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Asymmetry of Gains and Losses: Behavioral and Electrophysiological Measures

Diego Gonzalo Flores
Brigham Young University

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Diego Gonzalo Flores Garnica

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Doctor of Philosophy

Harold Miller Jr., Chair
Bruce Brown
Blake D. Hansen
Brock Kirwan
Scott C. Steffensen
Chongming Yang

Department of Psychology

Brigham Young University

ABSTRACT

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Diego Gonzalo Flores Garnica
Department of Psychology, BYU
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The purpose of this research was to explore the effects of small monetary or economic gains and/or losses on choice behavior through the use of a computerized game, and to determine gain/loss ratio differences using both behavioral and electrophysiological measures. Participants (N=53) played the game in several 36 minute sessions. These sessions operated with concurrent variable-interval schedules for both rewards and penalties. Previously, asymmetrical effects of gains and losses have been identified through cognitive studies, primarily due to the work of nobel laureates Daniel Kahneman and Amos Tversky (1979). They found that the effect of a loss is twice (i.e., 2:1) that of a gain. Similar results have been observed in the behavioral laboratory as exemplified by the research of Rasmussen and Newland (2008), who found a 3:1 ratio for the effect of losses versus gains. The asymmetry of gains and losses was estimated behaviorally and through event-related brain potentials (ERPs) and the cognitive (Kahneman and Tversky) and behavioral (Rasmussen and Newland) discrepancy elucidated.

In the game, the player moves an animated submarine around sea rocks to collect yellow coins and other treasures on the sea floor. Upon collecting a coin, one of three things can happen: The player triggers a penalty (loss), the player triggers a payoff (gain), or there is no change. The behavioral measures consisted in counting the number of clicks, reinforces, and punishers and then determining ratio differences between punished (loss) and no punished condition (gain) conditions. The obtained gain/loss ratio corresponded to an asymmetry of 2:1. Similarly ratio differences were found between male and female, virtual money and cash, risk averse versus risk seeking, and generosity versus profit behavior. Also, no ratio difference was found when players receive information about other player's performances in the game (players with information versus players without information). In electroencephalographic (EEG) studies, visual evoked potentials (VEPs) and ERPs components (e.g., P300) were examined. I found increased ERP amplitudes for the losses in relation to the gains that corresponded to the calculated behavioral asymmetry of 2:1. A correlational strategy was adopted that sought to identify neural correlates of choice consistent with cognitive and behavioral approaches. In addition, electro cortical ratio differences were observed between different sets of electrodes that corresponded to the front, middle, and back sections of the brain; differences between sessions, risk averse and risk seeking behavior and sessions with concurrent visual and auditory stimuli and only visual were also estimated.

Keywords: prospect theory, video game, concurrent variable-interval schedule, gain (reinforcer), loss (punisher), gain/loss asymmetry, P300, event-related potential (ERP), Emotiv Epoc, risk aversion, loss aversion, risk tolerance, coin dispenser, waveform

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CHAPTER 1: Introduction

In Plato's *Protagoras* (1967), the main argument between the elderly Protagoras, a celebrated Sophist, and Socrates is about measurement. Aware that Protagoras has argued that "man is the measure of all things", Socrates suggests a new object of measurement:

> . . . Like a practiced weigher, put pleasant things and painful in the scales, and with them the nearness and the remoteness, and tell me which count for more. For if you weigh pleasant things against pleasant, the greater and the more are always to be preferred: if painful against painful, then always the fewer and smaller. If you weigh pleasant against painful, and find that the painful are outbalanced by the pleasant—whether the nearby the remote or the remote by the near—you must take that course of action to which the pleasant are attached. (Plato, 1967, p. 356b)

How pleasure and pain govern human behavior has long been of interest to philosophers, economists, psychologists, and many others. Rene Descartes (1596 – 1650), in his *Treatise of Man* (1662), argued that behavior is reflexive but that humans also possess a soul capable of logical reasoning. The soul interacts with the body and can dominate the reflexes. The mind's content arises, in part, from sensory experiences. However, he also held that some ideas were innate and existed in all humans independent of personal experience. For John Locke (1632-1704), all the ideas people have are directly the consequence of experience after birth. Thomas Hobbes (1588-1679) agreed with Descartes's dualism, but, unlike Descartes, believed that the mind operates just as predictably as a reflex. Hobbes proposed that voluntary behavior is governed by the principle of hedonism, that is, a human's sole intrinsic good is the overall pursuit of pleasure. In short, a hedonist strives to maximize net pleasure by minimizing pain.

Utility theory, which is a cornerstone of the rational perspective of economics, is rooted in the hedonist principle.

On the other hand, a fundamental corollary to the principle, according to Kahneman and Tversky (1991), is that the pain associated with giving up a good is greater that the pleasure associated with obtaining it. The asymmetrical relationship between gains and losses results in what is commonly known as *risk aversion* and contradicts the utility theory of choice.

Utility Theory and Rational Choice

In *Nudge*, Thaler and Sunstein (2009) differentiated "Econs" from "Humans." The former are rational decision makers. For many economists, rational agents (Econs) are first and foremost self-interested; they are able to compare potential outcomes and select those that maximize one's benefits and minimize one's costs. The rational decision-maker has orderly preferences, that is, when faced with a choice, she or he gauges each alternative's "subjective utility" and chooses the alternative with the highest. LeBoeuf and Shafir (2005) stated that "Deciding, then, is simply a matter of choosing the option with the greatest expected utility" (LeBoeuf & Shafir, 2005, p. 243). Utility theory holds that behavior is normatively rational and adaptive. In contrast to Econs, Humans are ordinary people who operate by rules of thumb or heuristics that often lead them amiss. They are too prone to generalization, are biased in favor of the status quo, and are more concerned to avoid loss than to achieve gains, among other shortcomings. Kahneman (2011) has pointed out that economists adopted expected utility theory as a dualism: "as a logic that prescribes how decisions should be made, and as a description of how Econs make choices" (p. 270).

In contrast, although "economists assume that behavior is rational. . . operant psychologists assume that it is the product of habit determined by particular schedules of reinforcement" (Lea, 1987, p. 99). Moreover, cognitivists and behaviorists have shown that "losses loom larger than gains" (D. Kahneman & Tversky, 1979; Rasmussen & Newland, 2008), meaning that the aversion to a loss of a certain magnitude is greater than the attraction to a gain of the same magnitude. Consistent with this finding, studies of emotion have shown that affective responses are faster and stronger to proximate negative events than to positive ones (Gehring & Willoughby, 2002).

Utility theory has been criticized on the basis of the repeated observation of violations of the most fundamental requirement of consistency. After reviewing the violations, Kahneman and Tversky (2000) concluded that descriptive accounts of choice outcomes can lead to different but equally robust, elegant, and comprehensive principles of human decision making. These empirically derived principles emphasize the weaknesses and limitations of utility theory, but, as Kahneman and Tversky concluded, they are not yet sufficient to challenge utility theory as a normative theory of decision making. Similarly, Herrnstein (1990) concluded that "the theory of rational choice fails as a description of actual behavior, but it remains unequaled as a normative theory. It tells us how we should behave in order to maximize reinforcement, not how we do behave….." (p. 356).

Alternative Views of the Asymmetry of Gains and Losses

Cognitivists, behaviorists, and, more recently, neuroscientists have argued in favor of an asymmetry between the effects of gains and losses (Fox & Poldrack, 2009b). Such asymmetry is an indication that humans are sometimes biased in their decision making and do not always maximize outcomes as utility theory suggests.

The Asymmetry of Gains and Losses: A Cognitive Perspective

In their SEinal article on prospect theory, Kahneman and Tversky (1979) identified several violations of utility theory. First, they defined choices as adjustments to current utility from a personal reference point and explained that most people prefer the sure gain over a risky prospect of an expected value. This preference is called *risk aversion*. Second, decision makers tend to underweigh low-probability events and overweigh high-probability ones. Finally, the manner in which alternatives are presented can influence the choices made.

Additionally, some individuals prefer a risky gamble over a certain loss. This preference is called *risk seeking*. "With the exception of prospects that involve very small probabilities, risk aversion is generally observed in choices involving gains, whereas risk seeking tends to hold in choices involving losses" (LeBoeuf & Shafir, 2005, p. 245). For Tversky and Kahneman (2000), "the asymmetry of pain and pleasure is the ultimate justification of loss aversion in choice" (p. 157).

Kahneman and Tversky (1979) also argued that individuals make decisions based on the potential value of losses and gains rather than on an aggregate outcome and that individuals evaluate these losses and gains using certain heuristics. And they pointed out that "Our perceptual apparatus is attuned to the evaluation of changes or differences rather than to the evaluation of absolute magnitudes" (Kahneman & Tversky, 2000, p. 32). Specifically, . . . the value function is (i) defined on deviation from the reference point; (ii) generally concave for gains and commonly convex for losses, [and] (iii) steeper for losses than for gains" (p. 34). Other essential features of prospect theory are that "values are attached to changes rather than to final states, and that decision weights do not coincide with stated probabilities" (D. Kahneman & Tversky, 2000, p. 31).

It is important to note that prospect theory coincides with the behavior-analytic concept of *melioration*. In reference to the *matching law* (also known as the *law of relative effect*), Herrnstein (Rachlin & Laibson, 1997b) noted a question that had not been answered, namely, “Is there a process that guarantees matching at equilibrium, a dynamic process that does for matching theory what maximizing does for maximization theory?” (p. 75). Just as utility theorists believe that choices at equilibrium always maximize utility, within specified constraints, Herrnstein and Vaughn (1980) proposed that behavior allocates toward higher local rates of reinforcement. This process is called melioration and differs from maximization in requiring the organism to respond only to the difference between local reinforcement rates from individual behaviors (Rachlin & Laibson, 1997b) rather than to overall, aggregated rates. Unlike maximization, which, for Rachlin and Laibson (1997) “requires the selection of the biggest aggregation of reinforcement across behaviors” (Rachlin & Laibson, 1997a, pp. 75-76), melioration is a dynamic process in which a difference between local rates of reinforcers leads to continuous change in the distribution of behavior so as to achieve an equality of local reinforcer rates. Sometimes melioration maximizes the overall rate of reinforcement; more often, it produces a lower-than-maximal reinforcer rate (Davison & McCarthy, 1988).

By contrast, Tversky and Kahneman (2000) reported that people evaluate the outcomes of risky prospects according to a value function that has three essential operating characteristics or cognitive features: reference dependence, diminishing sensitivity, and loss aversion. According to the concept of reference dependence, the carriers of value are gains and losses defined relative to a reference point. Kahneman (2011) stated that prospect theory is more complex than utility theory and explained that “. . . In Bernoulli’s theory you need to know only the state of wealth to determine its utility, but in prospect theory you need to know the reference state" (p. 281). For Kahneman, outcomes that are better than the reference point constitute gains and outcomes below the reference points constitute losses. (Ariely, Huber, & Wertenbroch, 2005) speculated that ". . . the concept of losses looming larger than gains might not have had such a deep impact on psychology and economics, because researchers have long postulated diminishing returns over the full range of most utility functions" (p. 134).

Diminishing sensitivity is the property of decision making that accounts for changes in a variable having less impact the farther the variable is from the reference point. Kahneman (2011) also stated that ". . . diminishing sensitivity continues to favor risk aversion for gains and risk seeking for losses, but the overweighting of low probabilities overcomes this effect and produces the observed pattern of gambling for gains and caution for losses" (p. 318). On this view, probabilities are not treated linearly; instead people tend to overweight small probabilities and to underweight large ones.

It is widely known that, given two options, people compare the outcomes of their chosen option versus the alternative they could have selected. Economists define the gap between the two as the "cost of opportunity". Comparison can be instructive, especially when the difference is unfavorable. This may result in "regret" of, given a favorable difference, in "rejoicing". However, feelings of regret are typically stronger than feelings of rejoicing (Fox & Poldrack, 2009a).

Tversky and Kahneman (2000) maintained that ". . . an immediate consequence of loss aversion is that the loss of utility associated with giving up a valued good is greater than the utility gain associated with receiving it" (p. 145). This phenomenon is known as the *instant endowment* or the *endowment effect*. Another phenomenon associated with loss aversion is the *status quo bias*, namely, that individuals favor the retention of the status quo over other options because the value of giving up a good is considered greater than the gain produced by a newly received good. Several studies have shown that the reluctance to sell a good that one owns is substantially greater than the reluctance to buy a good. Specifically, Kahneman, Knetsch, and Thaler (2000) reported that a loss is two times more punishing than a gain is rewarding:

> . . . These observations, and many others, can be explained by a notion of loss aversion. A central conclusion of the study of risky choice has been that such choices are best explained by assuming that the significant carriers of utility are not states of wealth or welfare, but changes relative to a neutral reference point. Another central result is that changes that make things worse (losses) loom larger than improvements or gains. The choice data imply an abrupt change of the slope of the value function at the origin. The existing evidence suggests that the ratio of the slopes of the value function in two domains, for small or moderate gains and losses of money, is about 2:1 (p. 199).

