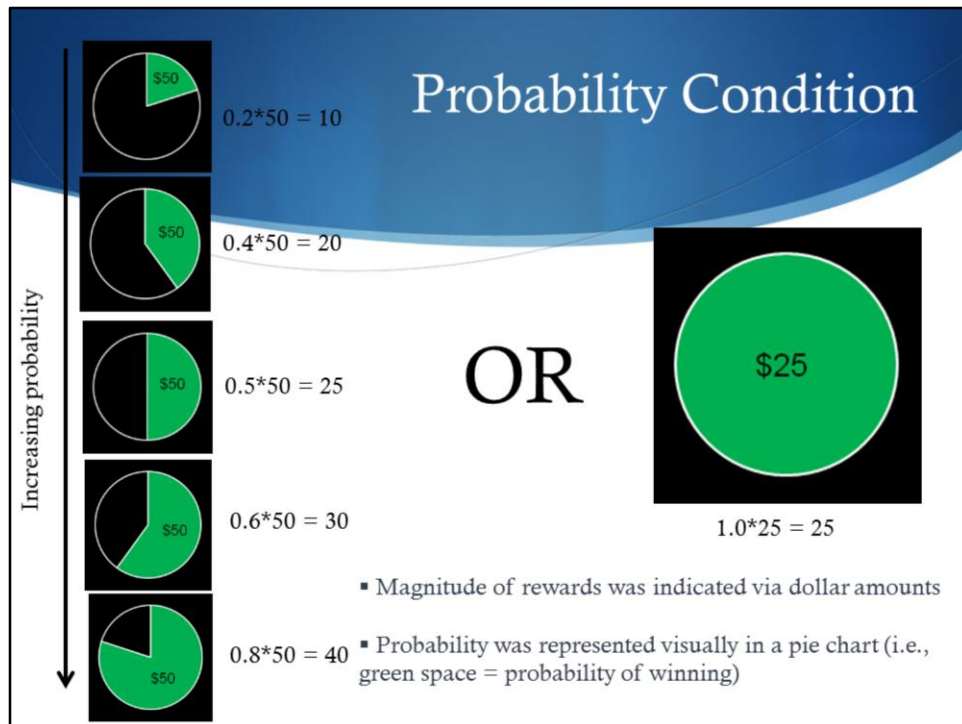
# Current Study: Decision Making Task

- Participants chose between two options in each trial.
- One was 'risky' the other a sure gain of money.
- In one condition, probability was varied while magnitude was held constant (the reverse in the other condition).
- All decisions in the gain frame.



In this current study, the Decision Making Tasks of Magnitude and Probability Block 1 and 2 were displayed in the manner presented. There was a 100 trials in the combined Blocks which were counterbalanced throughout the study.

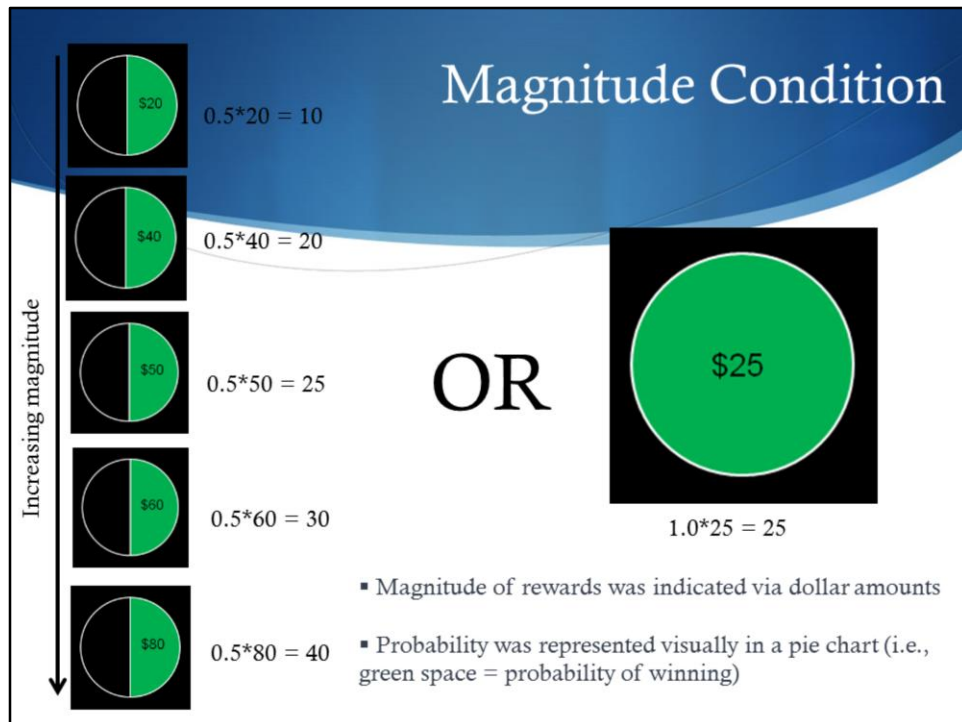
Participants first saw a slide with 2 choices side by side for 4 s, then a fixation appeared with two empty choice boxes and a plus sign in the middle for 2 s, then another slide was shown where the two choices were shown again but this time a decision had to be made in 2 s, this was then followed by another fixation slide of 10-12s.



