Gender and its Relation to Risk-taking

MSc, Cognitive Science

Data Science Final

May 2022

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Link to Code: AlainaMartine/DataScienceCode (github.com)

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Introduction

Why humans make the decisions and have the behaviors they do is still one of the more widely researched questions in this day and age, with many different aspects of behavior and choices being measured. One aspect of behavior that has been highly investigated over the years is risk-taking behaviors in humans and why these behaviors might occur. In trying to further understand varying human nature many risk-reward tasks have been run to analyze this. Furthermore, more specific studies have also investigated the variable of gender to see if any differences can be found between genders in the assessment of risk. This study serves to continue investigating this topic and looks into a risk-reward card task. This task assesses the choices people make in selecting cards with a monetary value and a "risk", or percent likelihood they would receive the money, along with doing this in a "fast" and "best" condition. This task is run on different genders and then analyzed using Bayesian Generalized Linear Mixed Models with the hopes of seeing whether males or females tend to be riskier, and possibly assessing the reasons why. The benefits would be to see if one gender does show less risky choices, if this can then be used to incorporate teachings into society to prevent risky behavior and alleviate issues such as excessive drinking and gambling, which are often associated with risk. Based on previous literature, which is described further below, it is predicted that females will tend to engage in less risky behavior overall and use more patterns associated with thoughtful decision-making in the card task.

Background

Risk-taking and Impulsivity

Risk-taking has been around as long as humans, and despite the potential problems it is associated with, there still seems to be difficulty in finding solutions to allow more thoughtful and rational human behavior. But what exactly is "risk-taking", and the rewards associated with it? Well, when it comes to research, there is quite a lot of evidence to define what exactly "risk-taking" entails. Risk-taking is usually defined as a form of engaging in risky tasks and impulsivity, with impulsivity being defined as "a predisposition toward rapid, unplanned reaction to internal or external stimuli without regard to the negative consequences of these reactions" ("What is Impulsivity?"). There are also studies arguing different facets of impulsivity associated with risk-taking as well including "negative urgency (e.g., rash action to negative emotion); premeditation (e.g., lack of forethought); perseverance (e.g., sustain attention); sensation seeking (e.g., seek out novel/ thrilling experiences); positive urgency (e.g., rash action to positive emotion); impulsive action (e.g., the inability to inhibit a prepotent response); and impulsive choice (e.g., impulsive decision making)" (Stamates & Lau-Barraco, 2018). Furthermore, risk-taking and impulsivity are also known to differ between humans due to different brain functioning (Rolls, Wan, Cheng, & Feng, 2022). There is also a large difference between age groups, especially adolescents who consistently score higher in impulsivity measures and are more affected by risk-reward tasks than other age groups (Bjork & Pardini, 2015). However, despite age differences, neurological aspects of risky behavior seem to fall in the common area of the medial orbitofrontal cortex for most people (Rolls et al., 2022). This part of the brain has been found to be associated with reward as seen in a study where the neurons in this region

stopped firing as primates became more satiated when drinking food and water (Grabenhorst & Rolls, 2011). This is strongly associated with risk-reward tasks where the reward can drive risky behavior, potentially to extremes (Grabenhorst et al., 2011). Studies have also found an opposite area in the brain, the lateral orbitofrontal cortex, which when having low connectivity is associated with non-reward and punishment (Grabenhorst et al., 2011). This could potentially serve as an area to minimize and reduce risky behavior. So, from this, risky behavior can be found in everyone, but to different extents in age groups and is affected by varying personality factors. However, despite being fairly prevalent in human nature in general, risky behavior and reward-seeking can result in detrimental issues, such as death, due to addictive patterns that can result from reward-seeking. This makes these behaviors often dangerous, often inspiring research that investigates ways to curb and minimize engagement in these behaviors and understand why they occur.

