The Effect of Color on Monetary Decisions Regarding Risk

Danielle Shorenstein

Advised by Ifat Levy

Yale University

Correspondence to:

Danielle Shorenstein

Yale University

Email: Danielle.shorenstein@yale.edu

ABSTRACT

People tend to be risk averse when making monetary decisions (Daniel Bernouli, 1738; John Pratt, 1964; Kenneth Arrow, 1965), generally preferring an economic option with lower risk (e.g., a 100% chance of $5) over an option with the same expected payoff but higher risk (e.g., a 50% chance of $10). The present study investigates the effect of color on these decisions for all-male participants. Color has previously been revealed to have several effects on human cognition and behavior (Elliot & Maier, 2012). This is especially true for the color red (Mehta & Zhu, 2009; Hagemann, Strauss, & Leißing, 2008), which has been associated with aggression and dominance for males in a competitive context (Hill & Barton, 2005) and with impaired cognitive ability on achievement tasks (Elliot, Maier, Moller, Friedman, & Meinhardt, 2007). The current study applies the effect of red in the realm of economic decision-making; specifically, when men are offered a risky choice (for example, a 75% chance of gaining $12) versus a sure gain of $5. The previous aggression results suggest that red may make males more risk-seeking in monetary decisions, whereas the previous cognitive ability results suggest that red may impair males' ability to make the best monetary decisions. I find support for only the second of these effects: red impaired participants' ability to make the best monetary decisions. This study provides the foundation for research in how color could affect economic decisions regarding risk.

TABLE OF CONTENTS

SECTION I: INTRODUCTION

Color is one of the most salient features in our visual field, yet we rarely think about the effects that color has on the judgments we make. People often focus on the aesthetic aspect of color perception without recognizing that through biologically engrained and learned associations, color carries meaning. Color thereby automatically and unconsciously influences psychological functioning and affects behavior (See review by Elliot & Maier, 2012). A lot of research over the past decade has shown how color affects perception, cognition, and behavior (see review by Elliot & Maier, 2012). Most of these studies explore color's effects in the context of competition, achievement, attention, creativity, and attraction; however, little research has been done on how color affects economic decisions, and more specifically, economic decisions which involve risk assessment.

Risk is present in any investment decision that individuals make. According to rational economics, people should prefer investments with the highest risk-adjusted returns. However, most modern economic theories, including expected utility theory and prospect theory, assume that people are risk averse when making risk-related decisions regarding monetary gains. If two different investments have the same expected return based on their risk-return profiles, people generally choose the lower risk investment (Bernouli, 1738/1954; Pratt, 1964; Arrow, 1964).

There may be certain contexts that influence people's risk attitudes. For example, studies have shown that risk-related economic decisions can be influenced by internal states such as ones' current emotional state (Loewenstein, Weber, Hsee, & Welch, 2001) and hunger level (Symmonds, Emmanuel, Drew, Batterham, & Dolan, 2010; Levy, Thavikulwat, & Glimcher, 2013). Just as hunger and emotions have a pervasive effect on our judgments and decisions, so too does color. It is therefore possible that the context of color could influence monetary

decisions that are made regarding risk. This study seeks to assess how the context of red (versus blue) can affect men's decisions and risk preferences regarding monetary gains.

This research has real world implications as well as implications for past academic research conducted regarding risk preferences. Real world implications include the influence of the context of color when people are gambling (an activity requiring decisions involving risk) as well as the context of color used in marketing and everyday purchases. This research could also call into question past academic studies that use colors (and especially red) as a visual aid in their experimental design to investigate decisions made regarding risk.

SECTION II: THEORETICAL FRAMEWORK

2. 1 Risk Aversion

We are often faced with decisions where we must choose between outcomes that are uncertain. When we can accurately assess the probabilities for different outcomes (for example when we toss a fair coin, or spin a roulette wheel), this is called *risk* (Glimcher, 2008) and the *expected value* (EV, or the product of probability and amount, see Glimcher 2008 and Weber & Camerer 1987 for reviews) can be calculated. If people were *risk neutral*, then, when choosing between risky options, they would always choose the option with the highest expected value (this is the classical economic approach founded by Pascal, 1670/1966).

Research, however, has shown that risk-related decisions are most often subjective; both men and women tend to be *risk averse* (Bernoulli, 1738/1954; Holt & Laury, 2002). Risk aversion means that when faced with uncertainty, we attempt to reduce that uncertainty, leading us to accept a more certain expected payoff than a payoff that is less certain, but has a higher EV (Bernoulli, 1738/1954). Therefore, when presented with two different investments with a similar

expected return, people will prefer the option with lower risk (Bernouli, 1738/1954; Pratt, 1964; Arrow, 1964; Holt & Laury, 2002). Expected-utility theory, termed "EU," posits that people make choices under risk by assessing the likelihood of all the possible outcomes and subsequently integrating this information in order to arrive at the decision with the highest subjective value (Bernouli, 1738/ 1954; Neumann & Morgenstern, 1947). EU takes into account people's hesitancy towards taking large risks, which often leads people to choose an investment that is low risk, but has a lower EV than an alternative high-risk investment that has a higher EV. For example, when faced with a choice of gaining $50 for sure or a 50% chance of gaining $120, people will often choose the sure gain of $50, even though the EV of the risky option ($60) is higher (Abdellaoui et al. 2007).

Risk preferences can be tested in the laboratory using an experimental design with paired lottery choices. The majority of participants are risk averse even when the payoffs are less than $5 (Holt & Laury, 2002; Levy et al. 2010). When payoffs are hypothetical, risk preferences do not tend to change as the payoffs increase; however, when payoffs are paid in cash, people tend to become more risk averse as the payoffs increase (Holt & Laury, 2002).

2.2 Color & Psychological functioning

According to Elliot and Maier (2012), color carries meaning and automatically and unconsciously influences peoples' psychological functioning. The meanings associated with different colors are grounded in two sources. First, biologically engrained responses to color have developed through evolutionarily beneficial responses; second, through conditioned learning, we associate colors with the item or idea that they tend to be paired with and these learned associations influence our behavior (Elliot & Maier, 2012). Colors that have longer

wavelengths (i.e. red and orange) tend to be arousing, whereas shorter wavelength colors (i.e. green and blue) are calming (Stone & English, 1998). Red is often associated with mistakes (teachers circling answers that are wrong on tests in red ink) as well as danger (a red stop sign, sirens, or a warning signal) (Elliot, et al., 2007), and is associated with aggression and dominance in men (Edward & Duntley,1939; Hill & Barton, 2005; Edwards, Hamilton, Duntley, & Hubert, 1941). In contrast, blue tends to be associated with the ocean and sky, entities that promote openness, tranquility, and peace (Naz & Epps, 2004). We make these associations automatically and process color without intention or awareness (Ling & Blades, 1996; Patel, Blades, & Andrade, 2002).

Color often carries different meaning in different contexts. Elliot and Maier's review (2012) sets up a model of how color influences psychological functioning called the color-in-context theory. We associate colors with the item or idea that they tend to be paired with and these learned associations influence our behavior (see review by Elliot & Maier, 2012). Colors, however, can have different meanings in different contexts. "Context" is defined as "the set of circumstances that frame a color and determine its meaning in integrated fashion" (Elliot & Maier, 2012). In the current experiment, red can carry different meanings and influence behavior in different ways depending on if it is viewed in a competitive context for males, or an achievement context.

