The Effect of Fear on Effort & Reward Decision-Making

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Honor Pledge

I pledge my honor that this paper represents my work by the University Regulations and that I did not violate the Honor Code.

/s/ Persis Akua Baah

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Abstract

The feeling-is-for-doing and affect-as-information models seem to predict contradictory conclusions about how emotions influence decision-making. But the theories may not be contradictory, perhaps emotional tags are too universal. Emotional tags do not consider how high/low arousal influences individual effort/reward sensitivity. This study examines how much participants considered the costs and benefits when pumping balloons to earn points of monetary value. It compares how this was affected by the fearful sounds they heard. This experiment also shows how participants evaluated their own arousal/valence states. Eye-tracking technology was utilized to provide data about attention and information processing times. This will be done to strengthen the claim about how effect affects effort/reward decision-making. Research such as this can help practitioners use mood arousal states as information to create tailored pharmaceutical and behavioral therapy interventions and predict patient behavioral patterns.

Keywords: fear conditioning, decision-making, arousal, eye-tracking, effort, and reward

Introduction

The two prevailing theories on how emotions affect decision-making seem to be contradictory. The feeling-is-for-doing model posits that emotions elicit motivational goals to overcome problems, whereas the affect-is-for-information model that the appraisals of emotions influence decision-making (Schwartz & Close, 1983 and Zeelenberg et al. 2008 as cited in Chiu, 2022).

Using sadness as an example, the affect-as-information model would predict that if a person is feeling sad, they would interpret activities as being more effortful, thus having lower effort utility. On the contrary, the feeling-for-doing model posits that sad people would want to get out of their emotional state. Thus, they would receive rewards and have higher reward sensitivity. Perhaps, these theories are not contradictory but have different applications for different people. Perhaps, these applications are driven by arousal. Two sad people could have varying levels of arousal, and thus different behaviors. This would explain why a low-arousal, sad person may intercept effort as too costly, per the affect-as-information model. And why a high-arousal, sad person may seek out rewards, per the feeling-is-for-doing model.

Historically, emotions have been studied by considering using a two-dimensional construct of valence and arousal. However, given how complex emotions are in actuality, the Appraisal Tendency Framework (ATF) was used to show how emotions of the same valence/arousal could have different behavioral effects. The ATF model posits three things: emotions involve cognition; emotions cause behavior and physiological reactions; and emotions can affect behavior.

Pilot Study

For a senior thesis project, I propose a project that extends on the methodologies and findings of a Chiu et al. (2022) pilot study. The study entitled "How does sadness influence effort-based decision making?" aimed to study how sad-induced participants evaluated the effort-reward tradeoff. 47 participants were recruited from Prolific and played an online game in which they had to decide whether to press a balloon fewer time and earn fewer points or press a different balloon more times and earn more times. For example, a participant could be presented with the choice of pressing a red balloon 30 times and earning 4 points or pressing a blue balloon 50 times and earning 5 points. The procedure of the study included having participants complete an affect rating; watch a 90-second affect induction video clip; complete the rating again; and then complete 20 trials of the balloon game. This procedure was run four times, with the first effect being neutral and the next three being sad.

Results showed that after the sad inductions, participants highly significantly chose to select the high effort/high reward balloon. Additionally, there was a significant correlation between lower self-affect ratings and the high effort/high reward balloon choice. This study is interesting because it supports the feeling-is-for-doing model.

In my experiment, I hope to extend this pilot, by also considering the fear mood. The feeling-is-for-doing model seems to be supported by this sad induction. Studies have shown that "many negative emotions have comparable variances along the valence dimension, but most emotions' variances differ along the arousal dimension" (Heffner et al., 2022,). However, will it still be supported when subjects are in a negative valence, high arousal state? In my senior thesis, I plan to investigate the following research question: How does the intensity of arousal impact an individual's effort/reward sensitivity?

Hypothesis

The two main theories guiding this study would be feeling-is-for-doing and affect-as-information. A null hypothesis would be that no matter the effect, an individual's calculated cost/effort equation wouldn't diverge significantly from that of their neutral state. This would mean that the theories would not more than chance explain the individual's behavior during different effect inductions. I would hypothesize that when individuals are highly aroused, they would experience a higher effort utility. Based on the findings of the Yang et al. (2017) study, I would also hypothesize that when in a lower arousal state, individuals would experience a higher reward utility**.** Both theories have been scientifically proven but different affect inductions can show which theory is more supported on an individual level. Particularly, how different expressions of arousal within the same valence change the effort/reward analysis.

Eye-tracking Technology

Lastly, eye-tracking is another element that would be interesting to include. When used to measure eye re-dwells, a study found that a higher number of re-dwells in a decision task could imply a comparison between the choice and the alternatives (Wallin et al., 2013). Additionally, a review on eye-tracking technology found that eye movement could track certain information processing patterns and attention direction (Lai et al., 2013).

Conducting the entire experiment while participants use the eye tracker might provide interesting results. Eye gazes and oscillations could help answer the following questions: How often and how long did the participant's eyes oscillate between the two balloons? When they choose a balloon, did their eyes lock into that image for the remainder of the trial or did they look to the unchosen balloon (perhaps regretting/weighing/confirming their decision)? When pressing the buttons, is a participant's gaze fixed on the word "presses' ', "points", or something else? Because eye gazing and oscillation can reflect attention and choice, this data can be

mapped into an individual effort/reward model. Doing so could answer this set of questions: Is there a correlation between the balloon a participant chose and where her eyes are focused? Did individuals have more eye oscillations when the effort/reward differences between the balloons were larger or smaller? For example, in a trial where the point allocations for the balloon are more stratified, a higher eye oscillation would show that an individual showed uncertainty or ambivalence in their choice. This consideration could show if participants had difficulty deciding.

Relevance

A study like this observing the effects of different emotions on decision-making has several applications. In the psychiatric context, understanding how emotions influence decision-making can help understand how depressed/anxious mood states influence effort/reward actions. As we know, decreased energy is a core symptom of depression (Berwain et al., 2020). A study conducted by Yang et al. (2014) found that patients with subsyndromal depression and MDD had a decreased willingness to do effortful tasks which also correlated with a decreased anticipatory and consummatory pleasure.