The Asymmetry of Gains and Losses: A Behavioral Perspective

The basic principle of reinforcement was formulated by Thorndike (Thorndike, 1911) as the law of effect, which states that actions that are followed by feelings of satisfaction are more likely to be repeated, but actions that are followed by feelings of annoyance are not. Ferster and Skinner (1957) began systematic work on behavioral choice involving schedules of reinforcement, and it was most extensively studied by Herrnstein (Herrnstein, 1961; Rachlin & Laibson, 1997a). In the basic procedure, the subject (typically, a food-deprived pigeon) was exposed to two or more possible response alternatives, each with its own reinforcement schedule. Studies using this or similar methods consistently have yielded similar results across a variety of species and reinforcer types: The proportion of responses to an alternative matches the proportion of reinforcers received for responding to that alternative. If twice as many reinforcers are provided for one alternative, then, on average, twice as many responses are made to that alternative.

Herrnstein summarized utility theory in this way:

> . . . Behavior is depicted as seeking an equilibrium that maximizes something–be it total subjective utility, hedonic value, reinforcement, energy intake, or reproductive fitness–within limitations of memory and discriminative acuity as well as the limitations imposed by the environment. Each mixture of behaviors and their outcomes is viewed as a unique bundle, and the organism is supposed to select the best bundle, on whatever is the relevant dimension. Equilibrium is reached with a distribution of activities that cannot be detectably improved upon by a redistribution of choices; that is, the obtained outcomes are maximized. (Rachlin & Laibson, 1997a).

By contrast, according to the matching law, the equilibrium is defined as equality between the ratio of the frequencies of any two behaviors, B_1 and B_2 that matches their obtained reinforcers, R_1 and R_2, as follows:

$$B_1/B_2 = R_1/R_2 \qquad (1)$$

The generalized matching relation (Baum, 1974) is:

$$(2) \qquad B_1/B_2 = k\,(B_1/B_2)^{c}$$

In logarithmic form, it is:

$$Log\,(B_1/B_2) = log\,k + c\,log\,(R_1/R_2) \qquad (3)$$

where the two free parameters, log k and c, describe bias and sensitivity, respectively. Rasmussen and Newland (2008) found that there was a substantial bias towards an unpunished alternative in their participants. They also pointed out that direct comparisons of the relative effects of reinforcers and punishers on behavior are difficult to make because they are qualitatively different stimuli, and thus absolute measurement becomes problematic. In order to solve this dilemma, they standardized the reinforcer-punisher differential by using a system of points that translated into monetary gains and monetary losses. Because money can be used as a punisher (monetary loss, which is a form of negative punishment) and also as a reinforcer (monetary gain), they addressed the question of whether one cent lost was equivalent to one cent gained in terms of its relative effect on behavior. On the basis of their experimental findings, they concluded that:

> . . . When humans are offered a choice between two response alternatives, the allocation of behavior is captured well by the generalized matching relation, and sensitivity to reinforcer ratios resembles that seen in other studies with human and non-human species.
>
> Punishing one alternative reduces the sensitivity of behavior to reinforcer ratios and produces a significant bias toward the unpunished alternative, even when the two alternatives deliver the same net reinforcer amount. In fact, when monetary gain is the same on the alternatives, it appears that losing a penny is three times more punishing than earning the same penny is reinforcing. (Rasmussen & Newland, 2008, p. 65)

The Asymmetry of Gains and Losses: An Electrophysiological Perspective

Kahneman (2011) noted that “the brain’s response to variations of probabilities is strikingly similar to the decision weights estimated from choices” (p. 315). Studies using electrophysiological methods, specifically, the electroencephalogram (EEG), allow for the recording of scalp visual evoked potentials (VEP) and event-related potentials (ERPs) (Chiappa, 1997; Luck, 2005). The term VEP refer to electrical potentials, initiated by brief visual stimuli, which are recorded from the scalp overlying visual cortex. The P300 wave form is a VEP wave form that has six components that are the focus of interest in this study: N50, P100, N100, P200, N200, and P300. The P300 component is the main focus of the analysis. The P200, N200, and P300 are specifically ERP's, however, the term ERP will be used to refer all the VEP components.

ERPs are recordings of the brain's activity linked to the occurrence of an event, such as the presentation of a stimulus, and they can a temporal record of brain events. ERP researchers have shown that the human brain responds differentially to positive and negative outcomes within a few-hundred milliseconds of their incidence following both self-identified errors and automated error feedback (Goyer, Woldorff, & Huettel, 2008). The EEG is an ongoing measure of electrical activity on the scalp relative to a reference point. By contrast, ERPs are more discrete and have distinct waveforms that may be correlated with specific cognitive activities (Bernat, Nelson, Steele, Gehring, & Patrick, 2011). An ERP waveform consists of a sequence of positive and negative deflections known as peaks. The labels N50, P100, N100, P200, N200, and P300 are commonly used, where P and N indicate positive or negative deflections, respectively, and the number indicates an ordinal position in the waveform.

P100 peak is associated with selective attention, and is an obligatory sensory response that is elicited by visual stimuli reaching the visual cortex. The P100 is linked to variation in stimulus parameters: contrast, spatial frequency direction, subject state of arousal. The N100 is linked to spatial attention, occurs when an individual is presented with an item from that of the prevailing contexts and is larger for discrimination than detection. The P100 and N100 are VEPs that occur regardless of the task as long as the subject is attentive with eyes open. The P200 is larger for targeted and infrequent, simple stimuli. The N200 is typically evoked before a motor response, suggesting its link to the cognitive processes of stimulus identification and distinction and the P300 is elicited in the process of decision making. The P200, N200 and P300 are event-related potentials and are dependent upon the task. Ahead the N200 and P300 that are well-known links to cognition and decision making are described with additional detail.

N200. The N200 which is evoked around 180 to 325 msec following the presentation of a stimulus is typically evoked before a motor response, suggesting its link to the cognitive processes of stimulus labeling and distinction. Though there have been some inconsistent findings about N200 in auditory and visual modalities, N200 seems to reflect cognitive processes beyond the detection of stimulus mismatch or attention, such as monitoring, and regulation, feedback of information (Folstein & Petten, 2008). The N200 has been classified in three components: The N2a is known to reflect the automatic processing of the disparity between a mismatched stimulus and a sensory memory and reflect automatic change detection mechanisms based on memory traces, On the other hand, N2b and N2c are elicited only when attention is required. Specifically, N2b is assumed to reflect the detection of a stimulus mismatch, whereas, N2c is thought to reflect a subprocess of classification tasks (Folstein & Petten, 2008).

P300. The P300 wave has been defined as the maximum positive deflection occurring between 250 msec and 500 msec (although its latency can vary depending on stimulus modality, task conditions, subject age, etc.). The P300 component is measured by assessing its amplitude and latency. Amplitude (μV) is defined as the difference between the mean pre-stimulus baseline voltage and the largest positive-going peak of the ERP waveform within a time window. Latency (msec) is defined as the time from stimulus onset to the point of maximum positive amplitude within a time window (Polich, 2007). The P300 wave may only occur when the stimulus that is presented has meaning for the subject. Its occurrence depends entirely on the task performed by the subject, and it is not directly influenced by the physical properties of the eliciting stimulus.

For these reasons it has been considered an endogenous signal, dependent on internal rather than external factors. Typically, the P300 occurs when the individual needs to pay attention to the rarer of two events, even if that event is the absence of sensory stimulation. The amplitude is larger when subjects devote more effort to a task and smaller when the stimulus (target or non-target) is ambiguous. Any manipulation that postpones stimulus categorization increases P300 latency. Young and Sanfey (2004) found that the P300 in reward studies can be influenced by a wide variety of factors, including the magnitude of the chosen option, the valence and magnitude of the alternative option, and the relative value of the alternative outcome in comparison with the chosen outcome.

Gain/Loss ratio. The behavioral measurement of the gain/loss ratio relates to the ratio of the unpunished by the punished condition. Generally the values of the means (intercepts) of the unpunished condition, which corresponds to the gains, are higher in value than the intercepts of the punished condition which corresponds to losses. Thus, in the behavioral analysis the procedure followed to calculate the ratio that it has been identified as gain/loss ratio is to divide the unpunished by the punished condition. However, in the electrophysiological study the amplitudes of the losses are generally higher than the amplitudes of the gains and the ratio calculation is loss divided by gain (loss/gain). In order to keep consistency with the behavioral study, the ratio will continue being identified as the Gain/Loss ratio.

The Experiments

In addition to measuring the asymmetry of gains and losses using behavior-analytic methods, experiments were designed to examine the effects of gender, risk, altruism, and information, and the use of on-screen points or actual cash, in decision making that involve gains and losses.

Risk

As already discussed, loss aversion is encapsulated in the expression "losses loom larger than gains" (D. Kahneman & Tversky, 1979, p. 269) Because people are more willing to take risks to avoid a loss, loss aversion can explain differences in risk-seeking versus risk aversion. Until recently, researchers have not focused on the role of emotions like risk tolerance as a separate factor in the decision process.

Risk tolerance influences a wide decisions and can affect the mode of engagement in an activity where the outcome is uncertain. An example of risk tolerance was provided by one of the scientists who developed the Saturn 5 rocket that launched the first Apollo mission to the moon:

> . . . You want a valve that doesn't leak and you try everything possible to develop one. But the real world provides you with a leaky valve. You have to determine how much leaking you can tolerate. (Bernstein, 1996, p. 2)

Some individuals tolerate greater losses than other people do. A survey instrument (questionnaire) was used to measure participants' risk tolerance and to categorize them into two groups: risk averse and risk seeking.

Payoffs

A finding that is typically referred as the credit card premium propose that the use of a credit card as a payment mechanism increases the propensity to spend as compared to cash in otherwise identical purchase situations. "Thus, prior research seems to suggest that cash payments as opposed to payments with other formats elicit maximum pain of payment". (Chatterjee & Rose, 2012, p. 1129). The credit card premium suggest that the payment mechanism can have effects on the asymmetry of gains and losses.

The Experimental Series

Two sets of experiments were conducted. The first was a series of experiments that involved only behavior-analytic methods and measures and included experiments 1 to 3. Experiment 4 was also a behavior-analytic study and will be discussed separately in chapter 4. The experiment series involving behavior-analytic and electrophysiological measures will be discussed in chapter 5. I used the initials BEH for the behavioral measures only and EEG for the behavioral and electrophysiological measures.

Experiment 1. Twenty-six participants (male: $M = 22$) completed eight sessions. Only data sessions 4 to 6 were used in the analysis -the data of the first three sessions was not included considering behavioral stability. The last two sessions (7 and 8) were included in experiment 2. The experiment had three main objectives: (a) to compute the gain/loss ratio, (b) to examine the asymmetry of gains and losses as a function of gender, and (c) to examine the asymmetry as a function of risk.

Hypothesis BEH1: Participants were expected to be more sensitive to losses than to gains and to exhibit an asymmetry ratio between 2 and 3, consistent with the earlier findings of Kahneman and Tversky (1979) and Rasmussen and Newland (2008).

Hypothesis BEH2: Gender differences in the asymmetry ratio were expected, with a higher ratio for women than for men.

Hypothesis BEH3: On the basis of results from a risk questionnaire, participants were categorized as risk averse or risk seeking. A higher asymmetry ratio was expected for the risk-averse participants.

Experiment 2. Twenty-four of the previous 26 participants completed two additional sessions (sessions 7 and 8). They differed from the previous sessions in that the participants collected or deposited the gains and losses, respectively, using a coin dispenser/collector.

Hypothesis BEH4. Participants were expected to show increased loss aversion when playing the game using virtual points + coin dispenser compared to virtual points only.

Experiment 3. In this experiment, 11 new participants were recruited. Unlike experiments 1 and 2, they were informed about the amounts of money that the other participants earned during each session.

Hypothesis BEH5. It was expected that the addition of competition in the form of information about the other players' gains and losses would result in higher asymmetry ratios. Risk aversion and risk seeking was also explored in the context of competition.

Experiment 4. The classical economic view of individual decision making emphasizes rationality and selfishness. Ten new participants (age median=22), distinct from previous experiments, were recruited. This experiment was designed to include two groups of participants who were identified as the Profit group and the Charity group, respectively. The first phase of the experiment included four sessions (1-4). Participants in the Profit group were paid directly according to their performance. Those in the Charity group donated their profits to a non-profit organization of their choice. Phase 2 included sessions 5 through 10. In the odd-numbered sessions, all participants were paid directly according to their performance. In the even-numbered sessions, their earnings were donated to charity.