2.2.1 Red association with aggression in competitive contexts for males. Studies have shown that red is associated with aggression and dominance for males (Hill & Barton, 2005). Data from a popular multiplayer first-person-shooter computer game showed that red teams won significantly more often (54.9% of matches) than blue teams (45.1% of matches) (Ilie, Ioan, Zagrean, Moldovan, 2008). Well-matched taekwondo, boxing, and wrestling contestants in the

2014 Olympic Games had a higher probability of winning when they were randomly assigned to wear red versus blue outfits (Hill & Barton, 2005a). Further analysis of this Olympic data found that the red-association winning bias was solely apparent in men (Hill & Barton, 2005b). Even when males just imagined themselves competing in a taekwondo match against an opponent wearing red (versus blue), they perceived their opponent to be more dominant and threatening (Feltman & Elliott, 2011). Red also seems to confer an advantage in team sports, with the team wearing red winning more often than teams wearing other colors; since 1947, English male soccer teams wearing red uniforms have been champions more than expected by chance compared to teams wearing non-red uniforms (Atrill et al., 2008). Color even affects the evaluation of performance in the realm of competition. Male referees assign more points to taekwondo competitors dressed in red than those dressed in blue in a video-manipulated experiment (Hagemann, Strauss, & Leißing, 2008).

The effect of red improving performance in competition could be attributed to the fact that red is a signal of dominance in many species and may also be a sign of dominance and aggression in men, as well (Hill & Barton, 2005a). Literature on non-human species suggests that red often indicates dominance in males and induces aggression (Pryke, Andersson, Lawes, & Piper, 2002*;* Cuthill, Hunt, Cleary, & Clark, 1997*)*. Red coloration is associated with dominance in fish (Millinski & Bakker, 1990*),* birds (Pryke & Griffith, 2006), and non-human primates (Setchell & Wickings, 2005; Waitt et al., 2003*)*. By experimentally manipulating the color of finch's head masks through attaching an artificial red stimulus, the red-headed males dominated both the black-headed and yellow-headed birds in competition for food (Pryke & Griffith, 2006). Red is also naturally associated with aggression and dominance in men because a red complexion reflects testosterone levels (Edwards & Duntley, 1939; Edwards, Hamilton, Duntley,

& Hubert, 1941). Further, anger increases blood flow to the face, causing a ruddy complexion, whereas fear causes a decrease in blood flow to the face, leading to a pale complexion (Drummond, 1997; Drummond & Quah, 2001). This biological response implies that increased ruddiness during aggressive interaction may be a sign of relative dominance (Hill & Barton, 2005). Past research has interpreted the results of the associations of red with dominance in competitive sports as exploiting the automatic and innate responses of red as a sign of dominance in the natural world (Burley, Krantzberg, & Radman, 1982; Cuthill et al., 1997).

Research has thus shown the psychological effect on male behavior when red is involved in competitive environments. However, little research has shown the effect of red on economic decisions. Bagchi and Cheema (2013) conducted a study on color and its effects on willingness-to-pay in auctions and negotiations. In their first experiment, Bagchi and Cheema (2013) found that when auctions are presented on a red (versus a blue) background, people make higher bid jumps on eBay, eliciting higher overall bids. In their second experiment, Bagchi and Cheema found that a red (versus blue) background elicited lower price offers in negotiations. They attribute this effect to red inducing aggression through arousal. If red in fact does influence aggression through arousal, then it is likely that red (versus blue) will also affect risk preferences, with males becoming more risk seeking in the presence of red.

2.2.2 Red impairs ability in achievement contexts. Research by Elliot et al., (2007) suggests that red impairs both male and female's ability in achievement contexts. Through classical conditioning, we learn that red tends to be associated with mistakes (teachers circling answers that are wrong on tests in red ink) as well as danger (a red stop sign, sirens, or a warning signal, Elliot & Maier, 2007). These associations of red with mistakes and danger could have developed from the evolutionary inclination of many species to view red as a sign of danger. For

example, red on the chest or face of primates is a sign of testosterone and also signals a high status and thus a danger to any potential opponent (Setchell & Wickings, 2005). According to Elliot et al. (2007), due to these learned associations, in an achievement context, red carries the meaning of the psychological danger of failure which leads to an avoidance motivation and a resulting negative impact for achievement outcomes.

Studies have confirmed the association of red with avoidance and a resultant decrease in performance in achievement contexts. Elliot, Maier, Binser, Friedman, & Pekrun (2009, experiment 1) found that participants shown red (versus green or gray) on the cover of an IQ test physically moved their bodies further away from the test. Moller, Elliot, & Maier (2009) found that participants are faster at categorizing failure words presented in red than failure words presented in green, and that red is positively associated with failure and negatively associated with success. Elliot, et al., (2007, experiments 1-4), participants were faster at solving anagrams shown in green or black versus red. Further studies by Elliot et al. (2007, experiments 5) showed that when participants were primed with a red (versus a green or gray) cover page, they chose to take a test that had more easy items on it than moderately difficult items (Elliot et al., 2007, argues that selection of easy items indicates an avoidance motivation). In a last set of experiments by Maier, Elliot, & Lichtenfeld (2007), when participants were shown a red (versus gray) cover page of an IQ test, they performed worse on the test. All of these studies show that red in an achievement context carries the meaning of psychological danger and leads to an avoidance motivation that impairs performance.

SECTION III: GOALS OF THE PRESENT STUDY

The present study investigates how the context of color, specifically red (versus blue), can affect risk preferences. Most theories of choice regarding risk and uncertainty assume that people make decisions based on cognitive functioning. However, the risk-as-feelings hypothesis states that the affective experience during the decision-making process can also influence peoples' decisions (Loewenstein et al., 2001). Loewenstein et al. (2001) showed that emotional reactions to risky situations often differ from peoples' cognitive assessments of those risks. Hunger is another contextual state that influences risk attitudes towards economic decisions; people become more risk averse when they are satiated and less risk averse when they are hungry (Symmonds et al. 2010; Levy et al., 2013). If different contextual states (i.e. mood and hunger) influence how people respond to risky choices, and color has been shown to influence judgments and decision-making, then it is also possible that the context of color can influence behavior regarding risk.

To determine whether males' risk preferences regarding monetary decisions are affected by the context of red, I ran an experiment involving choices between a fixed sure gain and a series of lotteries with different payoffs and different levels of risk (similar procedure to Levy et al., 2010). A simple way to infer risk aversion is to analyze behavior for choices between different lotteries (Holt & Laury, 2002; Levy et al., 2010). In the current study, male participants make a series of binary choices between risky gambles (for example, a 75% chance of gaining $12) or accepting a sure gain of $5. Only male participants are used in this study because the color red tends to affect men more than it affects women, especially in the context of aggression (Hill & Barton, 2005; Hagemann et al., 2008; Atrill et al., 2008). I manipulated the color used (red or blue) in the representation of the lottery probabilities, in order to see whether red

influenced behavior regarding risky monetary decisions. In the "red trials" lotteries were shown with probabilities in red and white. In the "blue trials" lotteries were shown with probabilities in blue and white.

There are two proposed sets of hypotheses depending on which context is activated: an aggressive, competitive context, or an achievement context. The *red-aggression* hypothesis (H1), consistent with Bagchi & Cheema's research (2013) states that the presence of red will make men more aroused and aggressive, thereby making them more risk seeking. *The red-impairs-ability* hypothesis (H2), consistent with Elliot et al.'s, work (2007), states that the presence of red will impair participants' ability to make monetary decisions regarding risk which are most beneficial to them in terms of objective value. I will go into further detail for the hypothesized results in the results section.