Problems with Risk-taking, Reward-seeking, and Impulsivity

Reward-seeking, while common in humans, can lead to a multitude of issues if done in excess. Many of these issues entail engaging in risky behaviors or over-performing pleasurable tasks to the point addiction can occur, with some common ones being alcoholism and gambling. One study investigated participants who completed a self-survey assessing their risky and impulsive behaviors and then assessed their drinking habits. From this, it was found that those who drank more overall also had increased risk-taking behavior, especially behaviors with more extreme drinking such as binge drinking (Stamates & Lau-Barraco, 2017). Another study also investigated impulsivity rated by participants and their past 6-month use of alcohol, tobacco, or marijuana and found that higher self-rated impulsivity was linked to increased drug use as well (Chuang et al., 2017). Finally, gambling has also been found to be associated with impulsivity and reward-seeking behavior. Some researchers specifically performed a longitudinal study that measured males from 10-12 years of age with reported behavior and impulsivity issues along with anxiety and SES. They then investigated these males into adulthood and found that those who measured above the 70th percentile on impulsivity at a young age were six times more likely to become problem gamblers into adulthood (Vitaro, Arseneault, & Tremblay, 1999). From all this, it is clear that impulsivity, reward-seeking, and risk-taking can have large effects on engaging in problematic behaviors that can negatively impact the quality of one's life, even in the long-term. However, despite the severity, there does appear to be differences in certain groups, especially gender, which is investigated next.

Gender Differences

Interestingly enough, research has found that despite similar situations, females seem to consistently be less affected by impulsivity and engage in less risky behavior than males overall (Charness & Gneezy, 2012). Investigating this can offer a good insight into solutions by exploring the factors that females might possess to reduce this risk-taking. Ideally, perhaps research on this in the future can be used to curb human risk-taking and help the population remain safer. One study that demonstrates gender differences was performed in which both Spanish and American masters' students were investigated to see differences in risk-taking

between both cultures and genders within cultures. This study used a risk-taking measure choice dilemmas questionnaire. ANOVA was run and it found between both groups, Spanish and Americans that females consistently tested lower on risk-taking behavior (Zinkhan & Karande, 1991). Furthermore, in another study conducted on students taking an SAT, risk-taking was measured and compared between males and females (Ramos & Lambating, 1996). In this study, students took a mock SAT which involved penalizing students for guessing on questions and offering a zero just for leaving them blank. The study then ran males and females through to see if there would be more guessing, which was defined as risk-taking behavior, between the groups and found males, even when not sure about questions, were more likely to guess (Ramos et al., 1996). Females, on the other hand, were more likely to omit or leave answers blank rather than risk penalization (Ramos et al., 1996). Females have also been found to be risk-averse when handling financial or investment situations. One study investigated multiple previous studies on investment and analyzed the investment behavior of males versus females. From this, it found females tended to choose less risky investments and invest smaller quantities of cash than males do (Charness et al., 2012). Finally, in a phone study conducted in Alabama, it was found that females have a higher perceived risk in certain driving tasks and are more likely to be risk-averse (Rhodes & Pivik, 2011). However, despite this, it should be noted that some studies have found no difference between gender. This includes one study investigating risk-taking in extreme sports, where no difference was found between men and women in risk-taking behavior (Frick, 2020). However, this could possibly be argued to be a result of the fact that it is the riskiest population group for both genders, in which risk might plateau at the highest amount for both versus the usual measurements of the standard population. Based on all this, gender seems like a promising factor to investigate for curbing risk-taking behavior and in this study.