In the magnitude condition of the decision making task trial

The probability of winning increased 20, 40, 50, 60, 80 percent as indicated by the green, while the amount of money remained at \$50

The other side of the screen then displayed a risk averse option of \$25



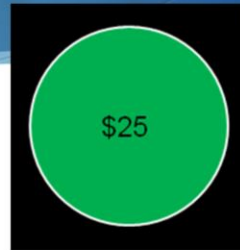
In the magnitude condition of the decision making task trial  
 The percentage of winning remained at 50 % as indicated by the green space, while  
 the amount of money increased by the dollar amounts of 20, 40, 50, 60, 80

The other side of the screen then displayed a sure gain of \$25

## Probability vs. Magnitude of Reward



50% chance of gaining \$50  
 $0.5 \times 50 = 25$



100% chance of winning \$25  
 $1.0 \times 25 = 25$

- Importantly, one decision in each condition was equivalent in *expected value*.
- If deciding “rationally”, participants should choose at about 50-50.

This is a slide of what participants saw during the decision making task trial of block 1 probability and block 2 magnitude

One side was always 100% chance of winning \$25 dollars and the other side was 50% chance of gaining \$50 dollars.

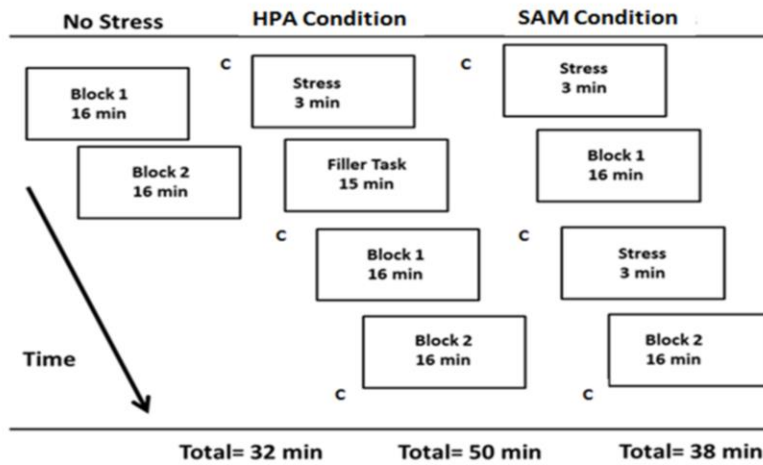
The green space indicates the percentage of probability of gaining money and the amount of money is written in the green space.

In this example, 2 choices would then be a 50% of winning \$50 and 100% chance of gaining \$25 and are thus equivalent in expected value.

# Pilot Study Stress Conditions

- No Stress
- “HPA Stress”: Participants were exposed to stress one time and completed a filler task before the decision-making task.
  - Attempt to allow cortisol to rise over time, but reduce SAM activity.
- “SAM Stress”: Participants were stressed immediately before each block of the decision-making task.
  - Attempt to fast SAM activation alone without HPA related cortisol increase.

# Pilot Study Overview



C = cortisol sample



# Experimental Variables

## **Independent Variables:**

- Stress Conditions (between)
- Probability and Magnitude Manipulation (within)
- Expected Value of the decision (within)

## **Dependent Variables:**

- Risk-taking
- Salivary Cortisol
- Skin Conductance

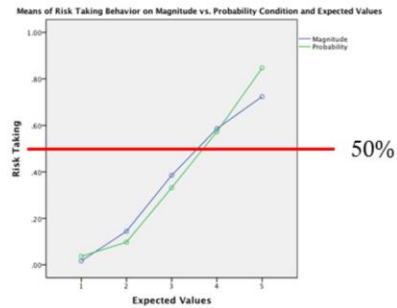
# Research Hypotheses

1. As trials are in the gain frame only, people should tend towards risk-averse decisions overall.
2. Stress will alter risk-taking differently when probability or magnitude is manipulated.
3. SAM and HPA conditions will be associated with different levels of cortisol.
4. Men will be more risk-seeking when exposed to acute stress as compared to women.