Hypothesis BEH6. Higher asymmetry ratios were expected from participants when they profited personally than when they made donations to charity.

Experiment 5. Sixteen (male: *M* = 23) participants took part in experiment 5. It included eight sessions with methods and materials similar to those in experiment 1. However, in addition to the behavior-analytic method for determining the asymmetry ratio electrophysiological measures (ERPs) were utilized. Recording was continuous during each of the 10 36-min sessions. The data analysis after signal filtering, amplifying, and averaging focused on the 1-sec epoch before stimulus presentation and on the 2-sec epoch following stimulus presentation. Amplitudes and latencies were measured for the within-subject- averaged P100, N100, P200, N200, and P300.

Hypothesis EEG1. Similar to the hypothesis for the behavioral asymmetry ratios (BEH1), the asymmetry ratios for ERPs associated with gains and losses were expected to be approximately 2:1 or 3:1.

Hypothesis EEG2. It was hypothesized that the differences in session's amplitudes would demonstrate a learning effect, that is, they would approach stable values over sessions.

Hypothesis EEG3. Higher asymmetry ratios were expected from risk averse participants compared to risk seekers.

Hypothesis EEG4. In the game when a gain or a loss occurs a message is displayed on the screen, simultaneously a distinctive sound for gains and another for losses is heard by the participant. Sessions 1 to 7 were played with both stimuli, however, in session 8 we suppressed the audio so that the participant only responded to the visual stimuli. In this experiment, we are comparing session 7 and 8 to determine if there is a significant statistical difference with the presence or absence of sound.

Hypothesis EEG5. The stimulus that signaled gains and losses consisted of two discrete events. It was hypothesized that the second event would produce a second P300 (2P300) wave following the first P300 wave.

CHAPTER 2: Method

The experiments were conducted at Brigham Young University (BYU) in Provo, UT. The study protocol was approved by the BYU Institutional Review Board (see Appendix A1), and written, informed consent was obtained from all participants. A video game was developed to produce behavioral data. An electronic interface between a coin dispenser and the game and an interface between the game and an EMOTIV - Brainwear® Wireless EEG Technology device (Emotive Epoc) were also developed for the research. Figure 1, shows the setting of the experiment. The game displayed on the screen, a mouse, speakers, a coin dispenser, and the Emotive Epoc device.

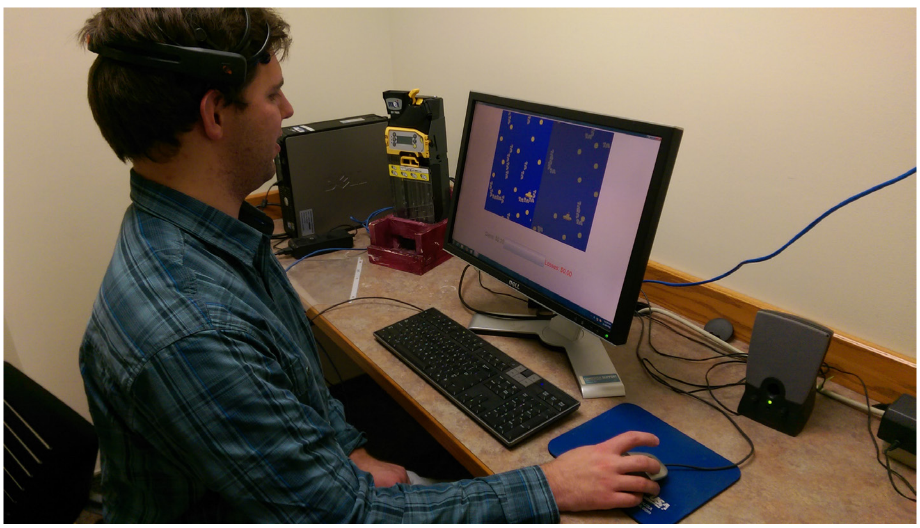

Figure 1. Setting of the experiment

Participants

Fifty-three BYU undergraduates (38 male and 15 female: *M* = 22) participated in the experiments. They were invited to play the video game in a series of 36-min sessions in which they could earn money. The in-session earnings were delivered to each participant at the end of a session. In addition, they received a $30 bonus at the completion of the study. Participants were also asked to complete a risk questionnaire at the beginning of the first session.

The Risk Questionnaire

The psychological approach to decision making can be traced to Daniel Bernoulli (1738)/(1954), who explained why people are generally risk averse. Qualls and Puto (1989) defined risk aversion as a decision maker's "preference for a guaranteed outcome over a probabilistic one having an equal expected value" (p. 180). Mandric and Bao (2005) measured risk aversion using a self-report scale, which was substantially shorter and simpler than other instruments that use choice dilemmas or batteries of gambles. I used their questionnaire with some small adjustments. Participants completed the questionnaire in approximately 10 to 15 min.

Participants played the game in an experimental 9 ft by 9 ft room containing a table and chair. A Dell desktop computer equipped with a 17-in monitor and a mouse was on the table. The room was artificially illuminated. The computer was connected through an Ethernet connection to a separate computer located in an adjacent room and that hosted the Emotive EPOC software for recording the EEG (only experiment 5). Participants were seated in front of the computer monitor and were asked to read the instructions for the game that appeared there. The instructions were written in English (see Appendix A3).

The SubSearch Game

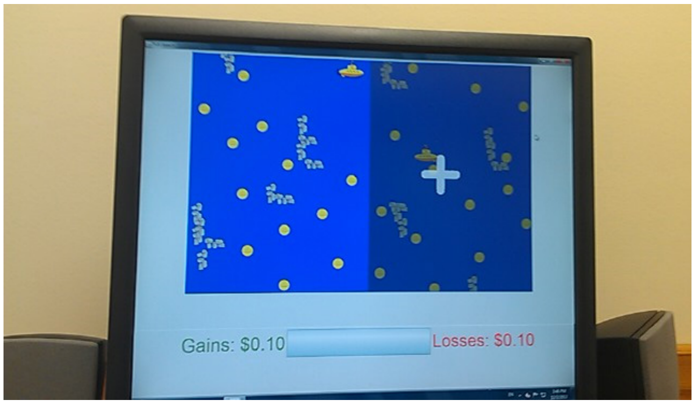

Figure 2. Subsearch Game

The SubSearch game main screen contained left and right panels. A fixation mark (shown here as the white plus-sign) preceded the presentation of the gain and loss messages. The cumulative counters of gains and losses were displayed on the bottom of the screen, as well as the button between them that the participant was required to click in order to resume the game after a gain or a loss. Note that a submarine appeared in each panel.

Participants were asked to guide a submarine using the computer mouse and to retrieve as many yellow objects as possible before reaching the sea floor. If the cursor rested on a submarine, moving the cursor moved the submarine. If the submarine was placed over one of the yellow objects, clicking the mouse retrieved the object. Underwater barriers complicated the submarine's movement between objects. Once the submarine reached the sea floor within a panel, it was returned to the surface for a new descent, this time with more frequent barriers. Thus the game became progressively more difficult as it continued.

The game was played in two different vertical panels separated by a vertical line (see Figure 2). Each panel was associated with its own interdependent concurrent variable-interval variable-interval (inter conc VI VI) schedules of reinforcement and punishment, thus creating a scenario wherein the participants could select between two different, uncertain alternatives.

Unlike the independent conc VI VI schedule in which the two schedules are independent of each other, the interdependent version assigns a reinforcer (or a punisher) according to a preset probability generator. If, for example, the generator was set to assign twice as many reinforcers to the left panel than to the right panel (p = 0.67), and the next reinforcer was assigned to the right panel, then it would be necessary for the participant to produce that reinforcer before the next one would be assigned. Thus, the interdependent schedule reduces the likelihood of extreme position (left or right) biases and assures that the scheduled proportion of reinforcers (or punishers) between the two panels remains close to the proportion of those that are actually delivered.

The overall schedule was a conjoint schedule, as each panel offered both a schedule of reinforcement and a schedule of punishment. The scene in each panel slowly scrolled toward the top of the screen. Only one panel was operative at a time. The other panel was darkened, and motion was paused (see Figure 1).

After the participant clicked the "Start–OK" message on the screen, a 36-min session commenced. The game allowed the participant to move the cursor from one panel to the other. However, each switch produced a changeover delay of 2 secs. During this interval, no reinforcers or punishers were delivered. Gains and losses were signaled by separate on-screen messages, each accompanied by a distinctive sound. When a gain or a loss for 0.5 s after which a fixation signal (+) was presented on the screen with a duration of 0.5 s, then a message was displayed on the screen indicating a gain or a loss. The messages were "+10¢" for a gain and "-10¢" for a loss. In the experiment that included the coin dispenser/collector, the two messages were "Collect a coin to continue" for gains and "Insert a coin to continue" for losses. Coins had a denomination of 10 cents (dimes). The participants placed coins released by the mechanical dispenser in a nearby container. When asked to deposit coins, participants took them from the container and inserted them into the device. The on-screen messages appeared for 1 sec. Then a button located at the bottom of the screen between the cumulative-gain and cumulative-loss counters started to blink. The game resumed after the participant clicked on the button. In the experiment that required the use of the coin device, the game resumed following the delivery or the deposit of a coin.

Each click that occurred during a session was coded, time stamped, and saved to an external MySQL database. The summary statistics included the total time spent responding in each panel, the total number of clicks that occurred in each panel, the total numbers of reinforcers and punishers that occurred in each panel, and the total number of changeovers.

Each session consisted of a fixed sequence of six 6-min conditions (conditions 1-6). Three of them (1, 3, and 5) contained conc VI VI schedules of reinforcement (gains only) and three (2, 4, and 6) contained conc VI VI schedules of reinforcement and conc VI VI schedules of t punishment. Table 1 summarizes the conditions. Condition 1 featured a conc VI1-m VI20-s schedule, meaning that 25% of the total reinforcers were allocated to the left panel and 75% to the right panel. There was no schedule of punishment. Condition 2 featured the same conc VI1 VI1 VI-20 schedule of reinforcement and a conc VI1 ext schedule of punishment, where "ext" refers to extinction that is the absence of reinforcers. In other words, 100% of the punishers were allocated to the left panel according to a VI1 schedule. No punishments were allocated to the right panel. The other four conditions featured different reinforcer ratios. Each unpunished condition was followed by a similar condition that included punishers only in the left panel under the same schedule as the reinforcers that were delivered in that panel. Each condition was accompanied by a different background color in both panels, for a total of six different colors. It should be noted that the values of the VI schedules in each concurrent pair of reinforcement schedules were selected to produce the same overall rate of reinforcement despite the difference in the ratios of those values (1:3, 1:1, and 3:1). Also, as previously noted, the schedule of punishment in the right panel was the same as that of reinforcement in the punished conditions. Thus the ratio of reinforcers to punishers was 1:1. The conditions were not randomized by sessions.

Table 1

Reinforcers and Punisher Rates per Condition. Rates are Numbers per Minute

Conditions	Left Reinforcers	Left Punishers	Right Reinforcers
Condition 1 – No punished	1.5	0	4.5
Condition 2 – Punished	1.5	1.5	4.5
Condition 3 – No punished	3	0	3
Condition 4 – Punished	3	3	3
Condition 5 – No punished	4.5	0	1.5
Condition 6 —Punished	4.5	4.5	1.5

At the end of each session, participants received the net amount of money they accumulated during the session. Once they completed the experiment, each received a one-time bonus of $30.

The Coin Dispenser/Collector

The MEI CASHFLOW® series 7000 was used. It contains five tube cassettes for the coins that are delivered or collected. An interface with the SubSearch game was developed that allowed the delivery or collection of coins according to signals generated by the game software. Figure 3 shows the coin dispenser that was used in this experiment

Figure 3. Coin dispenser / collector

The Emotive Epoc

The Emotiv Epoch EEG (see Figure 3) is a wireless Bluetooth® Smart device (2.4GHz band), which has 14 electrodes--AF3, F7, F3, FC5, T7, P7, O1, O2, P8, T8, FC6, F4, F8, and AF4—that transmit at a sample rate of 128 Hz. The device provides access to raw, dense-array, high-quality EEG data with software subscription. The resolution is 14 bits with 1 LSB = 0.51μV (16-bit analog to digital converter with 2 bits instrumental noise floor discarded). The bandwidth is 0.2 – 43Hz with digital notch filters at 50Hz and 60Hz. It includes a digital 5^{th}-order Sinc filter, and a dynamic range (input referred) of 8400μV. It is AC coupled and powered by a lithium polymer battery (480mAh). Figure 4 shows the Emotive Epoc device.