Firstly, the anticipated conclusions of my thesis project could help treatment providers understand the psychology behind why their patients may not be motivated to accomplish a task. An understanding such as this could help patients perhaps make tasks more rewarding/incentivizing, so they are inspired to accomplish their goals. It could help providers understand a patient's mood state by analyzing her pattern of decision-making. Secondly, it's interesting to note that in the Yang et al. (2014) study participants with MDD had lower pleasure ratings. In the Yang et al. (2017) study, participants who were induced with a sad affect had a higher reward sensitivity than those in the neutral and happy affect states. These two studies

show that emotional and mood states can have different influences on actions. The Yang et al. (2014) study explains that people with MDD may experience anhedonia, a symptom that impairs and decreases motivation and pleasure from rewards. More research is needed to compare how effort/reward-based decision-making differs based on high/low arousal, and negative valence mood states vs emotional states. This could also offer insight into specific symptoms that alter normative effort/reward decision-making tendencies.

A Berwian et al. (2020) study compares the effort/reward decisions of healthy control and patients in remission from MDD. Though all participants showed similar exertions of effortful behavior, patients showed higher effort sensitivity during the decision-making process, with those on medication having heightened sensitivity and increased decision-making duration. Some antidepressants are psychotherapeutic interventions that promote behavioral activation (Berwain et al., 2020, p. 514). They aim to inspire effort investment in depressed patients, who may experience reward-processing impairment. Another consideration could be that their reward processing is not impaired but that they weigh decisions as being too costly. Thus, understanding the effort/reward tendencies of a depressed patient in remission could help practitioners determine their probability of relapse. This shows the necessity of understanding the utility of effort/reward as influenced by emotions. Knowing whether a patient has lower/higher reward or effort sensitivity can help practitioners offer more targeting medical treatment, more specifically focusing on behavioral activation or the reward circuit.

Methods

Participants

Participants were found through the SONA student and paid pool. Students were given class credit, and all participants had the opportunity of receiving up to $10 in proportion to the points they earned out of the max available. Some SONA-paid pool participants were paid a few dollars more because the experiment went over time. All but one participant was aware of the terms of their monetary reward before they played the game. Of the participants, half were male, and the others were female. All of them were college students ranging in the ages of 19-22. Two were Black, three were Hispanic, and one was Asian and White.

Study Design

Participants were brought to the Princeton Neuroscience Institute eye-tracking room, where which we used the EyeLink 1000. The Institutional Review Board Protocol number was 11968. They sat in the seat and adjusted it to make sure that their head was in proper positioning for the eye-tracker. They were told not to move their head for the duration of the study. Their dominant eye was calibrated and validated. Then we tested that the sound was working and high enough on the headphones they were given. They then filled out the consent form, participant checklist, and demographic survey. They then played the game. After, they took the three mental health screening tests: The Generalized Anxiety Disorder Scale (GAD7), The Patient Health Questionnaire (PHQ9), and the Emotion Regulation Questionnaire (ERQ). Lastly, they were given mental health resources and told what the task was meant to research.

Task Design

In this task, there were 10 practice trials, followed by 1 practice emotion rating. Then, they had 1 emotion rating pre-mood induction. After, there was a 30-second sound block of an orchestra, that we hoped induced a fearful mood. After, the first block begins. There were 25 trails. Subjects saw two balloons; on one side they had the presses needed and the points to be awarded for the left balloon. The same was true for the balloon on the right side. All the subjects saw the same 25 pairs in the block, but the sequence was shuffled, and what appears on the left/right-hand side was also shuffled. During the block, there are two emotion ratings every 8 trials. At the end of the block, there is another emotion rating. And so, it repeats, pre-mood induction rating, block 2 starts (25 trials; 2 ratings per 8 trials), end of block mood rating.

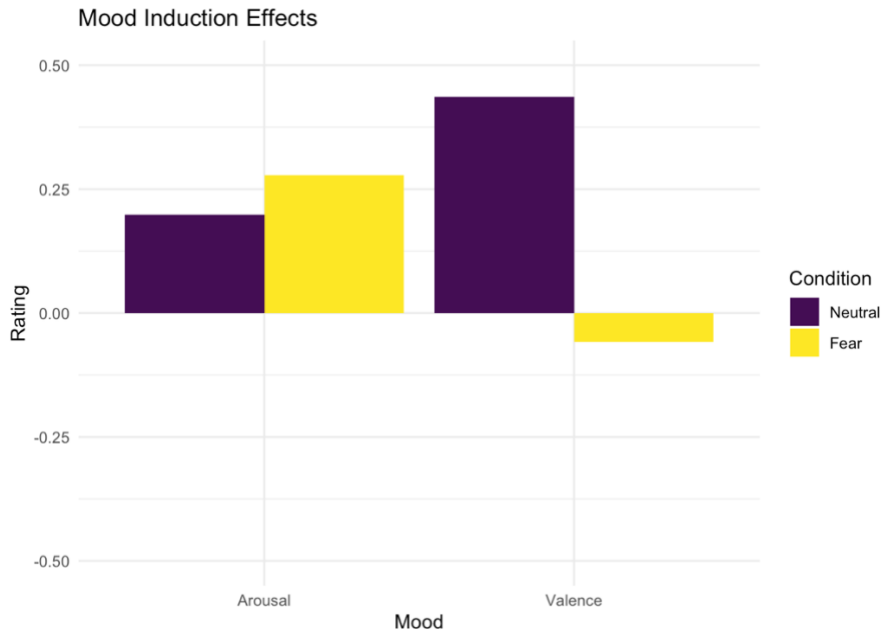
Results

Eye-tracking data was collected using the EyeLink Data Viewer. We selected the relevant metrics, exported them to Excel, and then imported them to R. Data was analyzed using R. None of the participants were excluded.

To determine the mood induction, we compared the self-assessed ratings before and after the fear mood inductions. A paired t-test comparing the neutral and fear valence rates had a p-value of 0.029. A paired t-test comparing the neutral and fear arousal rates had a p-value of 0.453. When graphing these data points, the moderate significance of the silence was more apparent. There is also a slight increase in arousal. When we digested this even more to compare the two fear blocks, it seemed that the low valence score remained, however the arousal, although higher, was still significant.