# Results

## Hypothesis 1 (Supported):

- Expected Value yielded a significant main effect on risk taking behavior,  $F(2.62, 167.91) = 136.52, p < .05$ .
- Risky behavior increased as expected value increased.
- On the EV equivalent trials, people chose the safe option more.



Hypothesis 1 stated that risk aversion is greater in sure gain and was not supported by the results. However, Risk taking was also observed to increased as expected values increased. AS you can see the graph is moving in a linear fashion when expected values is from low to high.

# Results

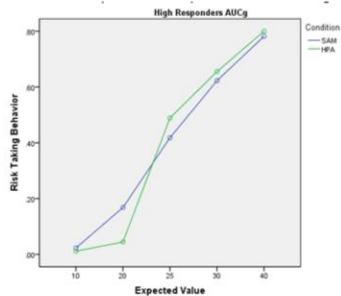
## Hypothesis 2 (Partially Supported):

- A trend was observed revealing low responders to stress (in terms of AUCg) took more 'risky' choices in the SAM condition compared to the HPA condition dependent on trials where the expected value of the choices was equivalent,  $F(2.62, 91.83) = 2.20, p < .15$ .
- However, probability and magnitude were not influenced by stress.

Hypothesis 2 stated that stress affects risk taking behavior differently when decisions are framed as probability or magnitude. After dividing both the SAM and HPA stress conditions into high and low responders of cortisol it did not respond

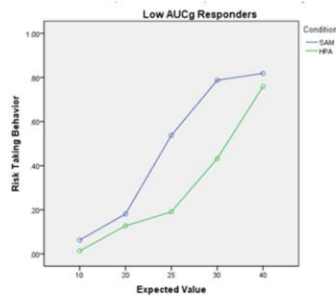
# Stress and Expected Value on Risk Taking behavior

## High Responders to Stress



Similar risk taking behavior.

## Low Responders to Stress



Different risk-taking behavior.

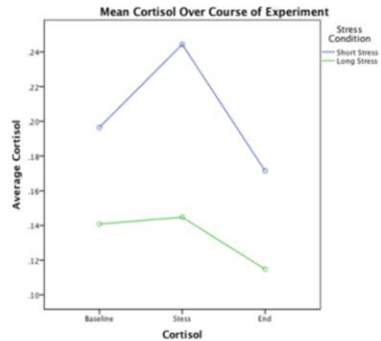
Using the Area under the curve calculations it was found that risk taking behavior were similar between the two stress conditions over the expected values in the high responders to stress however it was found that it differed in the low responders to stress as the SAM participants took more risk than did the HPA participants.

# Results

## Hypothesis 3 (Partially Supported):

- A trend towards a different levels of cortisol reactivity between SAM condition and HPA condition

$$F(1,37) = 2.95, p < .10.$$



Hypothesis 3 stated that SAM and HPA release differ in the cortisol reactivity was supported by the results. There was a statistical trend towards a significant difference between cortisol release and the SAM and the HPA condition. The figure displays how the two conditions increase in cortisol reactivity differently when stressed.

# Results

## **Hypothesis 4 (Partially Supported):**

- Males made more risky decisions but females made more conservative decisions,  $F(1,61) = 4.62, p < .05$ .
- There was, however, no interaction with stress condition.

In Hypothesis 4 it was hypothesized that men are more risk taking when exposed to acute stress in comparison to women. Results support that males are more risktaking than females except there was no effect of stress and was just overall.

# Discussion

- Stress did not influence risk-taking overall, but evidence was observed in support of a stress effect on trials where the expected value of each decision was equivalent.
- **When there is no clear better choice, stress may exert a larger influence.**
- Lower cortisol levels were associated with higher risk-taking in the SAM but lower risk-taking in the HPA condition.
- Sample size in the stress conditions is low, thus the design may be underpowered.

▪ Stress was found not to influence risk-taking overall but after the stress conditions were divided by high and low responders, there was evidence that would suggest a stress effect on trials where the choice of sure gain was harder to differentiate.

- **When there is no clear sure gain, stress may exert a larger influence.**

Additional gambles may be needed towards the center of the decision range, as above and below the mid-point so participants have a clear preference in terms of decision that could override the



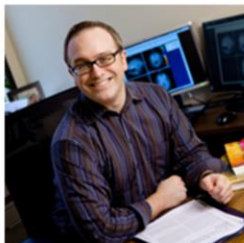
effects of stress.

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