Figure 4. The Emotiv Epoc – Brainwear®

The EEG

To allow the SubSearch Game to communicate with the EEG, and to monitor the EEG in real time, the two computers were connected by Ethernet through a single switch. The first computer ran the Subsearch game. Certain in-game events, such as displaying a gain or a loss message on the monitor, triggered a signal to the second computer. It collected the EEG data via a Bluetooth connection. It also compiled the data, temporally aligning the EEG data with the 8-bit codes received from Subsearch and saved them to a hard disk. Because of the limitations of Bluetooth range, both computers were located in the same room, but the interface for the second computer was in an adjacent room. The final output was a large csv file that contained a time-step column, the 14 electrode channels, and markers for each SubSearch on-screen message.

Data Processing

The data were imported using EEGLab® with the ERPLab® add-on. EEGLab® is an interactive Matlab® toolbox for processing continuous and event-related EEG, magnetoencephaographic (MEG), and other electrophysiological data that incorporates independent component analysis (ICA), time/frequency analysis, artifact rejection, event-related statistics, and several useful modes of visualization of the averaged and single-trial data.

Subsequently, a 1Hz high-pass filter, followed by a 50 Hz low-pass filter, was applied. Epochs were created for each gain or loss message in the SubSearch game and ranged from 1,000 msec before the message appeared to 2,000 msec after it disappeared. Any epoch containing an amplitude that exceeded 150 mV was rejected. The epochs were averaged for gains and losses separately to create a pair of waves for each participant in each session. Then grand averages were created by averaging each of the waveforms.

Figure 5 shows grand averaged the P300 VEP/ERP waveform (i.e., all subjects) with its correspondent components. The latencies for the N50, P100, N100, P200, N200, and P300 from the grand averages per electrode were determined by visual inspection of the waveforms, the grand averages per participant were processed automatically using as a reference the grand average per electrode. The amplitudes and latencies for the wave components per individual session were calculated according to the following steps:

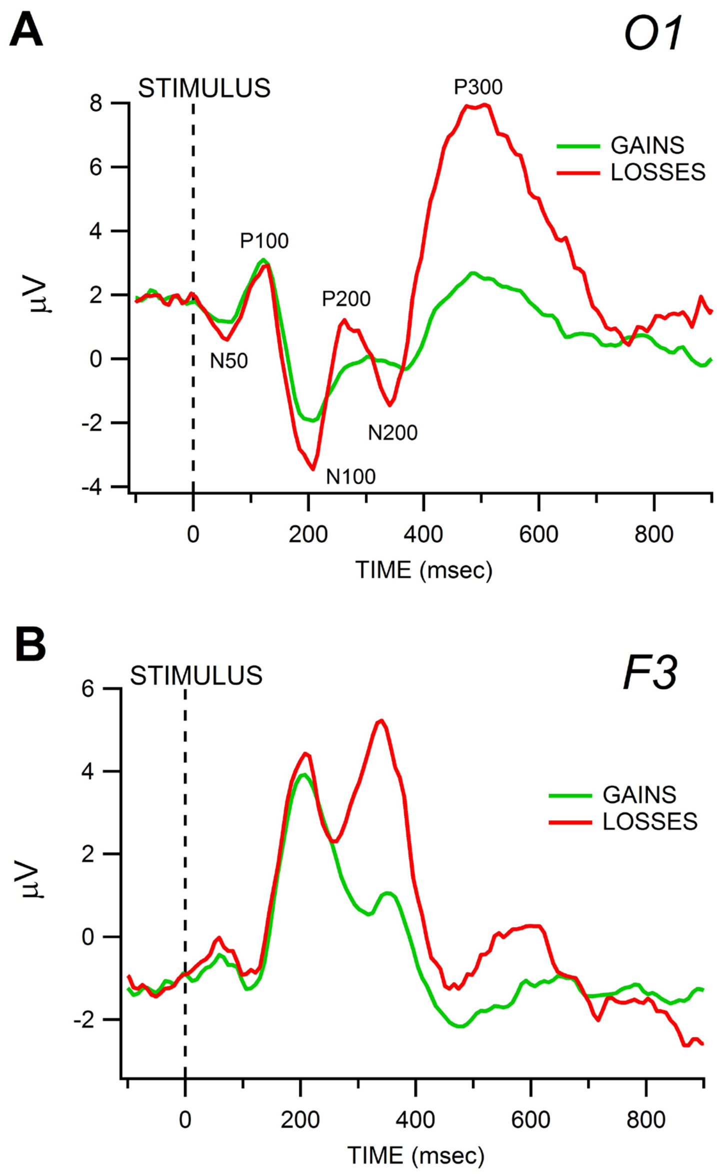

Figure 5. Grand Averaged P300 VEP/ERP waveforms

Grand averaged the P300 VEP/ERP waveform (i.e., all subjects) with its correspondent components

1. The positive and negative peaks from the wave were extracted.

2. The N100 component's latency was set as the lowest peak within 75 msec of the grand average of the N_{100} latency.
3. The P300 latency was set as the highest peak within 150 msec of the grand average of the P300 latency.
4. The N50 latency was set as the lowest peak between it and the new N100 latency.
5. The P100 latency was set as the highest peak between the N50 and the N100.
6. The N200 latency was set as the lowest peak between the N100 and the P300.
7. The P200 latency was set as the highest peak between the N200 and the P300.

To calculate the component associated with the second P300 when it occurred, a similar process was followed, except, instead of using the grand latencies, the second N100 was calculated as the lowest point between the first P300 and 1,500 msec, and the second P300 was calculated as the highest point between the second P100 and 1,900 msec.

Behavioral Data Analysis

All analyses were conducted with IBM SPSS Statistics 23 (IBM Corp., 2013, 2015), and Microsoft Excel®. Measures included the number of responses (clicks) to the left and right alternatives (B_L and B_R) and the number of reinforcers (R_L and R_R). The response ratio B_L / B_R and the reinforcer ratio R_L / R_R were employed in the analysis. The generalized matching relation was the basis of the analysis of behavioral choice. The results were analyzed using Baum's (1974) generalized matching law (Equation 2), which is repeated here:

$$\log (B_L / B_R) = \log k + c \log (R_L / R_R)$$

The subscripts *L* and *R* refer to the left and right alternatives. *k* and *c* are constants; *k* represents bias, that is, a consistent preference for one alternative over another (Miller, 1976).

Bias also may apply to the preference for uncertain losses over certain ones. The other parameter, *c*, refers to the sensitivity of behavior to reinforcement or to punishment, that is, the degree to which the ratio of responses to the two alternatives is affected by changes in the ratio of reinforcers or punishers. Bias values were calculated for all conditions.

Superimposing schedules of punishment on schedules of reinforcement created a mathematical challenge that is discussed in chapter 3 and was the reason for the adoption of the generalized matching law without explicit, formal consideration of punishment, an approach I identified as the “indirect method”. I calculated the ratio of net reinforcers received on the left alternative (R_L) to those received on the right alternative (R_R), as well as the ratio of responses (B_L/B_R), then log-transformed each (the logarithmic transformation and the use of geometric means is also discussed in chapter 3). The log of the response ratio was then expressed as a function of the log of the reinforcer ratio, and these data were fitted using linear regression. The antilogarithms of the intercept (*b*) of the fitted equations for conditions 1, 3, and 5 and for conditions 2, 4, and 6 were used to calculate the gain/loss ratios, which was the measure of gain-loss asymmetry. Table 2 (a sample table) shows the tables structure with means (*M*), slopes, intercepts, standard error of the estimate (*SE*), R^2 values, antilogs, and gain/loss ratios from a linear-regression analysis using the logarithmically transformed generalized matching law. The format is extensively used in the tables found in the appendices that show the gain/loss ratios calculations. In the tables the results are presented in two methods: A method that was used by Rasmussen and Newland that averages the individual slopes, intercepts and R^2 values to obtain the means for all participants (or categories) and a method that is labeled as the standard method with the results of the regression algorithm used in SPSS®.

Table 2

Sample Table – Behavioral Data Analysis

	No Punishment				Punishment				Gain/ Loss Ratio
	Slope (c)	Intercept (log k)	R^2	Antilog (k)	Slope	Intercept (log k)	R^2	Antilog (k)	
M									
SE									

Sensitivity (c) and bias (log k) estimates for each participant under the no-punishment and punishment conditions

To maintain consistency with other previous studies, the linear regression intercepts were used to calculate the gain/loss ratios in the behavioral measurement section. However, a Linear Mixed Model (LMM) was used in addition to the linear regression to determine statistical significance with two constraints: 1) the estimated means vary but not substantially from the estimated means (intercepts) calculated using linear regression and 2) due to the behavioral experiments were conducted independently, the LMM was also used, to analyze the data independently for each experiment. The electrophysiological analysis uses a full LMM with all factors incorporated in the analysis as only one experiment. The estimated means of the LMM (equivalent to the intercepts of the linear regressions) were used for the calculation of the gain/loss ratios. The LMM was also used to determine statistical significance.

ERP Data Analysis

The analysis of the averaged ERPs focused on the previously indicated various components of the average signal, with each component characterized by its amplitude, polarity (positive or negative), and latency. An ERP waveform unambiguously consists of a series of peaks (here termed positive peaks) and troughs (negative peaks), but these voltage deflections reflect the sum of several relatively independent underlying or latent components. To isolate the latent components so that they could be measured independently was challenging. Considerable effort was made to successfully distinguish between the observable peaks of the waveform and the unobservable latent components. The SubSearch video game was designed to minimize latent components and to make sure that the evoked P300 was, as much as possible, a direct result of the experimental design. An important objective of the design was to separate the processes related to monetary gains and losses from possible confounding factors. The EEG does not only record ERPs but also other, “noisy” signals. The method I used to reduce the latter signals was signal averaging. All the analyses featured epochs that were time-locked to the onset of the fixation signal that preceded the on-screen messages announcing reinforcers and punishers. Additionally, the modulating effects of valence and magnitude on the ERPs were examined. Figure 6 shows the sequence of events in the video game. The ERP epochs started with a blank screen that appeared simultaneously with scheduled delivery or a reinforcer or punisher. Five-hundred msec later, a fixation mark appeared on the screen. After another 500 msec had passed, the gain or loss message appeared on the screen. It was designed to signal the onset of the P300. Analysis of the epoch began 500 msec previous to the fixation signal. Immediately following the presentation of the reinforcer (or punisher) message, which remained on the screen until the participant resumed the game), there was a 1000-msec delay until the button at the bottom of the screen between the two cumulative counters began to blink. During this interval, the game was inoperative and remained so until the participant clicked the button. Indeed, it was this click that was assumed to generate a second waveform similar to the P300.

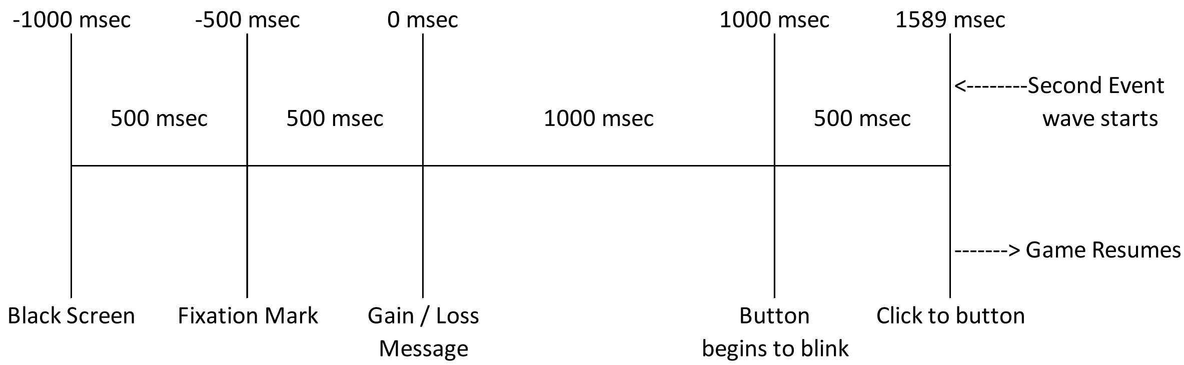

Figure 6. The timeline for the components of the ERP epoch

APPENDIX A

Consent to Be a Research Participant

Introduction
The current study is being conducted by Diego G. Flores, a doctoral student in Psychology, under the direction of Harold Miller PhD. (BYU Professor of Psychology) and Harold Miller's research team of graduate and undergraduate students. In order to decide whether or not you wish to be a part of this research study you should know enough about its risks and benefits to make an informed decision. This consent form gives you detailed information about the study, which a member of the research team will discuss with you.

Purpose
The research examines the effects of gains and losses.

Procedure
You will be asked to play a game on a computer for ten separate 30 to 60 minute sessions. At the beginning of the first session or the end of the last session you will be required to complete a 10 minute questionnaire (only once) that includes multiple-choice and yes/no questions. The sessions will take place in Harold Miller's laboratory (1190C SWKT). You will be asked to read instructions written in English. You will be seated in front of a computer monitor and provided with a computer mouse. The mouse will allow you to move two small submarines around obstacles in order to contact floating targets. A coin dispenser will be connected to the computer. When you make contact with a target, a message will appear on the screen indicating that you can collect or insert a coin. The game will resume when you have done so. You should try to collect as many coins as possible.