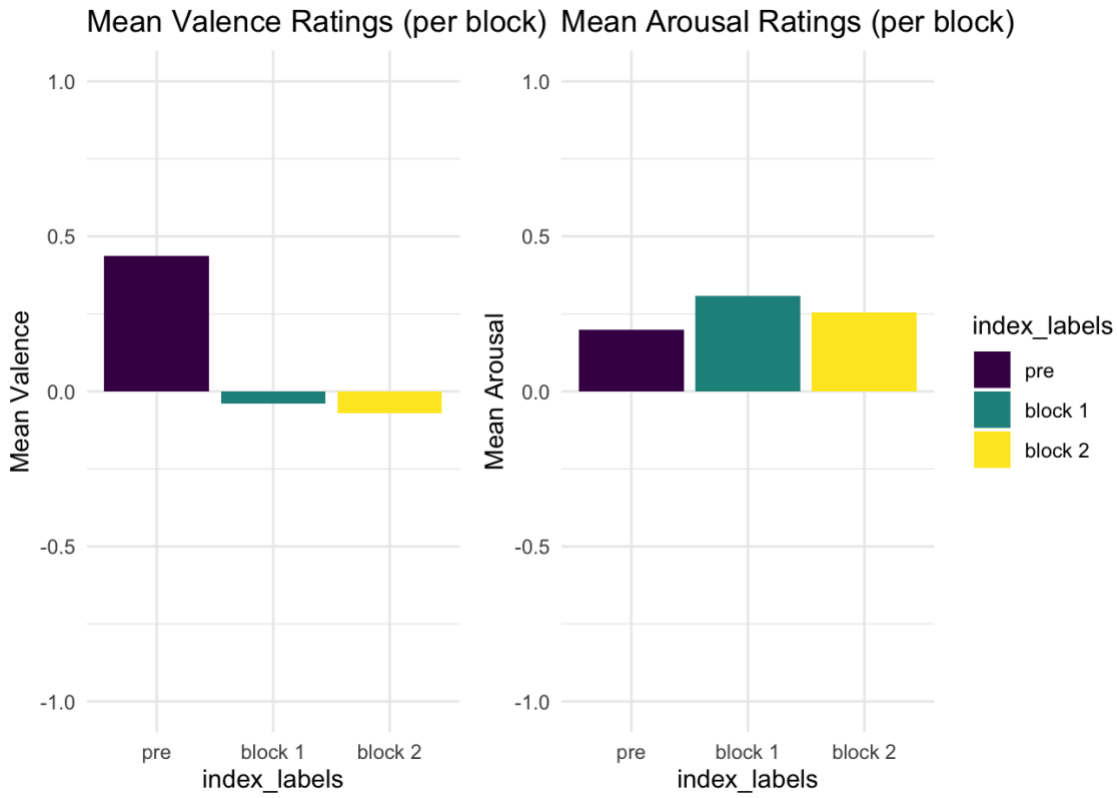
Graph 1

Mood Induction Effects



Graph 2

Mean Valence and Arousal Ratings (per block)



To understand the effort/reward ratio, we took the proportion of time participants were looking at the needed presses and averaged it for each mood. So, the data for the trials in pre-block, before the mood induction, was averaged. Then, the data for both fear blocks were averaged. A higher number would mean that they were more inclined to look at the effort needed. After, we took the difference between the fear and neutral ratio. This new ratio allowed us to see how the mood induction affected their eye gaze. So, a higher difference ratio would mean that during the fear blocks, they paid more attention to the presses/effort needed to bump the balloon. The result of a paired t-test between the effort ratio of neutral mood and the effort ratio of fear mood was a p-value of 0.2028. Although there was no statistical significance

between these two metrics, when we graphed the data points, there seemed to be a positive trend in one outlier. It showed that participants' eyes tended to focus more on effort when they were induced with fear, as compared to the neutral condition.

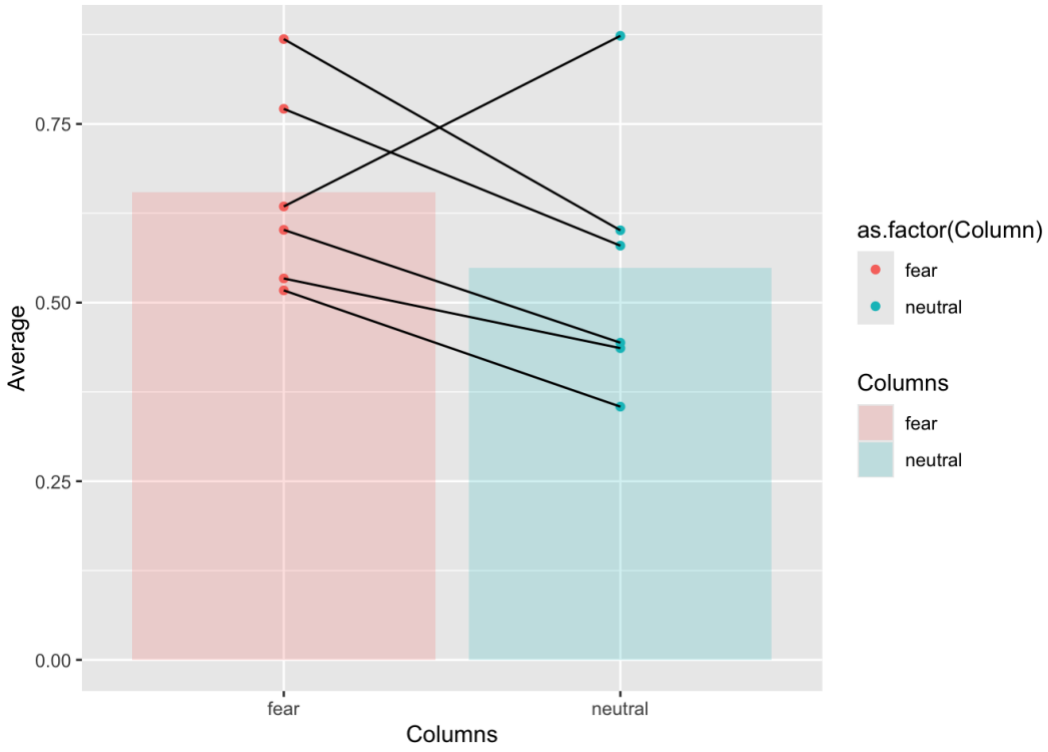
Table 1

Effort Ratio for Neutral and Fear Conditions

```
##   subject   neutral      fear  difference
## 1       1 0.6011688 0.8687810  0.26761225
## 2       2 0.5796944 0.7711549  0.19146047
## 3       3 0.3543845 0.5171515  0.16276696
## 4       4 0.4438875 0.6018114  0.15792395
## 5       5 0.8733126 0.6345381 -0.23877448
## 6       6 0.4362609 0.5338208  0.09755991
```