SECTION IV: METHODS

4.1 Participants:

Participants included healthy male Yale undergraduates (n=22), ages ranging from 18 to 22 (M=20.00, SD=1.27). I excluded one participant because he failed to make a choice on many of the trials. Participants received $10 for taking part in the study as well as an additional payment based on their choice in a randomly selected trial.

4.2 Procedure:

I used a similar procedure as Levy et al., 2010, involving a computer game with binary choices between risky lotteries and a sure gain. After consenting to the study, participants received $10 and were given instructions for how to play the computer game, followed by

practice questions to ensure that they fully understood the task. Participants were told that in each trial, they would be presented with a lottery shown alongside a sure gain (which was always $5). Different trials would have varying risk levels and different winning amounts. Participants were instructed to select whether to "play the lottery" or accept the sure gain of $5. In half of the trials, the lottery was shown on the right side of the screen and the sure gain on the left, and in the other half, the lottery was shown on the left side of the screen and the sure gain on the right. Participant's choices were recorded with "1" for the option on the left and "2" for the option on the right.

There were two different types of trials: red trials and blue trials. In red trials, the lotteries appeared on the screen in the form of a bag that had a certain number of red and white chips totaling 100; in the blue trials, the lotteries appeared on the screen in the form of a bag that had a certain number of blue and white chips totaling 100. There were 7 different lotteries for both red and blue trials with winning probabilities of: 13%, 25%, 38%, 50%, 62%, 75%, and 87% (see Figure 4.1 below for all of the different lotteries). I showed the participant that all of the bags that he saw on the screen represented physical bags that had the number of red/blue and white chips as were shown by the shaded regions on the screen.[1] The participant had the opportunity to examine the contents of each bag if he wished.

[1] We used these physical bags to make sure that the participants knew that they would have a chance to play one of these lotteries out to earn more money. People tend to be more motivated when payoffs are real (Smith, 1991).

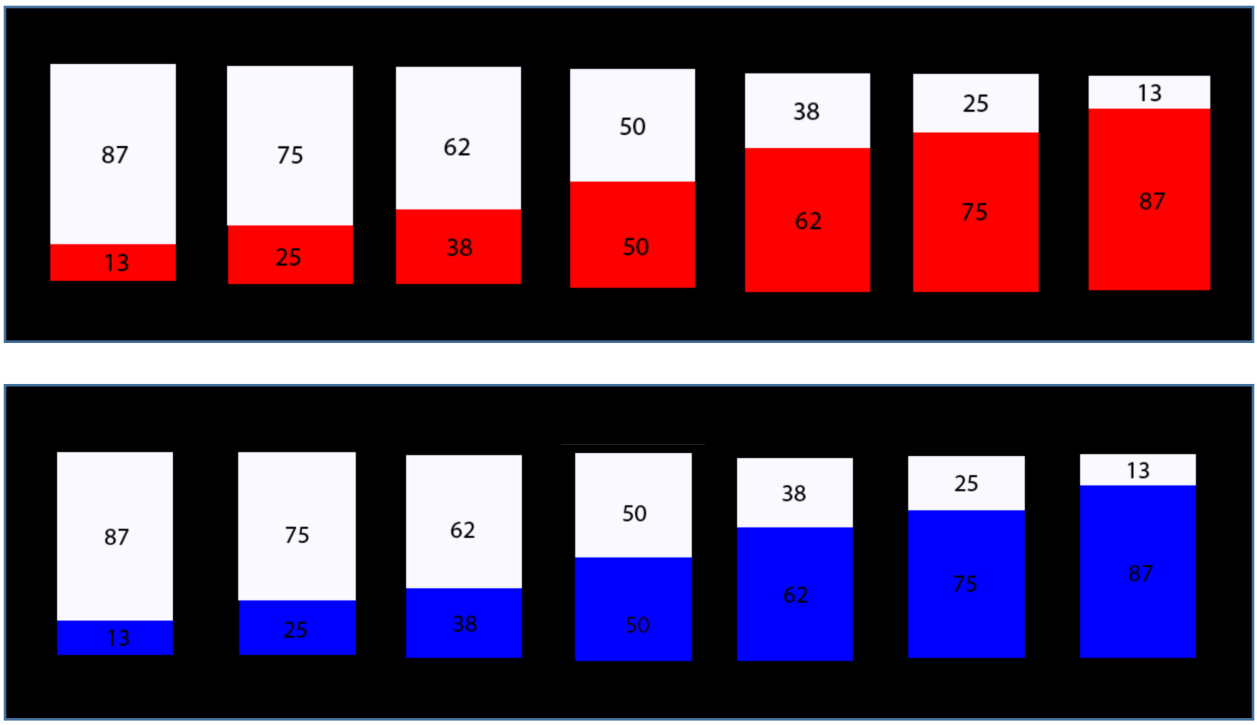


Figure 4.1: The 14 different lotteries used in this experiment. There were 7 lotteries for both the red and blue trials. The white shaded region represents the number of white chips, and the red/blue shaded region represents the number of blue/white chips. For example, in the lottery on the top left panel, there would be 13 red chips and 87 white chips. Each of these lotteries had a corresponding physical bag.

In half of the red trials, the winning color was red, and in the other half the winning color was white. In half of the blue trials, the winning color was blue and in the other half, the winning color was white (look at figure 4.2 below for clarification). Numbers above and below each bag indicated how much money the participant would receive if he picked either a colored or white chip from the bag. Five different dollar amounts ($5, $8, $12, $16, and $25) were paired with the seven different blue and red lotteries. In each lottery either the red/blue or the white value was the winning amount, leading to a total of 70 different red and blue trials. Each trial was repeated twice throughout the experiment, totaling 280 trials (See figure 4.2 below for an example of red and blue trials).