Two of the sessions will include an electro-encephalogram (EEG). While you play the game, we will measure brain-wave activity from sensors placed on you scalp while you complete the task. We will use a neuro-technology for personal interface for human computer interaction. The Emotiv EPOC is a high resolution, multi-channel, wireless neuro-headset. The sensors for recording brain activity are both painless and harmless; they merely record the small electrical signals produced by your body. The experimenter will clearly explain where the sensors will placed before applying them.

Additional instructions to play the game are attached to this form.

Risk/Discomforts
There are minimal risks for participating in this study. The risks associated with EEG in this study do not differ from a standard clinical EEG. Sensors are cleaned and disinfected after each use.

Benefits
There are no known direct benefits to you as a result of participating in this study.

Confidentiality
If you decide to participate in this study, the researcher will get information that identifies you such as name, age, telephone number, and email address. The investigator will create a link between this information and your data files in the experiment. This link will be kept secure and will be available only to the researchers. Your responses to the procedures of the study will be securely stored, and all information will be presented in aggregate form and will be anonymous.

Compensation
You will receive $30 bonus at the end of your participation. Additional amounts will be paid according to your performance in the game at the conclusion of each session.

Participation
Your participation in this research is entirely voluntary. You have the right to withdraw at any time or refuse to participate entirely without jeopardy to your class, status, grade, or relationship to BYU or researchers. If you wish to withdraw from the study, simply inform the experimenter. If you do choose to withdraw from the study you will not receive the completion bonus.

The researchers may withdraw you from participating in the research in necessary, such as when your reaction to testing is judged to be harmful or if you are not complying with research procedures.

Questions About The Research
We have used some technical terms in this form. Please feel free to ask about anything you don't understand and to consider this research and the consent form carefully –as long as you feel is necessary –before you make a decision. If you have questions about this experiment you may contact Diego Flores at diego@byu.net (801-362-4789), Harold Miller, PhD. at harold_miller@byu.edu or (801)422-8939.

Questions About Your Rights As A Participant
If you have additional questions about your rights as a participant, you may contact the BYU Institutional Review Board Administrator, A-285 ASB, Brigham Young University, Provo, Utah 84602, Phone (801) 422-1461, irb@byu.edu.

I have read, understood, and received a copy of the above consent to participate in research, and am participating of my own free will:

Name of the participant: ____

Signature: ______________________ Date: ____________

Risk Aversion Survey

A. Selected original items from the CDQ **(Kogan and Wallach, 1964)**

1. Mr. D is the captain of College X's football team. College X is playing its traditional rival, College Y, in the final game of the season. The game is in its final seconds, and Mr. D's team, College X, is behind in the score. College X has time to run one more play. Mr. D, the captain, must decide whether it would be best to settle for a tie score with a play which would be almost certain to work or, on the other hand, to try a more complicated and risky play that could bring victory if it succeeded but defeat if it did not..

   Imagine that you are advising Mr. D. Listed below are several probabilities or odds that the risky play will work. Please check the lowest probability that you would consider acceptable for the risky play to be attempted.

   -------- Place a check here if you think Mr. D should not attempt the risky play no matter what the probabilities.
   -------- The chances are 9 in 10 that the risky play will work.
   -------- The chances are 7 in 10 that the risky play will work.
   -------- The chances are 5 in 10 that the risky play will work.
   -------- The chances are 3 in 10 that the risky play will work.
   -------- The chances are 1 in 10 that the risky play will work.

2. Mr. F is currently a college senior who is very eager to pursue graduate study in chemistry to obtain the Doctor of Philosophy (Ph.D.) degree. He has been accepted by both University X and University Y. University X has a world-wide reputation for excellence in chemistry. Although a degree from University X would signify outstanding training in this field, the standards are so rigorous that only a fraction of the degree candidates actually receive the degree. University Y, on the other hand, has much less of a reputation in chemistry, but almost everyone admitted to the program is awarded the Ph.D. degree, which has much less prestige than the corresponding degree from University X.

   Imagine that you and several colleagues are advising Mr. F. Listed below are several probabilities or odds that Mr. F would be awarded a degree at University X, the one with the much-greater prestige. Please check the lowest probability that you would find acceptable to make it worthwhile for Mr. F to enroll in University X rather than University Y.

   -------- Place a check here if you think Mr. F should not enroll in University X, no matter what the probabilities.
   -------- The chances are 9 in 10 that Mr. F would receive a degree from University X.

-------- The chances are 7 in 10 that Mr. F would receive a degree from University X.

-------- The chances are 5 in 10 that Mr. F would receive a degree from University X.

-------- The chances are 3 in 10 that Mr. F would receive a degree from University X.

-------- The chances are 1 in 10 that Mr. F would receive a degree from University X.

B. Typical gambles used to infer risk aversion

1. You are offered a chance to buy the following gamble for 50 cents:

    1. A 50% chance of winning $1
    2. A 50% chance of winning nothing

    Please indicate whether or not you will buy the gamble. 1=Yes 2=No

2. You have a choice between the following two options:

    1. A sure gain of $750
    2. A 40% chance to gain $2000 and a 60% chance to gain nothing

    Please indicate which option you will choose.

3. You have a choice between the following two options:

    1. A sure loss of $1500
    2. An 80% chance to lose $2000 and a 20% chance to lose nothing

    Please indicate which option you will choose.

4. You are offered the chance to buy the following gamble for $3000:

    A 50% chance of winning $6000 and a 50% chance of winning nothing.

Please indicate whether or not you will buy the gamble. 1=Yes 2=No

C. General Risk Aversion Scale

General Risk Aversion Scale (The range of answers for each item is from 1= "Strongly Agree" to 7= "Strongly Disagree".)

		Strongly Agree						Strongly Disagree
1	I do not feel comfortable about taking chances.	1	2	3	4	5	6	7
2	I prefer situations that have foreseeable outcomes.	1	2	3	4	5	6	7
3	Before I make a decision, I like to be absolutely sure how things will turn out.	1	2	3	4	5	6	7
4	I avoid situations that have uncertain outcomes.	1	2	3	4	5	6	7
5	I feel comfortable improvising in new situations	1	2	3	4	5	6	7
6	I feel nervous when I have to make decisions in uncertain situations.	1	2	3	4	5	6	7

Instructions for the SubSearch Game

In this session, you will play a videogame in which you steer a submarine between sea barriers to make contact with undersea coins. To move the sub, click the mouse on the screen to indicate where the sub should go.

The screen will be divided vertically in half—each side with its own sub and coins. You may switch from one side to the other at any time. You will also notice the screen color changing from time to time. Something about the game also changes at that time.

Sometimes when the sub picks up a coin, a message will appear on the screen indicating that you can collect the coin and increasing your winnings. The game will resume when you have done so. When the sub reaches the treasure chest on the sea floor, you will move to the next level of the game.

Now and then, in addition to the message that tells you to collect a coin, there will be another message that tells you to deposit a coin, which will decrease your winnings. The game will resume when you have deposited the coin.

You should try to collect as many coins as possible. Once the session ends, you will receive a cash payment based on the number of coins you collected. You will receive a cash bonus of $30 at the end of the experiment.

If you are interested in receiving a report of the research, please notify the experimenter, who will ask for your contact information.

CHAPTER 3: Models of Matching and the Results from Experiments 1-3

The purpose of general laws is to explain and predict observable phenomena through the use of numbers and numerical operations—a process called measurement. The laws I have cited previously are Herrnstein's matching law (1961) and the generalized matching law (Baum, 1974). Both utilize behavioral events, such as responses, and environmental events, such as reinforcers to measure choice between alternatives. They have been used effectively in cases where reinforcers are used to influence an individual's behavior. However, the effort to add punishers to the g laws creates complications. As described earlier, in the generalized-matching-law approach to the current research, B represents the total number of clicks of the mouse and R the total number of reinforcers. Subscripts identify the left (L) and right (R) panels on the screen. The constants *k* and *c* represent sensitivity and bias parameters, respectively. The dependent variable is the ratio B_L/B_R, and the independent variable is the ratio R_L/R_R, which represents the ratio of reinforcers received on the left to those received on the right. Punishers, represented by P, were only delivered in the left panel. Here I consider a series of mathematical models of matching involving these variables and summarize their relative merits.

Models for Measuring the Asymmetry of Monetary Gains and Losses

I considered several models in order to accurately represent the conjoining of reinforcers and punishers. I summarize them here in three different groups: Adding punishers (ADD models), subtracting punishers (SUB models), and an indirect method (NP models) that does not take punishers into account at all. The optional use of geometric means and logarithmic transformations generated additional submodels in each category.

Adding Punishers (ADD Model)

Deluty (1976) and de Villiers (Villiers, 1977, 1980) developed two different quantitative models of punishment, which can be viewed as mathematical versions of the avoidance theory of punishment and the negative law of effect, respectively (Mazur, 2006). Both are rooted in Herrnstein's (1961) matching law. The ADD model is based on Deluty's (1976, 1982), where punishers are added to reinforcers, and the resulting version of the matching law is written as:

$$B_L / (B_L + B_R) = (R_L + P_R) / [(R_L + P_R) + (R_R + P_L)]. \quad (4)$$

This equation can be expressed in terms of response and reinforcer ratios (Gray, Stafford, & Tallman, 1991):

$$B_L / B_R = (R_L + P_R) / (R_R + P_L). \quad (5)$$

According to Gray et al., "This model suggests that the obtained levels of reinforcement operate directly on the behavior, while obtained frequencies of punishment operate inversely but in an additive manner." (1991, p. 320)

Subtracting Punishers (SUB Model)

In de Villiers' (1977, 1980) model, punishers are subtracted from reinforcers. Rasmussen and Newland (2008, p. 59) used de Villers' model and observed that:

. . . Few studies have examined matching with human participants and punishment, but in those studies, the punisher tends to subtract value from the reinforcers earned on an alternative, changing the value associated with that alternative and, therefore, the proportion of behavior allocated to the punished alternative. (2008, p. 59)

The mathematical model is:

$$B_L / B_R = (R_L - P_L) / (R_R - P_R). \qquad (6)$$

According to Rasmussen and Newland (2008), Deluty and de Villiers "found strong support for the subtractive model of punishment" (Rasmussen & Newland, 2008, p. 58).

In my research, the experimental design frequently produced a negative value of the ratio after subtracting punishers from reinforcers. This rendered the logarithmic transformation of the generalized matching law a mathematical impossibility. Consequently, several adjustments to Equation 6 were considered and are summarized below.

The Non-negative SUB model (*NNSUB)*. This model was identical to Equation 6 but excluded instances in which the ratio featuring reinforcers and punishers was negative,

The effect of this adjustment was to substantially affect the size of the resulting ratio and thus bring the measure of gain-loss asymmetry into question.

The Inverted SUB Model (INVSUB). This model is also identical to Equation 6, however, I used a mathematical artifice to avoid the calculation of logarithms of negative numbers. The artifice consisted of transforming only the negative numbers into positive numbers before the calculation of the logarithms, after the logarithms are obtained then the sign of the values are reversed, following that, the antilogs are calculated.

The Absolute Value SUB model (ABSSUB). This model altered the SUB model as follows:

$$B_L / B_R = | (R_L - P_L) | / | (R_R - P_R) |. \qquad (7)$$

Subsequently the absolute value of the difference of R_L - P_R is obtained and used to calculate the ratio. Another artifice –raising the ratios to the square to handle only positive values- can be used, however, results are equal to using the absolute value.

The SUB Plus k Model (SUBK).

In this model, the constant *k* is added to the ratios in order to eliminate negative values:

$$(B_L / B_R) + k = [(R_L - P_R) / (R_R - P_L)] + k. \qquad (8)$$

The Indirect or No Punishment (NP)

A different approach to modeling the relationship between reinforcers and punishers was Equation 3. The logic of the model is that the effect of punishers may be measured indirectly by any displacement of the effects of reinforcers. In other words, it is not necessary to conjoin reinforcers and punishers in order to measure their asymmetry. This model eliminates the problem of negative ratio values,

The Non-Linear (NL) Model

Considering the limitations of logarithmic transformation due to negative numbers, the Non-linear Model (NL) applied nonlinear regression to the generalized matching law.

Logarithmic and Geometric Transformations

Logarithmic transformation can be used to make highly skewed distributions less skewed. This can enhance the identification of patterns in the data, at the same time more readily meeting the assumptions of inferential statistics. Similarly, the use of geometric means "normalizes" the data distribution. In the present analysis, two categories (Log or No Log) were applied to the use of logarithms and two other categories (GeoMean or NoGeoMean) to the use of geometric means.