Graph 3

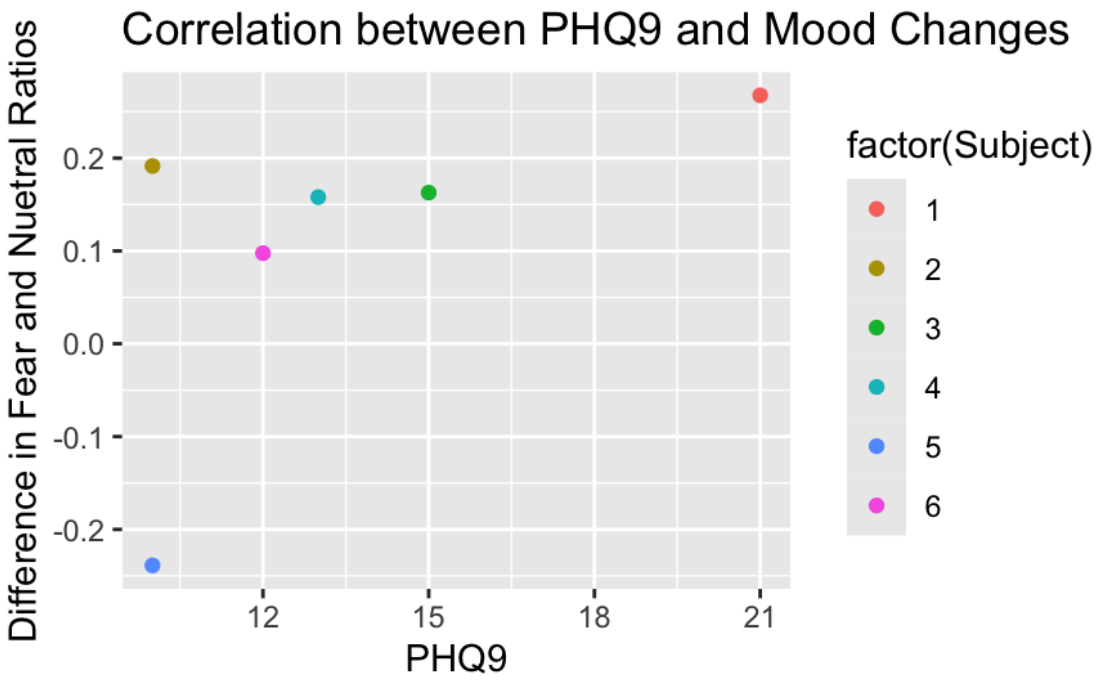
Average Effort Ratio for Mood Inductions



Next, a correlation table was made to compare the participant difference ratio to the results of their mental health self-rating and their score. The mental health ratings were scored by totaling—giving the value of 1 to the lowest answer choice and then increasing by 1 for the subsequent. The correlations between this ratio and the other metrics were as follows: Score (0.678), ERQ-Reappraisal (-0.047), ERQ-Suppression (-0.553), GAD7 (0.230), and PHQ9 (0.596). The p-value of the correlation between the PHQ9 ratings and difference ratio was 0.212. Although there was no statistical significance between these two metrics, when we graphed the data points, there seemed to be a positive trend in one outlier. It showed that as participants self-rating for depression increased so did their comparative focus on effort during the fear condition.

Graph 4

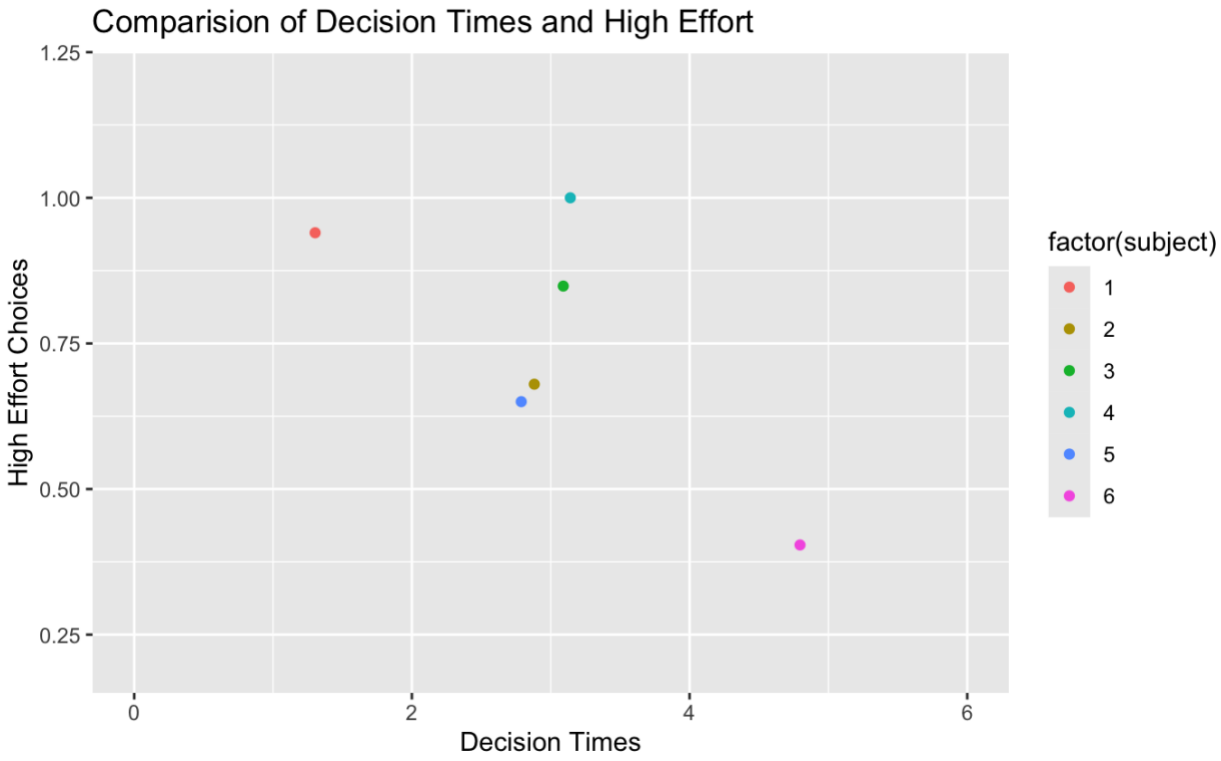
Correlation between PHQ9 and Mood Changes