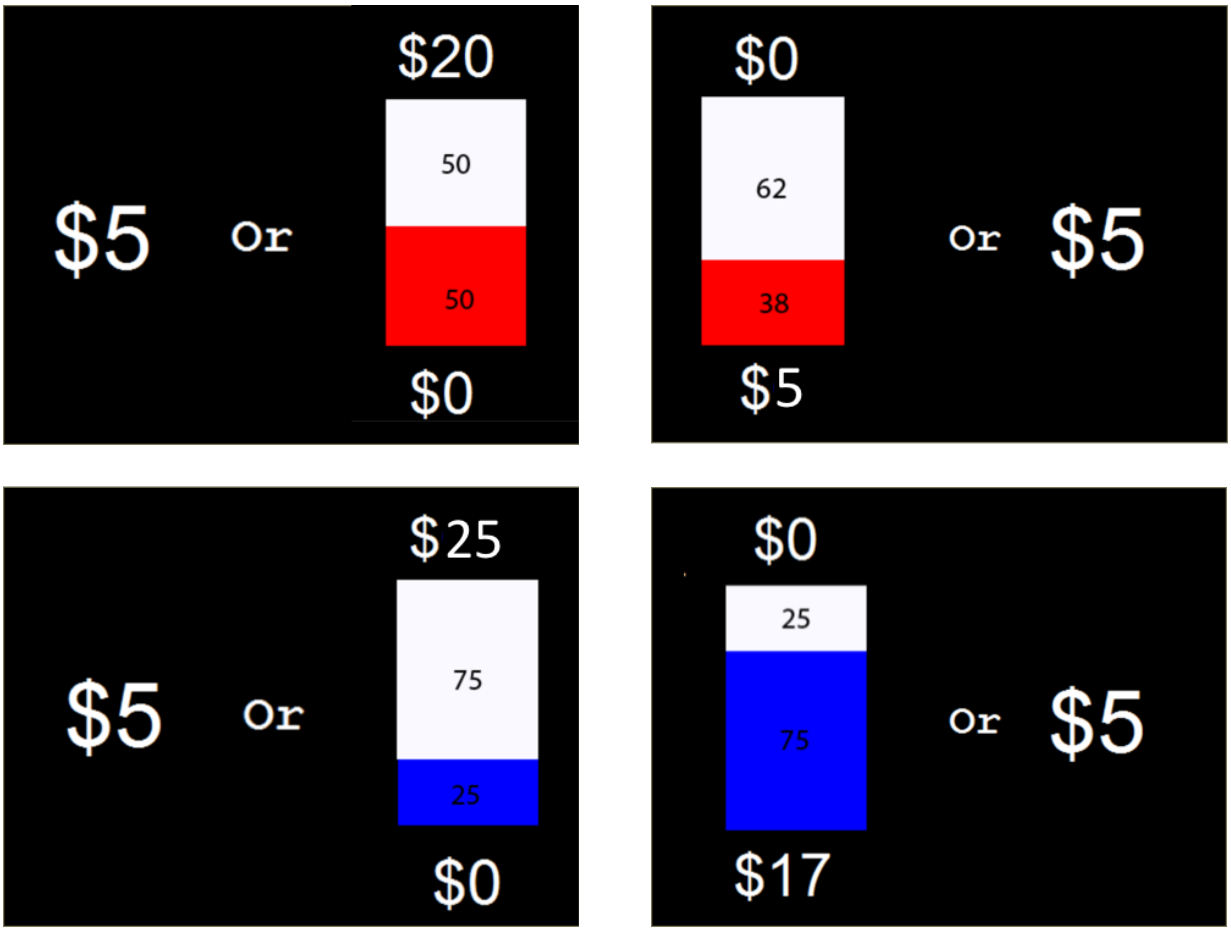


Figure 4.2: Four examples of red and blue trials. The top two trials are red trials: on the left white is the winning color and on the right red is the winning color. The bottom two trials are blue trials: on the left, white is the winning color, on the right blue is the winning color. Participants made a choice between which they would prefer: to play the lottery or to realize the $5 for sure.

The 280 trials were divided into eight different blocks, with each block containing 35 trials. Blocks were separated into red and blue blocks. During blue blocks, participants went through 35 trials with blue lotteries only. During red blocks, participants went through 35 trials with red lotteries only. Blue and red blocks alternated and whether participants started on a red or blue block was counterbalanced across participants. The order in which participants viewed the lotteries paired with varying winning amounts was randomized in each block to remove the confound of timing effects. The side of the screen in which the reference amount versus the

lottery amount appeared was randomized in order to remove the potential confound of a location preference.

4.2.1 Payment. Before starting the experiment, participants were informed that upon completion of the task, one of the trials would be randomly selected and their choice on that trial would determine how much money they would receive. This was done to ensure that participants were sufficiently motivated to play the computer game and were playing as if they were winning real money (Smith, 1991). To randomly select the trial for payment, the participant chose one red and one blue chip from a bag; the red chips were numbered 1-8 to represented the block number, and the blue chips were numbered 1-35 to represent the trial number. If the participant chose the reference amount in this randomly selected trial, then he would realize the $5 for sure, but if he chose to play the lottery in this trial, then he would choose a chip from the bag corresponding to the lottery in that trial, and was paid depending on which chip he picked and the corresponding monetary amount. If the participant did not make a choice on this trial, he would lose his original endowment of $10 (this was to make sure that participants made a choice on every trial).

4.2.2 Buss Perry Aggression Questionnaire. Participants then completed a Buss Perry Aggression Questionnaire (originally used in Buss & Perry, 1992), which asked participants to rate 29 different statements on a scale of 1 to 7 in terms of how characteristic they are of the participant (1 being extremely uncharacteristic, 7 being extremely characteristic). This questionnaire measures aggression on four different subscales: physical aggression, verbal aggression, anger, and hostility (see appendix I for the questions asked on the Buss Perry Aggression Questionnaire and further instructions on how to score).

4.2.3 Debriefing. After participants completed the Buss Perry Aggression Questionnaire, they were debriefed on the goals of the study and were asked what their strategy had been when making their choices on trials.

SECTION V: RESULTS

5.1 Results Testing H1: Red-Aggression Hypothesis

Results were coded as to whether participants played the lottery or chose the sure gain in each trial (sure gain=0, played the lottery=1, no decision=2). I used the number of times participants chose to play the lottery in different conditions to measure their risk preferences. The hypothesized results for red's association with aggression are as follows:

H1a: Men will choose to play the lottery more times on red trials than on blue trials.

H1b: On red trials, when red is the winning color (versus white), men will be more risk seeking. Thus, men will choose to play the lottery more often when red is the winning color than when white is the winning color.

H1c: Men who are more prone to aggressive behavior will be more influenced by the context of red. Therefore, men's score on the Buss Perry Aggression Questionnaire will be correlated to the difference between the number of times participants choose to play the lottery in red versus blue trials.

5.1.1 H1a: Are men more risk seeking in the presence of red? There was no significant difference between the number of times participants chose to play the lottery during red trials (*M*=54.95, *SD*=14.02) and the number of times participants chose to play the lottery during blue trials (*M*=55.67, *SD*=15.00), t=1.10, p=0.286 (see figure 5.1 below).[2]

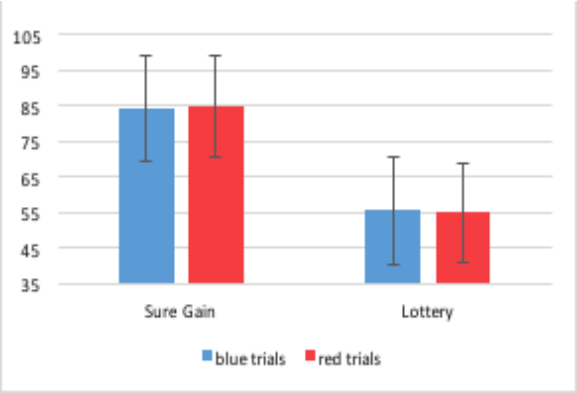


Figure 5.1: There was no significant difference between the number of times participants chose to play the lottery in red versus blue trials. Note that the error bars represent the SD.

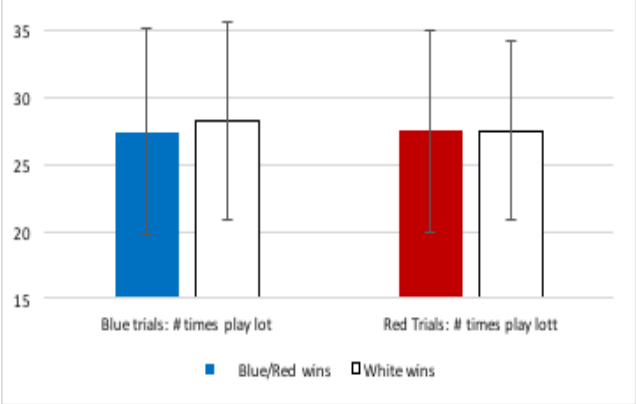


Figure 5.2: There is a significant difference between the number of times participants played the lottery in blue trials when blue was the winning color than when white was the winning color. There was no significant difference between the number of times participants chose to play the lottery within red trials when red was versus white was the winning color. Note that the error bars represent SD.