Experiment 1

Experiment 1 utilized the methods and data analytic procedures previously described. The results are presented in the following order: First, the gain/loss ratio was calculated using the different models already introduced. Second, a criterion for the selection of the preferred model was determined. Third, the overall gain/loss ratio was calculated using the preferred model. Fourth, the gain/loss ratio as a function of gender was calculated. Fifth, the gain/loss ratio as a function of risk was calculated. Table B1 in Appendix B at the end of the chapter displays the means for responses, obtained reinforcers, obtained punishers, and changeovers for all 26 participants in the non-punished conditions of this experiment. The corresponding results for the punished conditions appear in Table B2 in the same appendix.

Calculation of the Gain/Loss Ratio Using Different Models

Table 3 is a summary of the gain/loss ratios per category and model. The global average of the gain/loss ratios across all categories was 2.05 (see Appendix B). The rightmost column displays the absolute difference between the respective ratio and the grand average. The details of the ratios calculations are included in Appendix B (Tables B3 - B8). The submodel column serves to identify the model in the appendix.

Table 3

Gain/Loss Ratios Calculated Using Different Models and Geometric and Logarithmic Transformations

	Model	Submodel ID	Use of Logs	Use of Geometric Means	Use of Linear Regression	Use of Non linear Regression	Gain/Loss Ratio	Absolute difference from the global mean
Gain/loss ratios calculated using linear regression and the logarithmic transformation	NP	NGL1	Yes	No	Yes	No	2.23	0.18
	ADD	NGL2	Yes	No	Yes	No	2.36	0.31
	NNSUB	NGL3	Yes	No	Yes	No	3.72	1.67
	ABSSUB	NGL4	Yes	No	Yes	No	2.2	0.15
	INVSUB	NGL5	Yes	No	Yes	No	2.07	0.02
	SUBK	NGL6	Yes	No	Yes	No	0.8	1.25
Gain/loss ratios calculated using linear regression, geometric means, and the logarithmic transformation	NP	GL1	Yes	Yes	Yes	No	2.23	0.18
	ADD	GL2	Yes	Yes	Yes	No	2.47	0.42
	NNSUB	GL3	Yes	Yes	Yes	No	7.79	5.74
	ABSSUB	GL4	Yes	Yes	Yes	No	1.74	0.31
	INVSUB	GL5	Yes	Yes	Yes	No	2.36	0.31
	SUBK	GL6	Yes	Yes	Yes	No	1.03	1.02

Table 3 - Continuation

Gain/Loss Ratios Calculated Using Different Models and Variations of Geometric and Logarithmic Transformations

Category	Model	Submodel ID	Use of Logs	Use of Geometric Means	Use of Linear Regression	Use of Non linear Regression	Gain/Loss Ratio	Absolute difference from the global mean
Gain/loss ratios calculated using linear regression	NP	NGNL1	No	No	Yes	No	1.64	0.41
	ADD	NGNL2	No	No	Yes	No	1.51	0.54
	NNSUB	NGNL3	No	No	Yes	No	1.66	0.39
	ABSSUB	NGNL4	No	No	Yes	No	1.62	0.43
	INVSUB	NGNL5	No	No	Yes	No	n/a	n/a
	SUBK	NGNL6	No	No	Yes	No	0.95	1.1
Gain/loss ratios calculated using non-linear regression	NP	PWRNG1	No	No	No	Yes	1.68	0.37
	ADD	PWRNG2	No	No	No	Yes	1.78	0.27
	NNSUB	PWRNG3	No	No	No	Yes	2.39	0.34
	ABSSUB	PWRNG4	No	No	No	Yes	1.71	0.34
	INVSUB	PWRNG5	No	No	No	Yes	1.71	0.34
	SUBK	PWRNG6	No	No	No	Yes	0.81	1.24

Table 3 - Continuation

Gain/Loss Ratios Calculated Using Different Models and Variations of Geometric and Logarithmic Transformations

Category	Model	Submodel ID	Use of Logs	Use of Geometric Means	Use of Linear Regression	Use of Non linear Regression	Gain/Loss Ratio	Absolute difference from the global mean
	NP	PWRG1	No	No	No	Yes	1.73	0.32
Gain/loss ratios	ADD	PWRG2	No	No	No	Yes	1.9	0.15
calculated using non-	NNSUB	PWRG3	No	No	No	Yes	4.43	2.38
linear regression and	ABSSUB	PWRG4	No	No	No	Yes	1.43	0.62
geometric means	INVSUB	PWRG5	No	No	No	Yes	n/a	n/a
	SUBK	PWRG6	No	No	No	Yes	1.03	1.02

Criteria for the Selection of a Model

Table 4 is a summary of the criteria by which I evaluated the models in order to select one that was best-fitting. Four criterion were used with a scale of 1 to 6. The lowest the score the best fit. Central Tendency: the close the mean of the model to the global mean the lowest the score. Consistency Within Models: the sum of the absolute differences from the global mean inside each model, the lowest the difference the lowest the score (INVSUB obtained the highest score due to the formula is not applicable in all categories). Consistency Across Models: the lowest the standard deviation of the submodels inside the model the lowest the score. And Parsimony, the easiest to use the model the lowest the score. Based on the criteria NP was the best and ADD the second best model.

Table 4

Evaluation of Models to Determine the Best Fit

				Consistency			
Model	*M*	*SD*	Central Tendency	Within Models	Across Models	Parsimony	Total Score
NP	1.9	0.29	3	2	1	1	7
ADD	2.0	0.34	2	1	3	2	8
NNSUB	4.0	2.10	6	5	6	3	20
ABSSUB	1.74	0.37	4	3	4	4	15
INVSUB	2.05	0.22	1	6	5	5	17
SUBK	0.92	1.13	5	4	2	6	17

Table 5 shows the submodels inside the selected models that have the lowest absolute differences from the global mean. The submodel NGL1 was selected due to it was the easiest to use and the gain/loss ratios calculated were the same when geometric means were used. The NP model seemed to be more consistent.

Table 5

Final Model Selection

Model	Sub model	Ratio	Absolute difference from the Global mean
NP	NGL1	2.23	0.18
NP	GL1	2.23	0.18
ADD	PWRG2	1.90	0.15

Gain/Loss Ratio Results

The Overall Gain/Loss Ratio

Hypothesis BEH1 (see chapter 1) stated that the expected value of the asymmetry of gains and losses would be between 2 and 3, which is consistent with the earlier findings of Kahneman and Tversky (1979) and Rasmussen and Newland (2008). There was a highly significant difference between the unpunished and punished conditions at the .01 level $F_{(1.464)}$ = 154.790, p = 0.000. Small significance values (that is, those less than 0.01) indicated that the effect contributed to the latent factors model. For the statistical analysis, log (R_L/R_R) was the independent variable and log (C_L/C_R) was a covariate. Punishment was the factor analyzed in the model to determine the significance of the gains and losses. The estimates of the covariate residual were: estimate = 0.143500, SE = 0.009421. The estimated marginal grand mean was -

0.221 and the *SE* = 0.018. The punished mean was -0.48, *SE* = 0.25 and the unpunished mean was -0.395, *SE* = 0.025. The gain/loss ratio 2.23, confirming Hypothesis BHE1.

Individual Gain/Loss Ratios

Table 6

Experiment 1: Summary of the Gain/Loss Ratio per Participant

Female		Male	
Participant ID	Gain/Loss Ratio	Participant ID	Gain/Loss Ratio
101	4.28	1	1.27
102	6.18	2	2.03
103	4.34	4	2.03
104	1.57	6	3.18
105	1.04	7	1.03
106	1.54	8	25.88
107	1.09	16	0.96
108	1.65	17	0.88
109	5.8	18	2.51
110	3.14	19	1.07
111	9.59	22	1.13
112	3.4		
113	2.87		
114	1.1		
115	1.09		

Table 6 displays the ratios for individual participants. Table C1 (see Appendix C) includes a detailed description of the calculation of the individual ratios with the corresponding slopes, intercepts, and R^2 values for both the unpunished and punished conditions.

Gender

Hypothesis BEH2 stated that there would be gender differences in the asymmetry of gains and losses. The results of the mixed model analyses were that the difference between male and female participants was significant at the 0.05 level Gender $F_{(1.460)} = 3.954$, $p = 0.047$, Punishment $F_{(1.460)} = 91.566$, $p = 0.000$. All other interactions were not significant at the 0.05 level. The estimated covariate residual was 0.142731 and the *SE* = 0.009411. The estimated marginal grand mean was -0.216 and the *SE* = 0.018. Table 7 displays the means, *SE*s, *df*, and 95% confidence interval (CI) for the interaction between punishment and gender. The means of the LMM matched the intercepts (*k*) in the linear regressions that were used to calculate the gain/loss ratios.

Table 7

Experiment 1: Asymmetry of Gains and Losses – Gender Differences (Means and SEs)

df = 460

				95% CI	
Category	Gender	*M*	*SE*	Lower Bound	Upper Bound
No punishment	Male	-0.040	0.038	-0.114	0.035
	Female	-0.053	0.033	-0.118	0.011
Punishment	Male	-0.322	0.038	-0.397	-0.248
	Female	-0.449	0.033	-0.513	-0.385

Based on the means (intercepts) obtained in the regression analysis (see Table D1 in Appendix D) the gain/loss ratios were calculated. The overall ratio for male subjects was 1.92 and for females 2.49, which supported Hypothesis BEH2.

Risk

The LMM was used to analyze the asymmetry of gains and losses between risk-averse (RA) and risk-seeking (RS) participants. The difference was highly significant at the 0.01 level Punishment $F_{(1.460)} = 130.107$, $p = 0.000$, Risk $F_{(1.460)} = 47.451$, $p = 0.000$, and Punishment * Risk $F_{(1.460)} = 50.313$, $p = 0.000$. All other interactions were not significant at the 0.01 level. The estimate of the covariate residual was 0.117580, *SE* = 0.007753, and of the estimated marginal grand mean was -0.229, SE = 0.016, *df* = 460, 95% CI [-0.261,-0.198].

Table 8 displays the means of the LMM, SEs, *df*, and 95% CI for the interaction of punishment and risk. The means are the intercepts in the linear regressions that were used to calculate the gain/loss ratios.

Table 8

Experiment 1: Asymmetry of Gains and Losses – Risk Differences (Means and SEs)

df = 460

				95% CI	
Category	Risk Category	*M*	*SE*	Lower Bound	Upper Bound
No Punishment	RA	-0.044	0.033	-0.109	0.021
	RS	-0.051	0.031	-0.111	0.010
Punishment	RA	-0.635	0.033	-0.701	-0.570
	RS	-0.187	0.031	-0.247	-0.126

A complete list of the participants with their respective individual risk scores, slopes, intercepts, R^2 values, and gain/loss ratios for the unpunished and punished alternatives is displayed in Table E1 in Appendix E. The overall gain/loss ratio for the RA participants was

3.89 and for the RS participants 1.38, thus supporting the hypothesis that RA participants would have higher asymmetry ratios compared to risk seekers.

Risk Mediated by Gender

In addition to the RA versus RS comparison, the analysis was extended to RA versus RS differences mediated by gender. A complete list of the participants with their respective risk scores, slopes, intercepts, R^2 values, and gain/loss ratios for the unpunished and punished alternatives is displayed in Table E2 (see Appendix E).

The results were significant at the 0.01 level Punishment $F_{(1.452)} = 112.255$, $p = 0.000$. Gender $F_{(1.452)} = 4.037$, $p = 0.045$, and Punishment * Risk $F_{(1.452)}$, 24.729, $p = 0.000$. Risk $F_{(1.452)} = 41.182$, $p = 0.000$ was significant at the 0.05 level. All other interactions were not significant at the 0.05 level. The estimate of the covariate residual was 0.125436 and the SE = 0.008344. The estimated marginal grand mean was -0.225 and the SE = 0.017, df = 452, 95% CI [-0.258,-0.192].

Table 9 shows the means, *SE*s, *df*, and 95% CI for the interaction of punishment and risk. As before, the means were the intercepts in the linear regressions that were used to calculate the gain/loss ratios (see Table E3 in Appendix E for a full summary of the ratio calculations).

The LMM analyses resulted in a significant difference between the unpunished and punished conditions, $F_{(1.452)} = 112.255$, $p = 0.000$, between the male and female participants $F_{(1.452)} = 4.037$, $p = 0.045$, between RA and RS participants, $F_{(1.452)} = 41.182$, $p = 0.000$, and for the interaction of punishment and risk $F_{(1.452)} = 24.729$, $p = 0.000$. Punishment, risk, and punishment * risk were significant at the 0.01 level. However, gender was significant at the 0.05 level.