When assessing the decision time and the high-effort choices in the fear blocks, the p-value for the paired t-test was .0077 and the correlation was -0.71. This proved there was a significant relation and that participants who had shorter decision times were more likely to choose the more effortful choice. When looking at the proportion of high-effort choices made per block, there were varying trends when looking at the transformation of habit from neutral to fear state: from two participants increasing effortful choices to some decreasing to some maintaining. To determine if people should have consistent decision patterns throughout the trial, we took the middle 40 trials and sliced them. Comparing the first half to the second half, we found that high-effort choices seemed to be similar across the board.

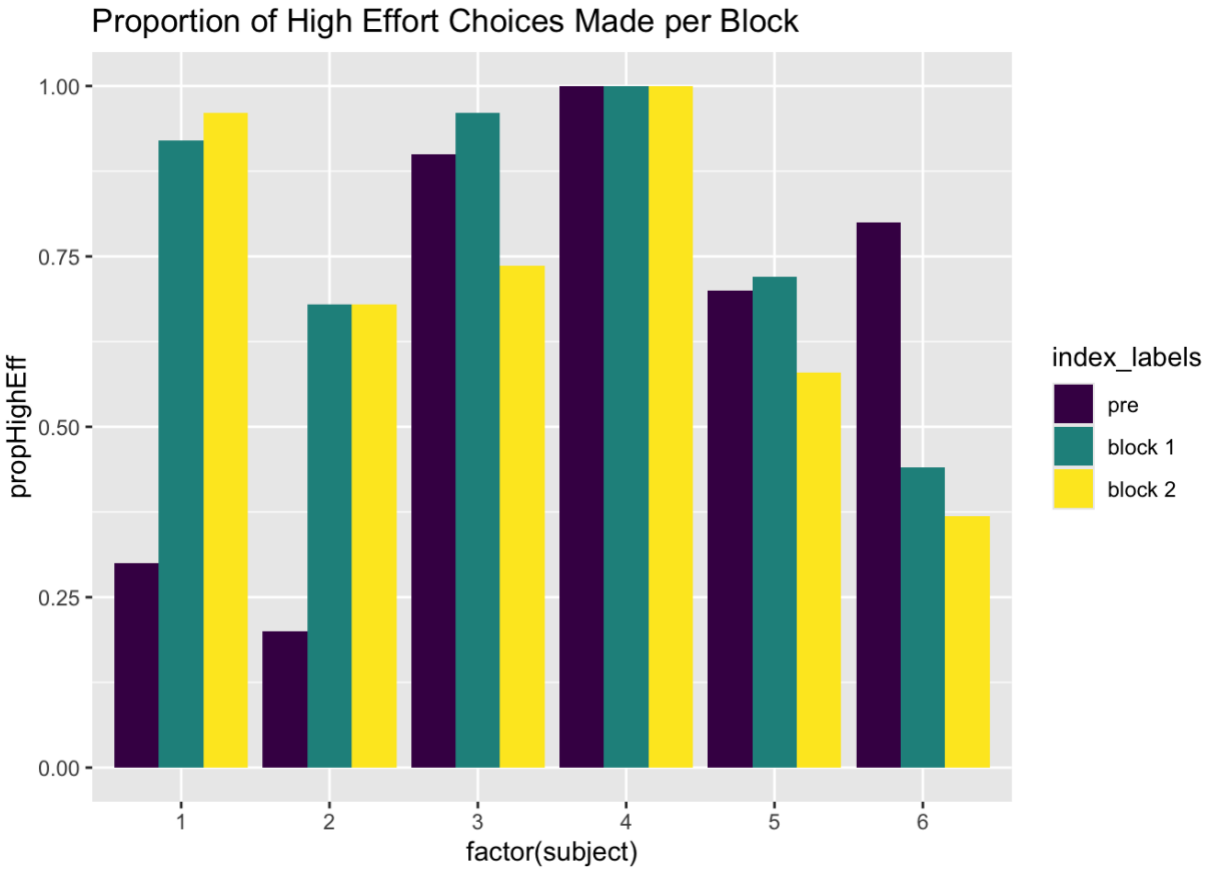
Graph 5

Comparison of Decision Times and High Effort



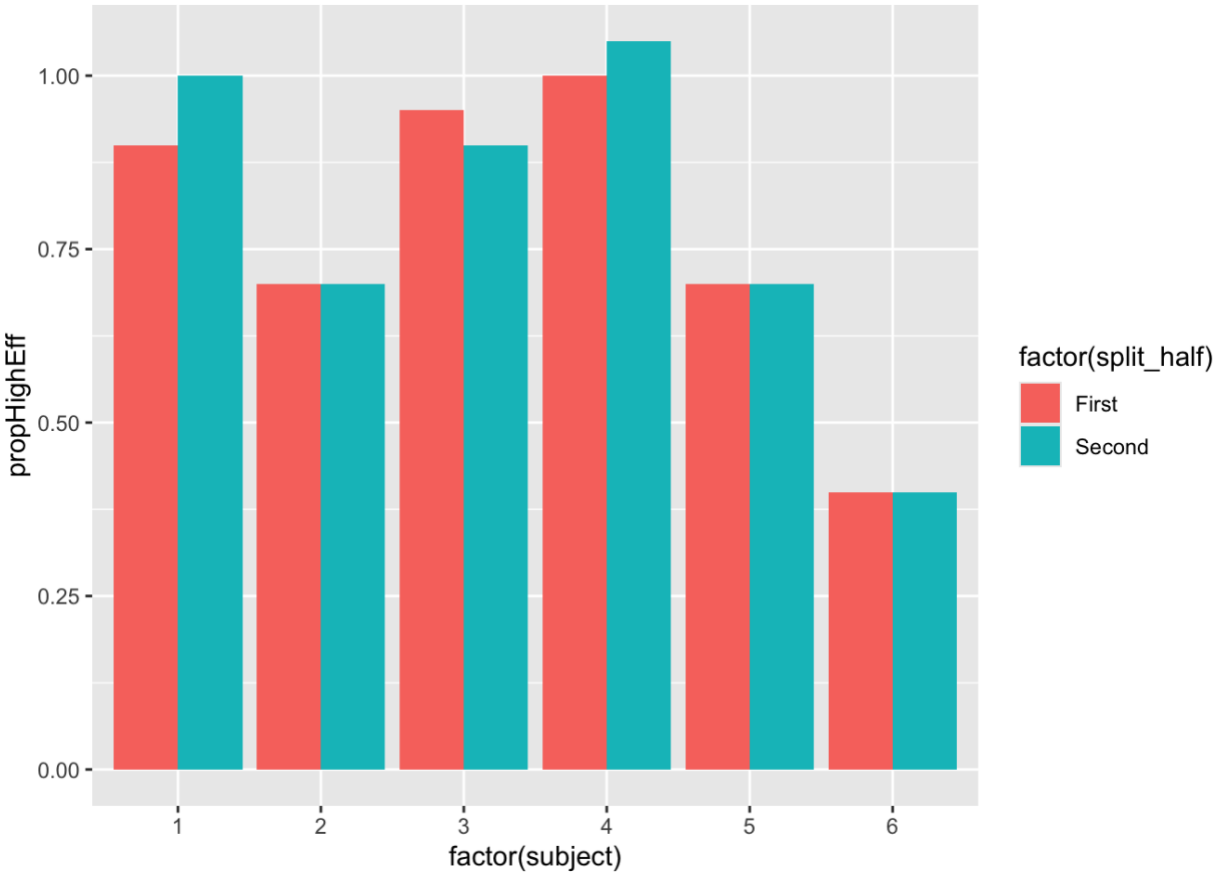
Graph 6

The proportion of High Effort Choices Made per Block



Graph 7

Middle 40 High Effort Choices per Subject



Finally, in the comments in the post-survey, most participants said that the game was clear to follow and easy. Three participants said that they deployed a ratio strategy (e.g. “compared whether it was worth pumping more for more points”), one said that he aimed to max his points, and two said that he had no strategy.

Discussion

In discussion of the limitations of this study, one of the main aspects was the lack of subjects. In this study, the goal was to understand where participants were looking (effort vs reward) and how this changed as they received a mood induction. One of the goals was to induce fear (high arousal, low valence mood). The negative valence induction seemed significant; however, the arousal did not have significance. This is probably due to the low number of participants, but also perhaps due to the unclear instructions. On the graph where participants plotted their valence/arousal, there were no definitions of these terms. In his exit survey, one participant commented that definitions would have been helpful. Perhaps participants were not aware of this terminology and thus over/underestimated their ratings. This also puts the accuracy of their self-ratings in question.

I would propose that a future study have a significantly larger number of participants, so that we may determine what hypotheses are most supported. Because of the few participants, there was more noise in the data. Results were inconclusive because they didn't have enough statistical power, thus high correlations and statistical significance were unable to be determined.