5.1.2 H1b: Differences in risk attitudes within red trials. Within red trials, will men be more risk seeking when red is the winning color? Within red trials, there was no significant difference between the number of times participants chose the sure gain versus to play the lottery when the winning color was red (*M*=27.48, *SD*=7.50) and when the winning color was white (*M*=27.48, *SD*=6.65), t(20)=0.0, p=1.0. Within blue trials, participants were less risk averse and chose to play the lottery significantly more times (on the 95% confidence interval) when the

[2] No sig difference between risk attitudes in blue and red trials

winning color was white (*M*=28.24, *SD*=7.42) than when the winning color was blue (*M*=27.43, *SD*=7.67, t(20)=2.16, p=0.043 (see figure 5.2 above).

5.1.3 H1c: Aggression questionnaire & correlation with risk preferences. Are men who are more prone to aggressive behavior more influenced by the context of red? I scored each participant's Buss Perry Aggression Questionnaire to get their overall aggression level (*M*=59.14, *SD*=14.57) as well as the subscales for physical aggression (*M*=19.75, *SD*=6.89), verbal aggression (*M*=14.39, *SD*=4.19), anger (*M*=11.43, *SD*=3.14), and hostility (*M*=13.57, *SD*=6.74) (see appendix I on how to score).

Due to the fact that there were no significant results for H1a and H1b, the results for the correlations between scores on the Buss Perry Aggression Questionnaire and participants' risk preferences are less applicable, however they are included. In general, people who scored higher on the Buss Perry Aggression Questionnaire also tended to display more risk aversion. There was a significant moderate to strong negative correlation between the total number of times participants chose to play the lottery, and their score on the aggression questionnaire, r(20)= -0.53, p=0.015. There was a significant moderate to strong negative correlation between participants' score on the aggression questionnaire and the number of times they chose to play the lottery on red trials, r(20)=-0.57, p=0.009. There was a significant moderate to strong negative correlation between participants' score on the aggression questionnaire and the number of times they chose to play the lottery on blue trials, r(20)=-0.49, p=0.027.

5.2 Results Testing H2: Red-Impairs-Ability Hypothesis

I calculated the EV that participants would receive given their choices across all 280 trials. The EV was calculated for each trial as follows:

EV = P • V, if participants chose to play the lottery

EV= $5, if participants chose the sure gain

Where P is the probability of winning a risky lottery and V is the winning lottery amount. Overall, the mean EV for the choices that participants made across all 280 trials was $2,045.43 (*SD*=84.49).[3]

If red impairs ability in achievement contexts, it is likely that participants will make worse decisions, as defined by decisions that lead to a lower calculated EV.[4] I hypothesize that participants will make decisions that lead to a lower calculated EV in red trials versus blue trials. Results were consistent with this hypothesis. There was a significant difference between the overall EV in all red trials and the overall EV in all blue trials, with participants making choices leading to a significantly lower EV in in red trials (*M*=1002.12, *SD*=46,70) than in blue trials (*M*=1043.32, *SD*=38.95), t(20)=-11.47, p<0.001 (see figure 5.3 below).[5]

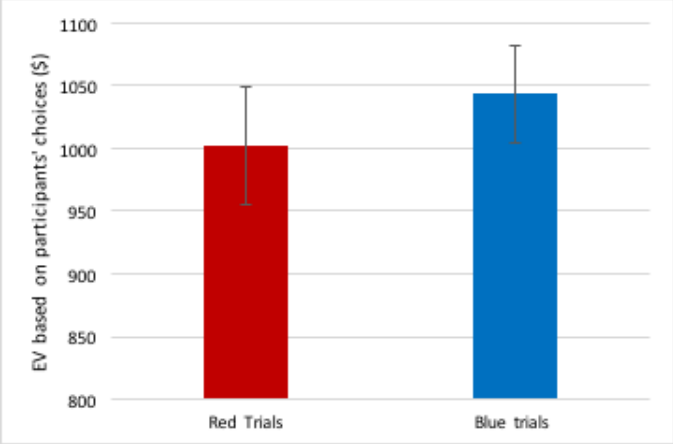


Figure 5.3: Participants made choices leading to significantly lower EVs in red trials than in blue trials. Note that the error bars represent the SD.

[3] Through EV maximization, the highest possible EV across all trials is $2,167.64.
[4] It is important to note here that during the debriefing, when participants were asked what their strategy was during this experiment, approximately half mentioned that they were trying to maximize their EV.
[5] Through EV maximization, the highest possible EV for all red and all blue trials is $1,083.82.

5.3 Possible Mechanisms for H2: Red Impairs Ability

Given the results, why do participants make choices leading to a lower calculated EV in red trials than in blue trials? There was no significant difference between the number of times participants played the lottery in red versus blue trials. Therefore, it is not the case that the color red is impairing participants' ability to maximize their EV by systematically making them more risk seeking or more risk averse. However, it is possible that participants made choices resulting in a lower EV on red trials than on blue trials because they became more risk seeking on certain probabilities and more risk averse on other probabilities, or a combination of both. It is also possible that participants became more risk seeking or more risk averse at certain lottery winning amounts. Another explanation is that red trials had more "noise" meaning that participants were less consistent with their choices on repeated lotteries.

5.3.1 Changes in risk preferences in certain lotteries. Are participants becoming more risk seeking or more risk averse on specific lottery probabilities? I graphed the average number of times participants chose to play the lottery as a function of lottery probability (recall that lottery probabilities include 13%, 25%, 38%, 50%, 62%, 75%, and 87%). When the choices of all participants are averaged, there is no significant difference in how risk seeking or risk averse participants are at certain lottery probability levels between red and blue trials (see figure 5.4 below). However, it is possible that there are individual differences; the presence of red may make some participants risk seeking at certain lottery probabilities, and other participants risk averse at certain lottery probabilities.

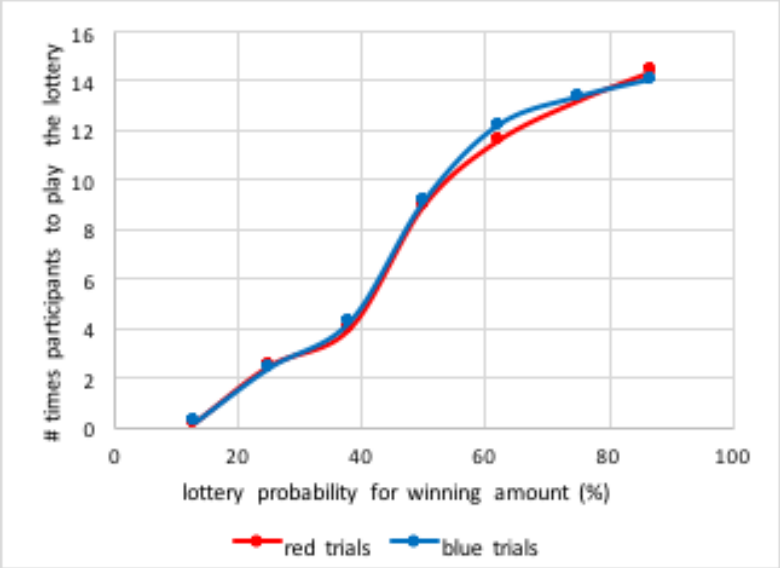


Figure 5.5: The number of times participants chose to play the lottery plotted against lottery probabilities (lottery probabilities include 13%, 25%, 38%, 50%, 62%, 75%, 87%)

5.3.2 Changes in risk preferences at particular winning amounts. Are participants becoming more risk seeking or more risk averse at certain lottery winning amounts? I graphed the average number of times participants chose to play the lottery as a function of lottery winning amounts (recall that lottery winning amounts include $5, $8, $12, $17, $25). When the choices of all participants are averaged, there is no significant difference in how risk seeking or risk averse participants are given certain lottery wining amounts between red and blue trials (see figure 5.5 below). There may, however, be individual differences between participants in which the presence of red makes some participants more risk seeking at certain winning amounts and others more risk averse at certain winning amounts.