Experiment

Based on females being found to be less prone to risk-taking in previous litertaure, this experiment serves to look into gender differences in risk-taking through a risk-reward task. This experiment is based on the experiment performed by Leuker, Pachur, Hertwig, & Pleskac (2019) in investigating risk-reward structures and the simplification of information processing during risky tasks. This task has been adopted and adapted to specifically focus on risky behavior between the different gender participants. It uses their original dataset, including participants, and experimental methods for the risky behavior task, but looks at gender, along with altering their analysis in order to investigate specifically gender and risk-taking. In this task, participants are given cards that list both an amount of money and a percentage likelihood of receiving said money. An example could be a €20 card that has a .8, meaning an 80% likelihood of receiving that money. These cards were also categorized by positive correlation, in which the value of the card went up with the percentage, negative correlation, in which the card value could go up but the percentage likelihood of receiving it went down, or uncorrelated, in which the card's money and percentage were not correlated with one another. Participants were presented with these patterns in the beginning however, they were not explicitly told about the correlations. This served to introduce the idea that patterns could occur. Then participants were put in either a “fast” group, where the goal was to make the highest expected value (EV) choice the quickest, within 1.5 seconds or the “best” condition in which time did not matter, just optimizing the amount of money did. This was to measure if when presented with patterns initially if

participants then used these potential shortcuts to improve how quickly and optimally they could make decisions. One portion of the experiment was divided 60% into “test gambles” which included various random payoff-probability conditions with no patterns. “Environment gambles” (40%) were then selected which were then consistent in presenting one risk-reward style (such as positive or negative correlation). These were mixed with the test gambles to reinforce the condition-dependent risk-reward structure. The goal was for participants to try to maximize their expected value (EV) but also adhere to their conditions, such as being quick to answer in the “fast” group. Eye-tracking was measured to assess where people looked when making the different decisions and potentially assess their behavior concerning optimizing their money or taking any mental shortcuts. Based on previous literature, we predicted women overall to make better and less risky choices, meaning they would do better on the measures associated with maximizing the value of the cards.

Methods

A total of 92 participants were run with 54 females and 38 males. Participants were compensated a fixed rate of €12 for performing this task along with a bonus on their performance in the choice task ranging from €1.13–€10.04.

Data Pipeline

The pipeline created for this project was written in R. It uses an original csv file from Leuker, Pachur, Hertwig, & Pleskac (2019) that has been modified to create individual male and female data files. These files are then run through R using Bayesian Generalized Linear Mixed Models for Stan to perform a regression analysis on the data (Stan Development Team, 2016). This produces an output from the data including the mean posterior distribution of the parameter, or statistic of interest, along with two-sided 95% credible intervals. These results are then able to be compared across gender and reported in the paper.

Choice Task

The main task performed is the choice task, in which participants were presented a card with the values of money and a percentage likelihood of receiving the money. They had two options that listed “p chance of winning x, otherwise nothing.” Participants were instructed to make the best decision between the two values offered and had to decide quickly (1.5s) for the “fast” condition. They also had rounds in which they were requested to make the “best” decision. The cards were presented in interleaved blocks with 16 choices per block. If the fast condition took too long to make a choice, they would lose their opportunity to later compete in a bonus round. Participants completed five practice trials for both conditions, and the positions of the gambles were randomized. This choice task consisted of test gambles (60%) which were identical across risk-reward conditions and uncorrelated. The other gambles (40%) were constructed based on the risk-reward structures (positive or negative). The set of gambles appeared twice for each participant once in the “best” trials and once in the “fast” trials.

Analysis

Eye-tracking was done by collecting binocular eye position data with an Eyetribe tracker sampled at 60 Hz. PsychoPy 1.83.01 and Pytribe were used (Dalmaijer, Mathôt, & Van der Stigchel, 2013). Participants sat 60 cm from the computer monitor and their eyes were calibrated with a 9-point grid before each task. Samples were preprocessed by parsing eye saccades and fixations. Fixations were plotted over time for each individual. A Bayesian Generalized Linear Mixed Models for Stan in R was used for regression analysis (Stan Development Team, 2016). The mean posterior distribution of the parameter, or statistic of interest was reported, along with two-sided 95% credible intervals. For these reports, four aspects were investigated to compare gender differences. Specifically, we looked at areas of interest (AOIs), response time, expected value choices, and within-gamble transitions. AOIs were defined as non-overlapping rectangles from the center of the screen highlighting important areas to gather information where participants' eye-tracking occurred. Response-time analyzed how quickly participants made their choices, while expected value choices analyzed how well participants optimized the value of the cards, and the expected value they thought they would get. Finally, within-gamble transitions specified how many attributes participants used to make a choice, an example being if they made a quicker choice they might just look at the money and not the percentage assuming it had been positive correlations, and thus looked within the cards less. All of these are compared to the baseline of the uncorrelated condition. For our hypothesis, we would expect to see women make less risky choices meaning they would have higher values for most of these than males. They would have higher expected value overall due to optimizing decisions and being less risky in their choices, more AOIs due to gathering more data with eye-tracking before making a choice and investigating areas of interest, and more within-gamble transitions due to looking more at everything in the card and not just one part and making a choice. However, response time is predicted to be longer for females due to a predicted longer assessment of the cards before choosing.