For example, there were varied trends in the data on the "Proportion of High Effort Choices Made per Block" graph. For participants 1 and 2, they made more effortful decisions after the fear induction. For participants 3-5, their choice habits seemed similar. For Participant 6, there was a stark decline in effortful choices. For participants 1 and 2, their choices could support the Feeling Is for Doing framework, because the negative valence, and high arousal emotion they felt may have led them to seek more costly rewards. On the other hand, participant 6's choice could lend to the Affect-As-Information model because the mood induction may have caused her to have a lower effort utility.

In addressing some of the issues in the code, I would propose that another iteration should have the same number of trials for each participant and the same number of max choices. This would allow for the comparison of participant scores and high-choice selections to be more informative.

An extension of this study would be to have another set of groups of participants who are induced with a different mood. I would hypothesize that according to the Feeling-Is-For-Doing model, higher arousal mode states would correlate to a person having a higher utility for effort. In addition, I would hypothesize that according to the Affect-Is-For-Information Theory, negative valence mode states would correlate with a person having lesser utility for effort. This would allow for more intra-group comparisons. One of the most notable would-be decision times. We could compare each mood group with the average time participants took to decide on a choice after the mood inductions. We could then compare these average times with arousal states and average high-choice selection. For example, perhaps being more aroused could make people make quicker decisions and more effortful decisions. This could support the Feeling-Is-For-Doing Model.

When considering the feeling-is-for-doing and affect-as-information there can be contrary predictions of decision-making patterns for a given emotional state. Perhaps, both theories can be proven true, and the inaccuracies lie in the naming of emotional cues. Individuals can experience different manifestations of emotions, most particularly arousal states. Thus, investigating arousal states can better clue how effects can influence an individual's effort/reward utility. It can show how a person's affect can be predicted by their decision-making patterns.

Additionally, based on her effort/reward utility, accurate hypotheses can be drawn from her mood and emotional state. It can also show how their mood state influences their motivation and demand appraisal. It can reveal the point at which a person's effort/reward sensitivity in decision-making changes their vigor in performance. Future research in this area can show what type of arousal/valence mood states correspond with different decision-making behaviors. Finally, it may show what type of intervention can be included to make sure that despite a person's low arousal, they are still able to carry out tasks.