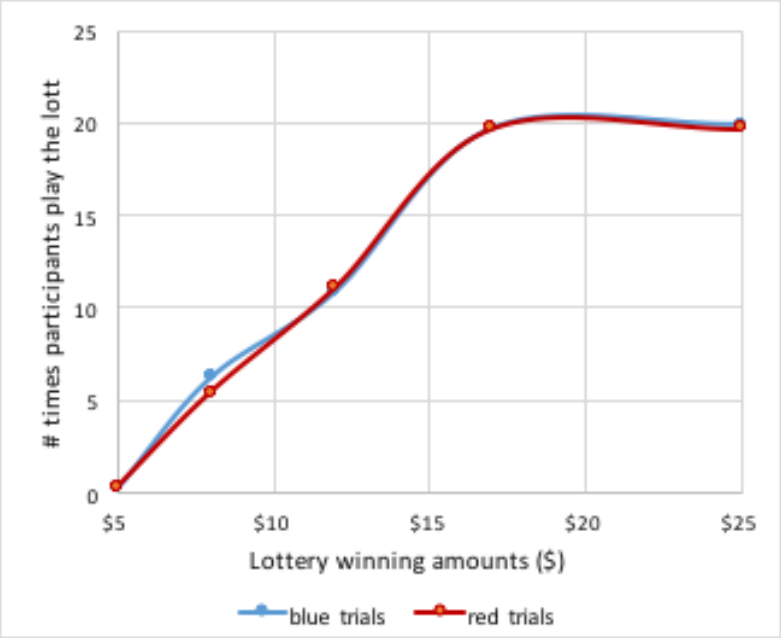


Figure 5.5: The number of times participants chose to play the lottery plotted against the lottery winning amounts ($5, $8, $12, $17, $25).

5.3.3 Presence of red increases noise. It is possible that the presence of red on certain trials increases the noise in participants' choices, meaning that they are less consistent in the choices that they make. There are 4 repetitions of every lottery paired with a given winning amount (for example, there are 4 repetitions of a 13% chance of gaining of $5, a 13% chance of gaining $8, a 13% chance of gaining $12, etc.). I looked at how consistent participants were in their choices with repeated lotteries. There was no significant difference in noise between red and blue trials. However, this may be due to an insufficient amount of data (given that there are only 4 repetitions of every possible lottery combination).

5.3.4 Red, avoidance motivation, and reaction time. Due to the fact that red induces an avoidance motivation, it is possible that participants spent less time on red trials than on blue trials. Participants had a mean response time on each trial of 2.10 seconds (*SD*=1.26). There was no significant difference between the amount of time participants took to make their choice on

red trials (*M*=2.22s, *SD*=1.29s) and blue trials (*M*=2.17s, *SD*=1.22s), t(20)=0.84, p=0.409 (see figure 5.5 below).

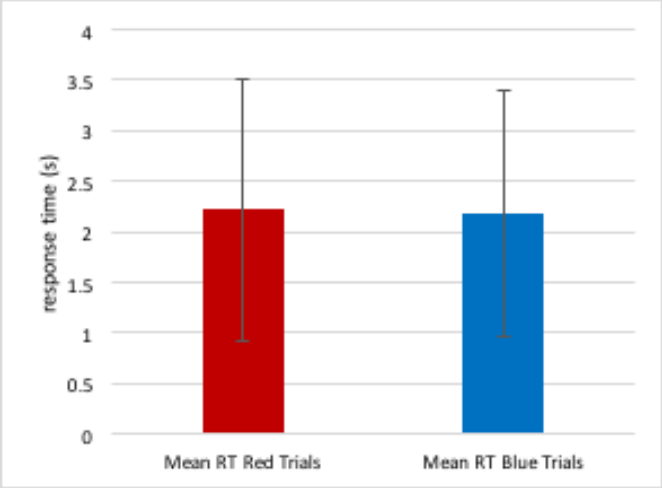


Figure 5.5: There was no significant difference between the response time on red versus blue trials. Note that the error bars represent the SD.

SECTION VI: GENERAL DISCUSSION

In this study participants make decisions on various trials between playing the lottery or accepting a sure gain. The experiment uses the color red (versus blue) to determine whether the the presence of red affects behavior in men. The study also looks within trials to compare whether behavior differs when red versus white is the winning color. Going into the experiment, I had two different possible hypotheses that were not mutually exclusive. I did not find results supporting H1; the context of red did not increase risky behavior in men. I did, however, find evidence supporting H2; the presence of red did impair participants' ability on the task as seen through the effect of color manipulation on the participants' resultant EV. Participants made choices that resulted in lower EVs in red trials than in blue trials. These results demonstrate that there is an influence of color on decision-making regarding risk; however, further research needs to be conducted to understand the mechanism behind this result.

Research on color has yielded context-dependent results. According to Elliot et al. (2007), "A given color has different implications for feelings, thoughts and behaviors in different contexts (e.g., achievement contexts, relational contexts)" (251). Within a competitive context, red induces aggression and dominance in men, examples include: a virtual, first-person-shooter game (Ilie et al. 2008); individual sports (Hill & Barton, 2005) and team sports (Atrill et al., 2008); and in auctions and negotiations (Bagchi & Cheema, 2013). However, this experiment may not have induced a competitive mindset because participants were not told that they were competing against an opponent. Instead, the present study induced an achievement mindset because participants' goal was to maximize their winnings. Due to this achievement context, it follows logistically that we obtained results consistent with H2, but not consistent with H1.

Even if this study does induce a competitive context, it is possible that the studies investigating the advantage conferred by wearing red in competitive contexts could be explained by the paradigm that red impairs ability in achievement contexts. Red uniforms may not confer an advantage to the competitor wearing red, but instead, seeing red, could trigger intimidation, and thereby impair opponents' ability. In competitive sports, the team/individual wearing red is not actually continuously looking at the color, instead his competitor is. Similarly, the literature on non-human species suggests that red indicates dominance in many species (Millinski & Bakker, 1990; Pryke & Griffith, 2006; Setchell & Wickings, 2005;Waitt et al., 2003); however, none of these animals view the red on themselves. Similarly, in men, a ruddy complexion is associated with aggression and dominance, whereas fear leads to pallor (Drummond, 1997; Drummond & Quah, 2001). These results are all consistent with the theory that seeing red engenders intimidation and as a result, the non-red competitor or non-red team may actually be performing worse *because* they are seeing red. Viewed from this red-engendering-intimidation

perspective, the literature on red within competitive settings may actually be consistent with the results in this study.

6.1 Limitations

6.1.1 Sample demographic. We used Yale undergraduates for this study. These participants may not make decisions regarding risk that are consistent with the general population. Many of these students have taken economics classes that teach them that the best strategy when making decisions under risk with small payoffs is to maximize EV. In fact, 9 out of 22 participants in the present study, specifically mentioned during the debriefing that they based their choice on each trial on which option (the lottery or the sure gain) would maximize their EV. Although this may not be consistent with the strategy of the larger population, given the results of this study, participants' strategy of EV maximization actually further proves the red-impairment hypothesis; the effect of red impaired participants' ability to carry out their strategy in this experiment.

This study did not include female participants because the literature of color's influence on behavior has shown a larger effect of red on male than on female behavior. However, the result of red impairing ability has been shown across both males and females (for example, in Elliot et al., 2007; Elliot et al., 2009) and therefore future studies should use male as well as female participants to see if results are consistent across both genders.