Results

Expected Value

For expected value in the “best” condition females had .13[.12, .15] with the numbers representing the mean and the 95% credible intervals of the posterior distributions. The numbers for the negative card correlation in the “best” condition were -0.26[-.45, -.07] and the positive correlation was -.21[-0.41, -0.02]. These numbers were taken with the uncorrelated condition as the baseline, which is why some negatives can be seen. The expected value for males in the “best” condition were 0.14[0.13, 0.15] with the negative correlation results being -0.40[-0.70, -0.10] and the positive correlation results being -0.40[-0.68, -0.12].

Females in the “fast” condition had an expected value difference of 0.06[0.05, 0.06]. The negative correlation condition was -0.28[-0.44, -0.13] and the positive correlation condition was -0.20[-0.36, -0.04]. For males in the “fast” condition the expected value difference was 0.06[0.06, 0.07]. The negative correlation condition was -0.18[-0.46, 0.10] and the positive correlation condition was -0.21[-0.47, 0.05].

Response Time

For response time, females in the “best” condition had an expected value difference of -0.02[-0.03, -0.01]. The negative correlation condition was -1.00[-1.68, -0.32] and the positive correlation condition was -0.69[-1.38,0.01]. Males in the “best” condition for response time had an expected value difference of -0.02[-0.03, -0.02] with the negative condition being -0.67[-1.41, 0.08] and the positive condition being 0.46[-0.24, 1.16].

Response time for females in the “fast” condition the expected value difference was 0.00[0.00, 0.00]. The negative condition was -0.11[-0.18, -0.03] and the positive condition was -0.05[-0.12, 0.03]. For the males in the “fast” condition of response time the expected value difference is 0.00[0.00, 0.00] with the negative condition being 0.00[-0.08, 0.08] and the positive condition being 0.04[-0.04, 0.11].

Areas of Interest

For areas of interest females doing the “best” condition had the expected value difference of -0.004[-0.007, -0.002]. The negative condition was -0.098[-0.411, 0.218] and the positive was 0.196[-0.134, 0.530]. Areas of interest for males in the “best” condition had an expected value difference of -0.004[-0.007, -0.002] with the negative condition being -0.635[-0.016, -0.254] and the positive being -0.096[-0.455, 0.265].

For the “fast” condition the expected value difference for females is -0.003[-0.004, -0.001]. The negative condition is 0.077[-0.258, 0.411] and the positive is 0.382[0.039, 0.727]. For males in the “fast” condition the expected value difference is -0.004[-0.006, -0.002] and the negative condition being -0.625[-1.121, -0.128] and the positive being -0.172[-0.637, 0.291].

Within-gamble Transitions

For within-gamble transitions females in the “best” condition had an expected value difference of -0.008[-0.012, -0.004] with the negative condition being -0.194[-0.659, 0.278] and the positive condition being 0.010[-0.472, 0.489]. For males in the “best” condition the expected value difference of the within-gamble transitions was -0.013[-0.017, -0.008]. The negative condition was -0.710[-1.287, -0.131] and the positive condition was 0.001[-0.545, 0.546].