Hypothesis BEH3 stated that a higher asymmetry ratio for gains and losses was expected for RA participants compared to RS participants. The overall gain/loss ratio for RA males was 2.95 and for RS males 1.35 for an overall asymmetry value of 2.18. The overall gain/loss ratio for the RA females was 3.70 and for the RS females was 1.76. Thus, RA female showed an overall asymmetry value 2.11 times higher than that for RS females. Hypothesis BEH3 was accepted.

Table 9

Experiment 1: Asymmetry of Gains and Losses – Risk Mediated by Gender

df = 452

Category	Gender	Risk Category	*M*	*SE*	95% CI Lower Bound	95% CI Upper Bound
No Punishment	Male	RA	-0.063	0.053	-0.167	0.041
		RS	-0.02	0.048	-0.115	0.075
	Female	RA	-0.082	0.045	-0.17	0.006
		RS	-0.028	0.042	-0.111	0.054
Punishment	Male	RA	-0.535	0.053	-0.639	-0.431
		RS	-0.148	0.048	-0.243	-0.054
	Female	RA	-0.649	0.045	-0.738	-0.561
		RS	-0.273	0.042	-0.356	-0.191

Experiment 2

Experiment 2 followed the analysis procedure as in Experiment 1. Participants completed six sessions in which cumulative gains and losses were displayed as points on the monitor screen. Only the last three sessions 4-6) were included in the analysis. During two additional sessions (7-8) featured the use of a coin dispenser/collector device in addition to the counters displayed on the screen (CD Refers to the coin dispenser/collector device).

Hypothesis BEH4 stated that participants were expected show increased loss aversion when playing the game using coins. A Linear Mixed Model (LMM) was used in which the independent variable was log (R_L/R_R), the covariate was log (C_L/C_R), and punishment and the coin dispenser were factors.

The results were: Punishment $F_{(1.754)}$, 223.917, p = 0.000, Coin Dispenser $F_{(1.754)}$ = 7.156, p = 0.008; Punishment * Coin Dispenser $F_{(1.746)}$, 12.968, p = 0.000. All other interactions were not significant at the 0.01 level. The estimate of the covariate residual was 0.167586 and the *SE* = 0.008631. The estimated marginal grand mean was -0.293 and the *SE* = 0.015, *df* = 754, 95% CI [-0.293,-0.233].

Table 10 is a summary of the means, *SEs*, *df*, and 95% CI for the interaction of punishment and coin dispenser/collector. The means are he intercepts from the linear regressions that were used to calculate the gain/loss ratios (see Table F1 in Appendix F for a full summary of the individual ratios for the participants playing the game points only and Table F2 for those for the two sessions feature cash as well).

Hypothesis BEH4 stated that participants would produce a larger gain/loss ratio when playing the game using coin dispenser/collector compared to points only. The gain/loss ratio for the latter condition was 2.23 and for the former was 3.70. That is participants playing the game with points and also the coin dispenser/collector demonstrated an asymmetry 1.66 higher than that when they played the game with points only. Thus, hypothesis BH4 was accepted. Details are presented in Table F3 and Table F4 in Appendix F.

Table 10

Experiment 2: Asymmetry of Gains and Losses – Points Versus Cash Plus Points

df = 754

				95% CI	
Category	Condition	*M*	*SE*	Lower Bound	Upper Bound
No Punishment	Points	-0.048	0.027	-0.101	0.005
	Points + CD	-0.020	0.034	-0.086	0.047
Punishment	Points	-0.395	0.027	-0.448	-0.343
	Points + CD	-0.587	0.034	-0.654	-0.521

Effects of Payoff Type Mediated by Gender

The LMM was also used to determine whether there was a significant difference between results from the payoff conditions of points only and points plus the coin dispenser/collector device that was mediated by gender differences.

The results were: Punishment $F_{(1.746)}$, 205.942, p = 0.000; Gender $F_{(1.746)}$ = 2.344, p = 0.126; Coin Dispenser $F_{(1.746)}$ = 7.387, p = 0.007; Punishment * Coin Dispenser $F_{(1.746)}$, 12.107, p = 0.001. All other interactions were not statistically significant at the 0.01 level. The estimate of the covariate residual was 0.167510 and the *SE* = 0.008673. The estimated marginal grand mean was -0.259 and the *SE* = 0.016, *df* = 746, CI [-0.289,-0.228].

Table 11 displays the means, *SEs*, *df*, and 95% CI for the interaction of punishment and coin dispenser/collector mediated by gender. The means are the intercepts in the linear regressions that were used to calculate the gain/loss ratios.

Table 11

Experiment 2: Asymmetry of Gains and Losses – Points versus Points Plus Cash Mediated by Gender

df = 746

					95% CI	
Category	Gender	Payoff Condition	*M*	*SE*	Lower Bound	Upper Bound
No Punishment	Male	Points	-0.040	0.041	-0.121	0.041
		Points + CD	-0.036	0.054	-0.142	0.071
	Female	Points	-0.054	0.035	-0.123	0.016
		Points + CD	-0.010	0.043	-0.095	0.075
Punishment	Male	Points	-0.323	0.041	-0.403	-0.242
		Points + CD	-0.543	0.054	-0.650	-0.437
	Female	Points	-0.449	0.035	-0.518	-0.380
		Points + CD	-0.616	0.043	-0.701	-0.531

The gain/loss ratio for female participants in the points-only condition was 2.49 and 4.06 in the points-plus-cash condition. That is, the latter condition produced an asymmetry value for the points-plus-cash condition that was 1.63 greater than that for the points-only condition. The gain/loss ratio for male participants in the points-only condition was 1.92 and 3.19 in the points-plus-cash condition. That is, the latter condition produced an asymmetry value for the points-plus-cash condition that was 1. 66 greater than that for the points-only condition. Female-VC were 1.29 more sensitive to losses compared to male-VC and female-CC were 1.26 more sensitive to losses compared to male-CC. Hypothesis BEH4 was accepted.

Experiment 3

Experiment 3 utilized the same data-analysis procedure as previously described. A group of 11 male participants (*M* = 22) was recruited to complete six sessions. They did so competitively, namely, each of them received information about the other participants' gains and losses prior to sessions 1-6. The 11 male participants (*M* = 22) of experiment 1 served as the control group. The control group did not receive information about other participants.

Hypothesis BEH5 stated that, in a competitive setting, participants would produce higher gain/loss ratios than those produced by participants who played the game without information about other participants' performance. A Linear Mixed Model (LMM) was used to test the differences between participants without information (NC) and those with information (C) and within the competition group risk averse (RA) and risk seekers (RS) were also tested for gain/loss differences. The independent variable was log (R_L/R_R), the covariate was log (C_L/C_R), and punishment and competition were factors.

The results were: Punishment $F_{(1, 388)} = 81.427$, $p = 0.000$; Competition $F_{(1, 388)} = 422$, $p = 0.516$; Punishment * Competition $F_{(1, 388)} = 0.108$, $p = 0.742$. All other interactions were not statistically significant at the 0.01 level. The estimate of the covariate residual was 0.104209, and the *SE* = 0.007482.

Table 12 displays the means, *SEs*, *df*, and 95% CI for the interaction of punishment and competition. The means were the intercepts in the linear regressions that were used to calculate the gain/loss ratios. Table G1 in Appendix G displays the individual results.

Table 12

Experiment 3: Asymmetry of Gains and Losses – Competition and No Competition (NC Refers to the No-Competition Condition and C to the Competition Condition

				95% CI	
Category	Competition Condition	*M*	*SE*	Lower Bound	Upper Bound
No Punishment	NC	-0.040	0.032	-0.104	0.024
	C	-0.008	0.032	-0.072	0.056
Punishment	NC	-0.323	0.032	-0.387	-0.259
	C	-0.310	0.032	-0.374	-0.246

APPENDIX B

Table B2

Experiment 1: Mean Responses, Obtained Reinforcers, Punishers, and Switches for the Punished Alternative

ID	Gender		Clicks Left	Clicks Right	Payoff Left	Payoff Right	Penalty Left	Penalty Right	Switches Left	Switches Right
1	M	*M*	393.8	517.1	8.9	10.8	11.1	0.0	9.3	9.6
		SD	87.4	143.9	3.5	5.8	4.1	0.0	2.7	2.6
2	M	*M*	138.8	324.9	10.1	9.3	10.7	0.0	32.5	32.7
		SD	65.8	75.3	4.2	6.3	3.5	0.0	14.8	14.7
4	M	*M*	245.0	432.3	7.1	8.3	9.8	0.0	12.5	12.4
		SD	166.5	199.4	2.9	5.2	3.3	0.0	8.1	8.4
6	M	*M*	212.3	849.9	5.3	7.1	5.9	0.0	8.5	8.7
		SD	188.1	231.4	4.0	6.2	5.1	0.0	3.0	2.8
7	M	*M*	325.8	334.6	9.3	8.4	12.5	0.0	13.7	13.7
		SD	60.1	53.8	5.4	5.1	4.4	0.0	12.1	12.0
8	M	*M*	40.9	1139.0	2.3	3.7	2.0	0.0	10.3	10.6
		SD	36.7	151.9	1.9	1.9	1.3	0.0	3.4	3.2
16	M	*M*	175.8	463.3	4.8	6.7	6.0	0.0	9.3	9.4
		SD	45.0	117.1	2.5	5.8	2.1	0.0	4.7	4.7
17	M	*M*	244.5	268.9	9.3	9.3	10.9	0.0	15.3	15.5
		SD	54.1	72.9	3.7	5.8	4.7	0.0	14.5	14.7
18	M	*M*	234.8	745.4	5.1	8.7	6.1	0.0	8.2	8.3
		SD	98.8	86.1	2.9	5.3	2.9	0.0	3.0	2.9
19	M	*M*	296.7	458.3	8.5	9.1	10.3	0.0	7.7	7.7
		SD	109.9	152.3	5.1	5.9	5.1	0.0	2.7	2.7
22	M	*M*	231.2	272.4	8.6	9.2	11.8	0.0	9.1	9.1
		SD	51.6	49.4	4.5	5.0	4.6	0.0	3.3	3.5
101	F	*M*	110.2	661.0	4.0	7.4	4.3	0.0	7.9	8.0
		SD	83.1	95.2	3.0	6.9	2.6	0.0	1.6	1.6
102	F	*M*	79.5	355.1	3.9	7.4	5.4	0.0	9.5	9.7
		SD	54.0	67.5	1.3	5.9	1.9	0.0	3.2	3.4
103	F	*M*	91.5	374.0	8.2	8.9	8.1	0.0	12.0	12.0
		SD	25.2	51.9	3.1	5.7	2.1	0.0	3.4	3.3
104	F	*M*	157.8	320.5	6.2	7.2	7.9	0.0	8.8	8.6
		SD	60.0	122.7	3.5	4.1	3.3	0.0	2.3	2.0
105	F	*M*	519.3	527.6	10.7	12.5	13.7	0.0	18.3	17.9
		SD	107.4	117.6	5.7	5.8	5.4	0.0	13.5	13.4
106	F	*M*	345.1	733.6	6.9	9.6	9.5	0.0	9.1	8.9
		SD	160.5	101.5	4.0	5.9	3.4	0.0	2.9	2.6
107	F	*M*	400.3	539.3	8.1	9.7	11.1	0.0	8.4	8.7
		SD	130.3	139.8	4.4	5.7	3.5	0.0	2.8	2.7
108	F	*M*	307.0	944.1	6.5	8.5	7.8	0.0	10.0	10.3
		SD	169.5	159.5	3.7	6.5	3.8	0.0	9.3	9.2
109	F	*M*	192.1	1049.3	4.7	8.0	5.5	0.0	9.7	9.5
		SD	175.2	194.6	3.0	5.3	3.9	0.0	4.6	4.9
110	F	*M*	143.5	264.7	9.1	7.6	11.3	0.0	10.2	10.1
		SD	60.8	96.5	5.6	4.5	5.6	0.0	3.7	3.7
111	F	*M*	43.9	1198.1	1.3	2.6	1.2	0.0	3.1	3.6
		SD	21.2	94.1	0.5	2.5	0.8	0.0	1.2	1.4
112	F	*M*	183.1	753.5	8.2	9.5	9.8	0.0	7.0	7.1
		SD	103.2	77.2	4.3	5.8	3.1	0.0	1.6	1.7
113	F	*M*	206.3	736.3	7.7	9.3	8.9	0.0	7.5	7.8
		SD	62.1	110.4	4.1	6.5	2.1	0.0	2.3	2.4
114	F	*M*	181.9	231.4	7.4	8.7	9.4	0.0	9.2	9.4
		SD	55.5	34.9	3.4	4.6	2.0	0.0	3.2	3.2
115	F	*M*	269.3	279.9	9.1	8.9	11.7	0.0	8.3	8.1
		SD	47.0	44.5	4.5	3.3	4.6	0.0	2.9	2.8