6.1.2 Controlling for luminosity and hue between the red and blue trials. This study did not control for the hue and luminosity used for the red and blue trials. Therefore, the results that we got could be a product of differences in the visual aspects of hue and luminosity rather

than a change in behavior due to red itself. Future studies should control for these technical aspects of color.

6.2 Future Directions Testing H1: Red-Aggression Hypothesis

In order to better test H1, we would need to run a similar experiment, but induce a competitive context. For example, we could have multiple participants participating in the experiment in a room together and tell them that only the person who has the highest final payoff, based on his choices on a few randomly selected trials, will get to keep the money after the experiment. Alternatively, we can tell participants that their final payoff will be ranked against all other participants, and the top three participants with the highest payoffs will receive a prize.

6.3 Future Directions Testing H2: Red-Impairs-Ability Hypothesis

Future experiments regarding color and risk preferences in monetary gambles should investigate H2, that red impairs peoples' ability to make monetary decisions regarding risk. Future studies should specifically tell participants to use the strategy of EV maximization in each trial. If participants are specifically instructed to maximize their EV, yet make choices leading to a lower EV in red versus blue trials, this will further prove the red-impairment hypothesis. Future studies should also look into the effects of using red and blue within the same trial as the winning and losing lottery probabilities in order to directly test the effects of red and blue (see appendix 2 for an example of a trial using red and blue as the lottery probabilities).

It would also be beneficial to run an experiment that has a different manipulation of color. Another color manipulation could be to make the entire background of the screen red

(instead of the black background used in this study) and have white and black as the colors to represent the lottery probabilities. Alternatively, between each trial we could flash a red or blue slide in order to prime participants with the color.

6.3.1 Future directions determining the mechanisms at play. The current study arrives at the conclusion that the presence of red impairs participants' decision making ability in this task, but I was unable to determine the mechanism that led to this. Future research should look into the possible mechanisms for this result. It is possible that there are individual differences in which the presence of red will make some participants more risk seeking for some probabilities, and will make others more risk averse at some probabilities. There could also be individual differences in which the presence of red will make some participants more risk seeking for some winning amounts and more risk averse for some winning amounts. The presence of red may increase noise, meaning that participants are less consistent during red trials. Although I did not find evidence in the current study for an increase in noise on the choices made during red versus blue trials, this could be due to an insufficient amount of data. In the present study there are only 4 repetitions of every possible lottery at each winning amount. In order to test this hypothesis, an experiment would have to be conducted that repeats lottery probabilities with the same winning amount many times in order to analyze whether participants were more consistent across blue trials than they were across red trials.

Within achievement contexts, red carries the meaning of the psychological danger of failure, and impairs peoples' ability (Elliot et al., 2007). Studies have also shown that red is associated with avoidance (Elliot et al., 2007; Moller et al., 2009). Elliot et al. (2009, experiment 1) found that participants shown red (versus green or gray) on the cover of an IQ test physically moved their bodies further away from the test. Future studies should video tape participants

while they are making their decisions in this task and see whether participants physically lean or move their bodies further away from the computer screen during red versus blue trials.

SECTION VII: Conclusion

This study yielded significant results for the hypothesis that red will impair participants' ability on monetary decisions regarding risk. Participants' choices led to significantly lower EVs on red trials than on blue trials. Future studies need to explore the possible mechanisms at play for red impairing participants' ability on this task.

This research has implications for past academic studies that use red as a visual aid during experiments where participants make decisions regarding risk. Past research on decision-making regarding risk and uncertainty has often used paired lottery choices that are depicted using different colors. If color influences decisions regarding risk, the results in studies gauging risk attitudes may be tainted by the colors used in the experimental design. Future research investigating decision-making regarding risk should carefully think about the use of color in experimental design to ensure that color is not a confound for the proposed hypotheses.

This research has many real world implications, especially for gambling websites, casinos, and marketing. If red impairs males' ability to calculate what their best choice would be in terms of EV, then it may be in a casino or gambling site's best interest to use a color scheme that includes red. Casinos have blackjack tables often covered in green felt; however, casinos may benefit from covering the tables in red felt, or using red décor. If red affects decisions made regarding risk, then this will also have implications for marketing. Every item that consumers buy has some sort of risk or uncertainty attached, and the color that marketers use can influence how likely someone is to buy the product. Research for decision-making regarding risk has

implications for many different real world applications as well as academic research. This study lays the groundwork for research in the area of color and behaviors regarding risk, but future research must disentangle the effects for why and how red impairs males' ability to make decisions regarding risk.

REFERENCES

Abdellaoui M, Bleichrodt H, Paraschiv C. Loss aversion under prospect theory: a parameter-free measurement. *Manage Sci* **53**: 1659–1674, 2007.

Attrill, M. J., Gresty, K. A., Hill, R. A., & Barton, R. A. (2008). Red shirt colour is associated with long-term team success in English football. *Journal of sports sciences*, *26*(6), 577-582.

Bagchi, R., & Cheema, A. (2013). The effect of red background color on willingness-to-pay: The moderating role of selling mechanism. *Journal of Consumer Research*, *39*(5), 947-960.

Bernoulli, D. (1954). Exposition of a new theory on the measurement of risk. *Econometrica: Journal of the Econometric Society*, 23-36.

Burley, N., Krantzberg, G. and Radman, P. (1982): Influence of color-banding on the conspecific preferences of zebra finches. Animal Behaviour 30, 444–455.

Cuthill, I. C., Hunt, S., Cleary, C., & Clark, C. (1997). Colour bands, dominance, and body mass regulation in male zebra finches (Taeniopygia guttata). *Proceedings of the Royal Society of London B: Biological Sciences*, *264*(1384), 1093-1099.

Drummond, P. D. (1997). Correlates of facial flushing and pallor in anger-provoking situations. *Personality and Individual Differences*, *23*(4), 575-582.

Drummond, P. D., & Quah, S. H. (2001). The effect of expressing anger on cardiovascular reactivity and facial blood flow in Chinese and Caucasians. *Psychophysiology*, *38*(02), 190-196.

Edwards, E. A., & Duntley, S. Q. (1939). The pigments and color of living human skin. *American Journal of Anatomy*, *65*(1), 1-33.

Edwards, E. A., Hamilton, J. B., Duntley, S.Q., & Hubert, G. (1941). Cutaneous vascular and pigmentary changes in castrate and eunuchoid men. *Endocrinology*, *28*(1), 119-128.

Elliot, A. J., & Maier, M. A. (2012). Color-in-context theory. *Advances in experimental social psychology*, *45*, 61-125.

Elliot, A. J., Maier, M. A., Binser, M. J., Friedman, R., & Pekrun, R. (2009). The effect of red on avoidance behavior in achievement contexts. *Personality and Social Psychology Bulletin*, *35*(3), 365-375.

Elliot A.J., Maier M.A., Moller A.C., Friedman R., Meinhardt J. (2007). Color and psychological functioning: The effect of red on performance attainment. *Journal of Experimental Psychology: General*, 136, 154–168

Glimcher, P. W. (2008). Understanding risk: a guide for the perplexed. *Cognitive, Affective, & Behavioral Neuroscience*, *8*(4), 348-354.

Goldstein, K. (1942). Some experimental observations concerning the influence of colors on the function of the organism. *American Journal of Physical Medicine & Rehabilitation*, *21*(3), 147-151.

Hill, R. A., & Barton, R. A. (2005). Psychology: red enhances human performance in contests. *Nature*, *435*(7040), 293-293.

Holt, C. A., & Laury, S. K. (2002). Risk aversion and incentive effects. *American economic review*, *92*(5), 1644-1655.