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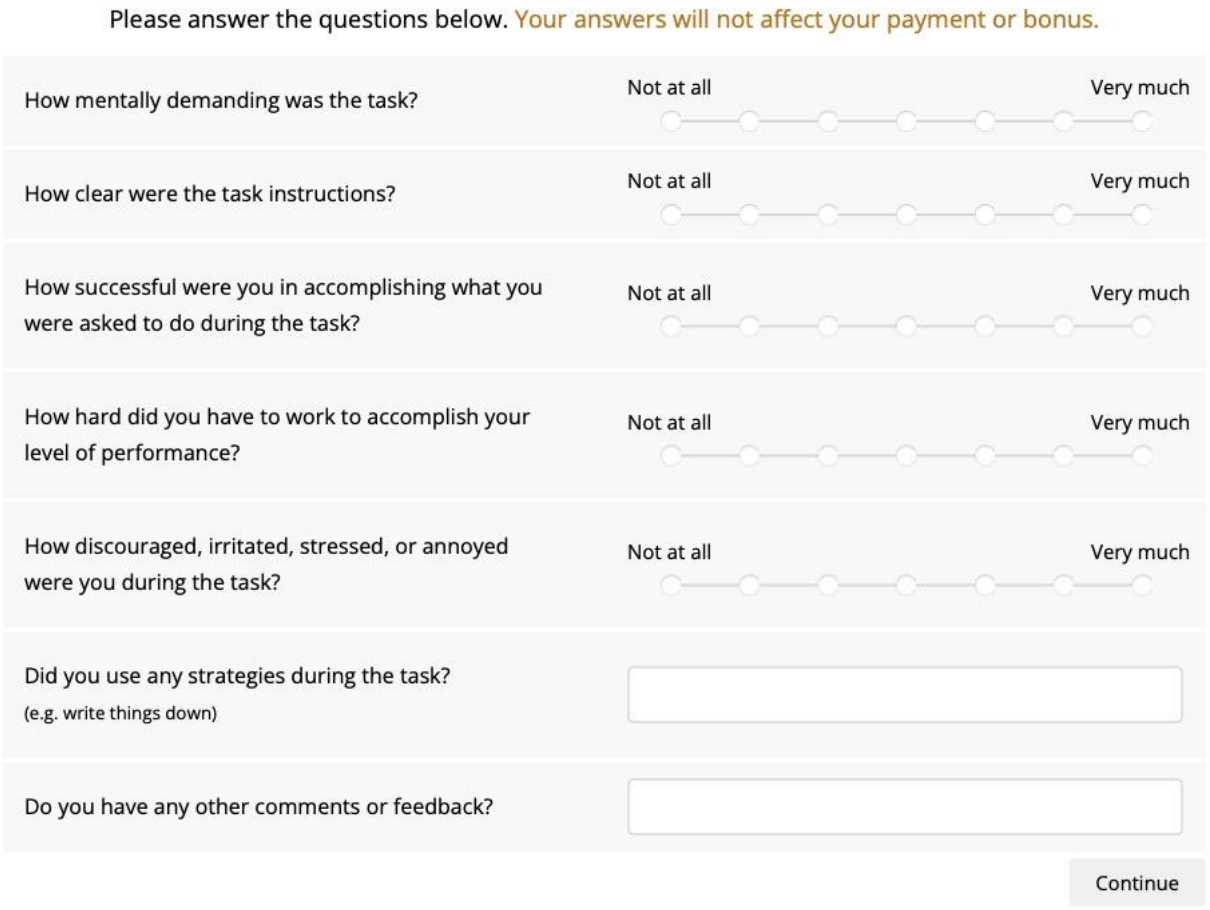
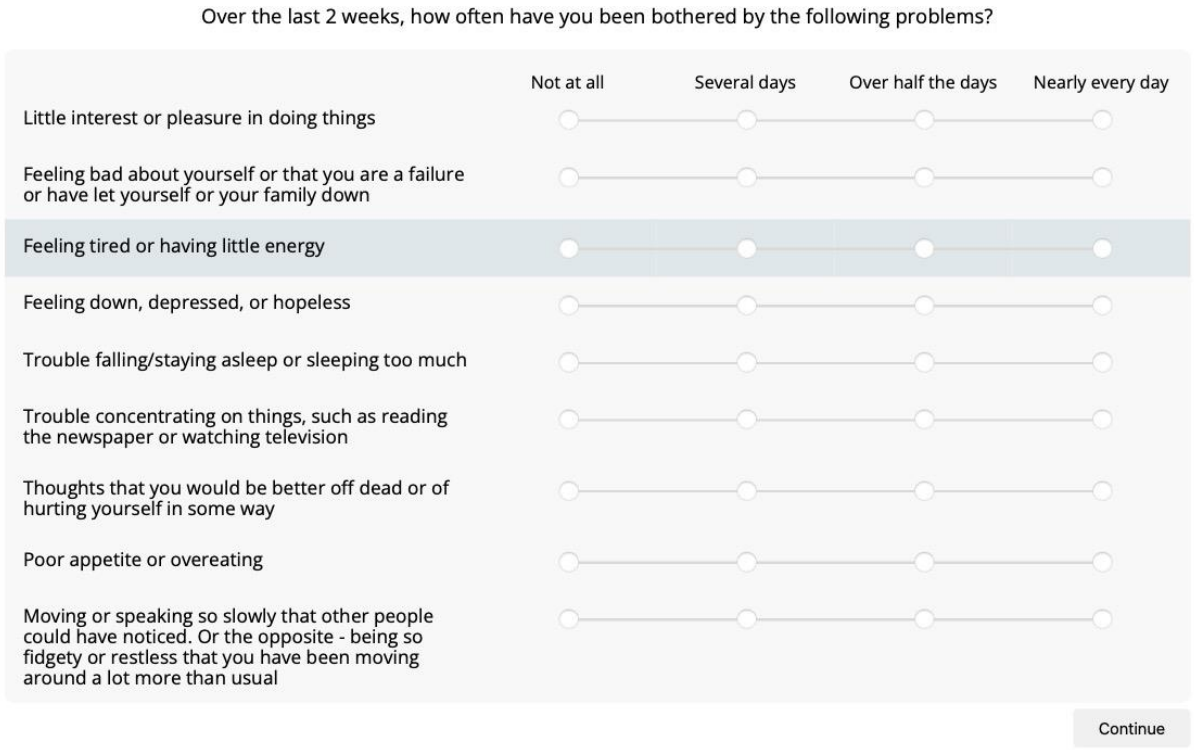
Appendix