For the “fast” condition the expected value difference for females was -0.002[-0.003, -0.001] with the negative condition being -0.017[-0.157, 0.122] and the positive being 0.090[-0.053, 0.233]. For males in the within-gamble transitions and in the “fast” condition, the expected value difference was -0.001[-0.003, 0.000] with the negative condition being -0.255[-0.458, -0.051] and the positive condition being -0.061[-0.252, 0.133].

Discussion

Expected Value

As can be seen, there appears to be some data that supports the hypothesis, as well as discrepancies. It was predicted that females would do better in optimizing the expected value based on previous research showcasing females taking fewer risks. However, for the expected value, it appears males and females have similar values for the expected value difference, as seen in the "best" condition. However, when looking into the negative and positive correlation conditions, we see that males tend to do slightly worse than the females, meaning they did not select cards with the most optimal values as well as females did in the "best" condition. However, both males and females seemed to fall in the negative values meaning it was lower than the uncorrelated condition. Perhaps this has to do with participants over assuming the expected values of the cards based on previously learned patterns (negative and positive correlation) and perhaps answering with less thought for both groups than the uncorrelated due to depending on these patterns, resulting in less optimal choices. The "fast" condition also had negative values for both groups, and males did better in the negative correlation condition but not the positive. Based on this, it appears there isn't a definitive gender difference in obtaining the more optimal expected value of the cards, although it can be noted that females perform slightly better than men in all but one instance.

Response Time

For response time, it was predicted that males would overall respond quicker due to the higher levels of risk-taking in males in previous research. For the "best" condition males did in fact have a quicker response time and even had positive values while females had negative. This was also seen in the "fast" group with males performing quicker than females in both correlation conditions as well. Both males and females did perform quicker overall in the "fast" trials when compared to the "best" trials, as well, which would be expected. From this, it appears this does confirm our hypothesis of males selecting their choices quicker.

Areas of Interest

For AOIs it is predicted that females will have higher values due to more data gathering and eye movements performed before making their final decisions on what to pick. This is seen in the "best" and "fast" conditions very firmly in the data analysis with females having fairly higher numbers than males. In fact, most of the female numbers are positive while male values are negative which shows fairly strong evidence to support the hypothesis that females do utilize eye tracking to detect more AOIs than their male counterparts.

Within-gamble Transitions

It is also predicted that females will have higher within-gamble transitions than their male counterparts, meaning they will look between the different card values more. This seems to be confirmed in the "best" and "fast" conditions where females do in fact, tend to score higher than males in both conditions. This means they look between cards more and take into account both percentages and monetary values more than just depending on one based on the given pattern.

Limitations

One limitation of this study is the small sample size being utilized. From this, any outliers can significantly impact the data meaning that future research should be performed with a more broad and increased scope of participants to assure the accuracy of the results.

Conclusion

Overall, it appears in an optimization of expected value card task, that female participants do in fact tend to make less risky choices than their male counterparts, as the hypothesis predicted. Females tend to take more time making a choice when selecting cards, have more eye-tracking in looking at AOIs on the cards before making a decision, and have more within-gamble transitions when measuring eye movements of looking at points between cards. This was seen consistently in both the "best" condition, where the goal was to receive the most money and the "fast" condition where limited time to select cards was also required. However, there were some discrepancies in the expected value results. Females tended to do better in the "best" condition for the expected value, however, males seemed to do better in the "fast" component. Despite this, both groups had fairly low scores when compared to the uncorrelated condition. This could possibly be due to simplification in using the learned correlation in the condition groups (such as positive correlation knowing a higher percentage will have a higher monetary amount) to an extent that resulted in less careful thought when selecting the cards. Despite this, overall, it does appear that females tend to have less risky behaviors when making decisions as seen in the longer response times, more AOIs being observed, and more within-gamble transitions occurring. This implies promising future research to investigate this possible risk difference between genders and look into possible causes, such as genetics versus societal circumstances, and see if these differences can be used to keep the populations safer. Overall, the hope is this could be used to reduce harm and death through risky behaviors, especially in those behaviors highly associated with risks, such as gambling and excessive drinking.

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