Ilie, A., Ioan, S., Zagrean, L., & Moldovan, M. (2008). Better to be red than blue in virtual competition. *Cyberpsychology & Behavior*, *11*(3), 375-377.

Ioan, S., Sandulache, M., Avramescu, S., Ilie, A., Neacsu, A., Zagrean, L., & Moldovan, M. (2007). Red is a distractor for men in competition. *Evolution and Human Behavior*, *28*(4), 285-293.

Levy, D. J., Thavikulwat, A. C., & Glimcher, P. W. (2013). State dependent valuation: the effect of deprivation on risk preferences. *PloS one*, *8*(1), e53978.

Levy, I., Snell, J., Nelson, A. J., Rustichini, A., & Glimcher, P. W. (2010). Neural representation of subjective value under risk and ambiguity. *Journal of neurophysiology*, *103*(2), 1036-1047.

Loewenstein, G. F., Weber, E. U., Hsee, C. K., & Welch, N. (2001). Risk as feelings. *Psychological bulletin*, *127*(2), 267.

Mehta, R., & Zhu, R. (2009). Blue or red? Exploring the effect of color on cognitive task performances. *Science, 323*, 1226-1229.

Meier, B. P., D'agostino, P. R., Elliot, A. J., Maier, M. A., & Wilkowski, B. M. (2012). Color in context: Psychological context moderates the influence of red on approach-and avoidance-motivated behavior. *PloS one*, *7*(7), e40333.

Millinski, M. and Bakker, T. C. (1990): Female sticklebacks use male coloration in sticklebacks and therefore avoid parasitised males. Nature 344, 330–333.

Moller, A. C., Elliot, A. J., & Maier, M. A. (2009). Basic hue-meaning associations. *Emotion*, *9*(6), 898.

Neumann, L. J., & Morgenstern, O. (1947). *Theory of games and economic behavior* (Vol. 60). Princeton: Princeton university press.

Pascal, B. (1966). Pensées (AJ Krailsheimer, Trans.). *Baltimore and Harmondsworth: Penguin Books*.

Pratt, J. W. (1964). Risk aversion in the small and in the large. *Econometrica: Journal of the Econometric Society*, 122-136.

Pryke, S. R., Andersson, S., Lawes, M. J., & Piper, S. E. (2002). Carotenoid status signaling in captive and wild red-collared widowbirds: independent effects of badge size and color. *Behavioral Ecology*, *13*(5), 622-631.

Pryke, S. R., & Griffith, S. C. (2006). Red dominates black: agonistic signalling among head morphs in the colour polymorphic Gouldian finch. *Proceedings of the Royal Society of London B: Biological Sciences*, *273*(1589), 949-957.

Rabin, M. (2000). Risk aversion and expected-utility theory: A calibration theorem. *Econometrica*, *68*(5), 1281-1292.

Setchell J.M., Wickings E.J. (2005). Dominance, status signals, and coloration in male mandrills (*Mandrillus sphinx*). *Ethology*, 111, 25–50.

Stone, N. J., & English, A. J. (1998). Task type, posters, and workspace color on mood, satisfaction, and performance. *Journal of Environmental Psychology*, *18*(2), 175-185.

Symmonds, M., Emmanuel, J. J., Drew, M. E., Batterham, R. L., & Dolan, R. J. (2010). Metabolic state alters economic decision making under risk in humans. *PloS one*, *5*(6), e11090.

Waitt, C., Little, A. C., Wolfensohn, S., Honess, P., Brown, A. P., Buchanan-Smith, H. M. and Perrett, D. I. (2003): Evidence from rhesus macaques suggests that male coloration plays a role in female primate mate choice. Proceedings of the Royal Society of London Series B-Biological Sciences 270, S144–S146.

APPENDIX I

Buss Perry Aggression Questionnaire:

Please rate each of the following items in terms of how characteristic they are of you. Use the following scale for answering these items.

1	**2**	**3**	**4**	**5**	**6**	**7**
extremely uncharacteristic of me						**extremely characteristic of me**

1) Once in a while I can't control the urge to strike another person.

2) Given enough provocation, I may hit another person.

3) If somebody hits me, I hit back.

4) I get into fights a little more than the average person.

5) If I have to resort to violence to protect my rights, I will.

6) There are people who pushed me so far that we came to blows.

7) I can think of no good reason for ever hitting a person.*

8) I have threatened people I know.

9) I have become so mad that I have broken things.

10) I tell my friends openly when I disagree with them.

11) I often find myself disagreeing with people.

12) When people annoy me, I may tell them what I think of them.

13) I can't help getting into arguments when people disagree with me.

14) My friends say that I'm somewhat argumentative.

15) I flare up quickly but get over it quickly.

16) When frustrated, I let my irritation show.

17) I sometimes feel like a powder keg ready to explode.

18) I am an even-tempered person.*

19) Some of my friends think I'm a hothead.

20) Sometimes I fly off the handle for no good reason.

21) I have trouble controlling my temper.

22) I am sometimes eaten up with jealousy.

23) At times I feel I have gotten a raw deal out of life.

24) Other people always seem to get the breaks.

25) I wonder why sometimes I feel so bitter about things.

26) I know that "friends" talk about me behind my back.

27) I am suspicious of overly friendly strangers.

28) I sometimes feel that people are laughing at me behind me back.

29) When people are especially nice, I wonder what they want.

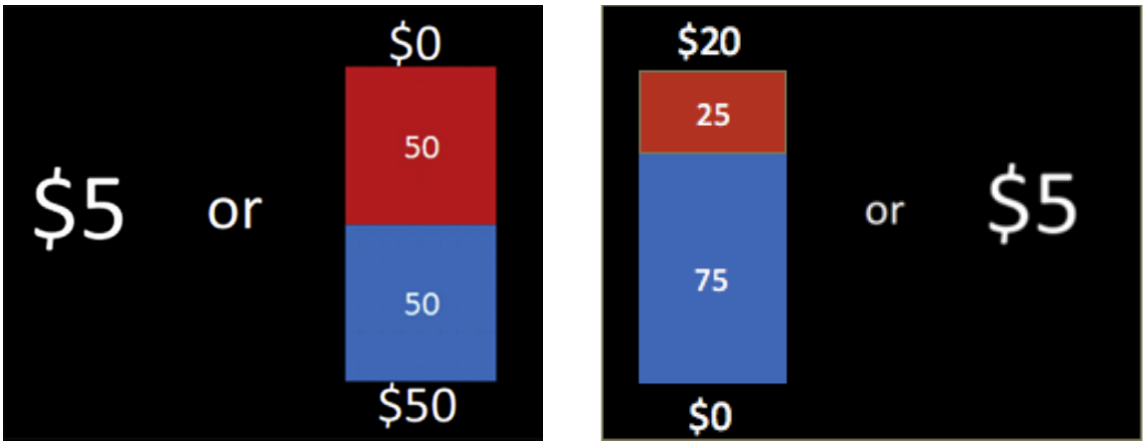
How to score the Buss Perry Aggression Questionnaire:

- The two scores with the asterisks are reverse coded (1=7, 2=6, 3=5, 4=4, 5=3, 6=2, 7=1) and all of the scores are added up.
- To divide the questionnaire into the different subscales:
    - Physical aggression: questions 1-9
    - Verbal Aggression: questions 10-14

- Anger: questions 15-21
- Hostility: questions 22-29

APPENDIX II

Red and Blue used within a Trial to Depict Lottery Probability



Procedure used in Levy et al., 2010: these are two examples of what participants saw on the screen for each trial. They could make a choice between playing the lottery or accepting the sure gain.