Post Survey



PHQ9


Over the last 2 weeks, how often have you been bothered by the following problems?
Not at all
Several days
Over half the days
Nearly every day
Little interest or pleasure in doing things
Feeling bad about yourself or that you are a failure or have let yourself or your family down
Feeling tired or having little energy
Feeling down, depressed, or hopeless
Trouble falling/staying asleep or sleeping too much
Trouble concentrating on things, such as reading the newspaper or watching television
Thoughts that you would be better off dead or of hurting yourself in some way
Poor appetite or overeating
Moving or speaking so slowly that other people could have noticed. Or the opposite - being so fidgety or restless that you have been moving around a lot more than usual
Continue

ERQ

Emotion Regulation Questionnaire (ERQ)
Gross & John
9/03

The Emotion Regulation Questionnaire is designed to assess individual differences in the habitual use of two emotion regulation strategies: cognitive reappraisal and expressive suppression.

Citation

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

Instructions and Items

We would like to ask you some questions about your emotional life, in particular, how you control (that is, regulate and manage) your emotions. The questions below involve two distinct aspects of your emotional life. One is your emotional experience, or what you feel like inside. The other is your emotional expression, or how you show your emotions in the way you talk, gesture, or behave. Although some of the following questions may seem similar to one another, they differ in important ways. For each item, please answer using the following scale:

1----------2----------3----------4----------5----------6----------7
strongly disagree **neutral** **strongly agree**

1. ____ When I want to feel more *positive* emotion (such as joy or amusement), I *change what I'm thinking about*.
2. ____ I keep my emotions to myself.
3. ____ When I want to feel less *negative* emotion (such as sadness or anger), I *change what I'm thinking about*.
4. ____ When I am feeling *positive* emotions, I am careful not to express them.
5. ____ When I'm faced with a stressful situation, I make myself *think about it* in a way that helps me stay calm.
6. ____ I control my emotions by *not expressing them*.
7. ____ When I want to feel more *positive* emotion, I *change the way I'm thinking* about the situation.
8. ____ I control my emotions by *changing the way I think* about the situation I'm in.
9. ____ When I am feeling *negative* emotions, I make sure not to express them.
10. ____ When I want to feel less *negative* emotion, I *change the way I'm thinking* about the situation.

Note

Do not change item order, as items 1 and 3 at the beginning of the questionnaire define the terms "positive emotion" and "negative emotion".

Scoring (no reversals)

Reappraisal Items: 1, 3, 5, 7, 8, 10; Suppression Items: 2, 4, 6, 9.

GAD7


Over the last 2 weeks, how often have you been bothered by the following problems?
Not at all
Several days
Over half the days
Nearly every day
Being so restless that it's hard to sit still
Trouble relaxing
Not being able to stop or control worrying
Feeling afraid as if something awful might happen
Feeling nervous, anxious, or on edge
Becoming easily annoyed or irritable
Worrying too much about different things
Continue

Form for Collaboration in Senior Thesis Work

Indicate below whether all or part of your thesis resulted from work done collaboratively with one or more other people.

Collaboration	X
No Collaboration	

Statement of Collaboration

Dr. Jamie Chiu was my research mentor for this project and advised me on each aspect. My experimental design was a continuation of her pilot study, and she helped me map out the additions and execute the tasks. She also gave me a set of studies that laid the foundation for my literature review. The game was mainly coded by Aetizaz Sameer and Dr. Jamie helped troubleshoot. Dr. Jamie handled paying the participants and putting our experiment online. My experiment script was based on Christine Nguyen's work. Dr. Yael Niv helped me think through how to visualize my data. My data analysis was mainly coded by Dr. Jamie and Dr. Muhammad Al Amin. I also received some help from Yufei Qin.

Statement of Overlap

My senior thesis introduction, experimental design, and discussion were heavily influenced by a junior paper experimental proposal.

Form for Overlap in Senior Thesis and Previous Work

Indicate below whether there is any overlap between your Senior Thesis and earlier work that you did for Junior reports, Junior independent work papers, or papers for various courses.

Overlap	X
No Overlap	

Approval Form for Undergraduate Research Involving Human Subjects

The Institutional Review Board for Human Subjects (IRB) is charged by the University Research Board with the task of protecting the interests and rights of human subjects involved in Princeton research. The IRB's responsibility includes the oversight of research conducted by undergraduates as part of their Junior Independent Work and Senior Thesis work as well as that conducted in fulfillment of course requirements. All students conducting research involving human subjects as part of their Junior Independent Work or Senior Thesis must receive approval from the IRB before beginning their research. The sooner students submit their requests to IRB the sooner they will receive this approval. Students should be encouraged to submit their materials to the IRB as soon as possible in the semester. The IRB meets only once a month and it is common for student submissions to require revisions, primarily because of the incompleteness of the original submission, before receiving approval.

Did your Senior Thesis involve research with human subjects?

Yes X

IF YES, please include the IRB protocol number and protocol approval date below.

Protocol # 11968

Approval Date 4/16/2020

Approval Form for Undergraduate Research Involving Experimental Animals

All research involving experimental animals at Princeton University must receive prior approval from the Institutional Animal Care and Use Committee (IACUC). The IACUC bases its decision about approval on the NRC Guide for the Care and Use of Laboratory Animals. All students conducting research involving animals as part of their Junior Independent Work or Senior Thesis must receive approval from the IACUC before beginning their research. Students should consult first with their advisers about whether the procedures they intend to use are already covered by previously approved submission to the IACUC. The IACUC meets only once per month, and it is common for new submissions to require revision before receiving approval, so students are strongly encouraged to attend to IACUC issues early in their planning.

Did your Senior Thesis research involve the use of experimental animals?

Yes	
No	X