Table B3

Experiment 1: Asymmetry Ratios Calculated Applying Logarithmic Transformation Only

Model ID	Use of Logs	Geo Means	Model		No Punishment Slope (c)	No Punishment Intercept Log (k)	No Punishment R^2	No Punishment Antilog (k)	Punishment Slope (c)	Punishment Intercept Log (k)	Punishment R^2	Punishment Antilog (k)	Gain/ Loss Ratio
NGL1	Yes	No	NP	*M*	0.06	-0.05	0.01	0.90	0.05	-0.39	0.00	0.40	2.23
			$B_L/B_R = R_L/R_R$	*SE*	0.04	0.02	0.28		0.06	0.03	0.46		
NGL2	Yes	No	ADD	*M*	0.06	-0.05	0.01	0.90	-0.05	-0.42	0.00	0.38	2.36
			$B_L/B_R = R_L/(R_R+P_L)$	*SE*	0.04	0.02	0.28		0.10	0.05	0.46		
NGL3	Yes	No	NNSUB	*M*	0.06	-0.05	0.01	0.90	-0.25	-0.62	0.05	0.24	3.72
			$B_L/B_R = (R_L-P_R)/R_R$	*SE*	0.04	0.02	0.28		0.16	0.11	0.53		
NGL4	Yes	No	ABSSUB	*M*	0.06	-0.05	0.01	0.90	-0.09	-0.39	0.01	0.41	2.20
			$B_L/B_R = \|(R_L-P_R)\|/R_R$	*SE*	0.04	0.02	0.28		0.07	0.05	0.41		
NGL5	Yes	No	INVSUB	*M*	0.06	-0.05	0.01	0.90	0.06	-0.36	0.01	0.43	2.07
			$B_L/B_R = (R_L-P_R)/R_R$	*SE*	0.04	0.02	0.28		0.05	0.03	0.41		
NGL6	Yes	No	SUBK	*M*	0.03	1.04	0.04	11.03	-0.07	1.14	0.02	13.71	0.80
			$B_L/B_R + k = [(R_L-P_R)/R_R]+k$	*SE*	0.01	0.01	0.01		0.03	0.03	0.01		

Note: Sensitivity (c) and bias (k) estimates for each participant under no-punishment and punishment conditions.

Table B4

Experiment 1: Asymmetry ratios calculated applying geometric and logarithmic transformations

Model ID	Use of Logs	Geo Means	Model		No Punishment Slope (c)	No Punishment Intercept Log (k)	No Punishment R^2	No Punishment Antilog (k)	Punishment Slope (c)	Punishment Intercept Log (k)	Punishment R^2	Punishment Antilog (k)	Gain/ Loss Ratio
GL1	Yes	Yes	NP	*M*	0.06	-0.05	0.02	0.90	0.02	-0.40	0.00	0.40	2.23
			$B_L/B_R = R_L/R_R$	*SE*	0.05	0.02	0.21		0.11	0.05	0.43		
GL2	Yes	Yes	ADD	*M*	0.06	-0.05	0.02	0.90	-0.14	-0.44	0.01	0.36	2.47
			$B_L/B_R = R_L/(R_R+P_L)$	*SE*	0.05	0.02	0.21		0.19	0.09	0.40		
GL3	Yes	Yes	NNSUB	*M*	0.06	-0.05	0.02	0.90	-0.30	-0.94	0.04	0.12	7.79
			$B_L/B_R = (R_L-P_R)/R_R$	*SE*	0.05	0.02	0.21		0.50	0.50	0.63		
GL4	Yes	Yes	ABSSUB	*M*	0.06	-0.05	0.02	0.90	0.13	-0.29	0.02	0.52	1.74
			$B_L/B_R = \|(R_L-P_R)\|/R_R$	*SE*	0.05	0.02	0.21		0.12	0.10	0.40		
GL5	Yes	Yes	INVSUB	*M*	0.06	-0.05	0.02	0.90	0.10	-0.42	0.03	0.38	2.36
			$B_L/B_R = (R_L-P_R)/R_R$	*SE*	0.05	0.02	0.21		0.07	0.05	0.40		
GL6	Yes	Yes	SUBK	*M*	0.06	0.44	0.07	2.74	-0.10	0.43	0.03	2.67	1.03
			$B_L/B_R + k = [(R_L-P_R)/R_R]+k$	*SE*	0.02	0.01	0.04		0.07	0.02	0.06		

Note: Sensitivity (c) and bias (k) estimates for each participant under no-punishment and punishment conditions.

Table B5

Experiment 1: Asymmetry Ratios Calculated Neither Applying Geometric Nor Logarithmic Transformations

					No Punishment				Punishment				
ID	Use of Logs	Geo Means	Model		Slope (c)	Intercept Log (k)	R^2	Antilog (k)	Slope (c)	Intercept Log (k)	R^2	Antilog (k)	Gain/ Loss Ratio
NGNL1	No	No	NP	*M*	0.021	0.946	0.028	N/A	0.002	0.576	0.000	N/A	1.64
			$B_L/B_R = R_L/R_R$	*SE*	0.008	0.026	0.313		0.010	0.031	0.387		
NGNL2	No	No	ADD	*M*	0.021	0.946	0.028	N/A	-0.106	0.628	0.006	N/A	1.51
			$B_L/B_R = R_L/(R_R+P_L)$	*SE*	0.008	0.026	0.313		0.093	0.050	0.386		
NGNL3	No	No	NNSUB	*M*	0.021	0.946	0.028	N/A	-0.069	0.570	0.022	N/A	1.66
			$B_L/B_R = (R_L-P_R)/R_R$	*SE*	0.008	0.026	0.313		0.030	0.025	0.383		
NGNL4	No	No	ABSSUB	*M*	0.021	0.946	0.028	8.841	-0.014	0.585	0.001	3.846	1.62
			$B_L/B_R = \|(R_L-P_R)\|/R_R$	*SE*	0.008	0.026	0.313		0.035	0.030	0.387		
NGNL5	No	No	INVSUB	*M*	This model is not applicable.								
			$B_L/B_R = (R_L-P_R)/R_R$	*SE*									
NGNL6	No	No	SUBK	*M*	0.021	11.717	0.028	N/A	-0.069	12.331	0.022	N/A	0.95
			$B_L/B_R + k = [(R_L-P_R)/R_R] + k$	*SE*	0.008	0.106	0.313		0.030	0.329	0.383		

Note: Sensitivity (c) and bias (k) estimates for each participant under no-punishment and punishment conditions.

Table B6

Experiment 1: Asymmetry Ratios Calculated Applying Only Geometric Transformations

					No Punishment				Punishment				Gain/
ID Model	Use Logs	Geo Means	Model		Slope ©	Intercept Log (k)	R2	Antilog (k)	Slope ©	Intercept Log (k)	R2	Antilog (k)	Loss Ratio
GNL1	No	Yes	NP	*M*	0.042	0.886	0.080	N/A	0.009	0.538	0.001	N/A	1.65
			$B_L/B_R = R_L/R_R$	*SE*	0.016	0.039	0.241		0.029	0.058	0.350		
GNL2	No	Yes	ADD	*M*	0.042	0.886	0.080	N/A	-0.144	0.622	0.008	N/A	1.42
			$B_L/B_R = R_L/(R_R+P_L)$	*SE*	0.016	0.039	0.241		0.187	0.091	0.346		
GNL3	No	Yes	NNSUB	*M*	0.042	0.886	0.080	N/A	-0.258	0.495	0.056	N/A	1.79
			$B_L/B_R = (R_L-P_R)/R_R$	*SE*	0.016	0.039	0.241		0.122	0.049	0.337		
GNL4	No	Yes	ABSSUB	*M*	0.042	0.886	0.080	N/A	0.200	0.500	0.025	N/A	1.77
			$B_L/B_R = \|(R_L-P_R)\|/R_R$	*SE*	0.016	0.039	0.241		0.145	0.058	0.343		
GNL5	No	Yes	INVSUB	*M*	This model is not applicable.								
			$B_L/B_R = (R_L-P_R)/R_R$	*SE*									
GNL6	No	Yes	SUBK	*M*	This model is not applicable.								
			$B_L/B_R + k = [(R_L-P_R)/R_R] + k$	*SE*									

Note: Sensitivity (c) and bias (k) estimates for each participant under no-punishment and punishment conditions.

Table B7

Experiment 1: Asymmetry Ratios Calculated Neither Applying Logarithmic Nor Geometric Transformations. A Non-Linear – Power Regressions Were Used

ID Model	Use of Logs	Geo Means	Model		No Punishment Slope (c)	Intercept Log (k)	R^2	Antilog (c)	Punishment Slope ©	Intercept Log (k)	R^2	Antilog (k)	Gain/ Loss Ratio
PWRNG1	No	No	NP	*M*	0.056	0.975	0.037	N/A	0.000	0.582	0.000	N/A	1.68
			$B_L/B_R = R_L/R_R$	*SE*	0.019	0.021			0.038	0.026			
PWRNG2	No	No	ADD	*M*	0.063	0.975	0.045.	N/A	-0.061	0.547	.004.	N/A	1.78
			$B_L/B_R = R_L/(R_R+P_L)$	*SE*	0.019	0.021			0.062	0.043			
PWRNG3	No	No	NNSUB	*M*	0.057	1.006	0.041	N/A	-0.105	0.420	0.014	N/A	2.39
			$B_L/B_R = (R_L-P_R)/R_R$	*SE*	0.012	0.014			0.036	0.025			
PWRNG4	No	No	ABSSUB	*M*	0.060	1.002	0.046	N/A	0.000	0.585	0.000	N/A	1.71
			$B_L/B_R = \|(R_L-P_R)\|/R_R$	*SE*	0.012	0.014			0.029	0.025			
PWRNG5	No	No	INVSUB	*M*	0.060	1.002	0.046	N/A	0.000	0.585	0.000	N/A	1.71
			$B_L/B_R = (R_L-P_R)/R_R$	*SE*	0.012	0.014			0.029	0.025			
	No	No	SUBK	*M*	0.036	10.943	0.042	N/A	-0.064	13.441	0.019	N/A	0.81
PWRNG6			$B_L/B_R + k = [(R_L-P_R)/R_R]+k$	*SE*	0.007	0.196			0.020	0.636			

Note: Sensitivity (c) and bias (k) estimates for each participant under no-punishment and punishment conditions

Table B8

Experiment 1: Asymmetry Ratios Calculated Applying Geometric Transformations Only. A Non-Linear - Power Regressions Were Used

ID Model	Use of Logs	Geo Means	Model		No Punishment Slope (c)	Intercept Log (k)	R^2	Antilog (k)	Punishment Slope (c)	Intercept Log (k)	R^2	Antilog (k)	Gain/ Loss Ratio
PWRG1	No	Yes	NP	*M*	0.062	0.954	0.059	N/A	-0.013	0.551	0.000	N/A	1.73
			$B_L/B_R = R_L/R_R$	SE	0.028	0.028			0.072	0.040			
PWRG2	No	Yes	ADD	*M*	0.062	0.954	0.059	N/A	-0.108	0.502	0.010	N/A	1.90
			$B_L/B_R = R_L/(R_R+P_L)$	SE	0.028	0.028			0.122	0.073			
PWRG3	No	Yes	NNSUB	*M*	0.062	0.954	0.059	N/A	-0.302	0.215	0.094	N/A	4.43
			$B_L/B_R = (R_L-P_R)/R_R$	SE	0.028	0.028			0.103	0.062			
PWRG4	No	Yes	ABSSUB	*M*	0.062	0.954	0.059	N/A	0.113	0.669	0.035	N/A	1.43
			$B_L/B_R = \|(R_L-P_R)\|/R_R$	SE	0.028	0.028			0.081	0.089			
PWRG5	No	No	INVSUB	*M*	This model is not applicable.								
			$B_L/B_R = (R_L-P_R)/R_R$	SE									
PWRG6	No	Yes	SUBK	*M*	0.059	2.751	0.077	N/A	-0.087	2.682	0.026	N/A	1.03
			$B_L/B_R + k = [(R_L-P_R)/R_R]+k$	SE	0.023	0.084			0.062	0.098			

Note: Sensitivity (c) and bias (k) estimates for each participant under no-punishment and punishment conditions.

APPENDIX C

Table C1

Experiment 1: Individual Gain/Loss Ratios

		No Punishment				Punishment				
ID	Gender	Slope (c)	Intercept Log (k)	R^2	Antilog (k)	Slope (c)	Intercept Log (k)	R^2	Antilog (k)	Gain/ Loss Ratio
1	M	0.115	-0.008	0.224	0.983	-0.212	-0.112	0.243	0.772	1.27
2	M	0.052	0.005	0.204	1.011	-0.211	-0.303	0.274	0.497	2.03
4	M	-0.008	-0.002	0.031	0.995	-0.297	-0.310	0.125	0.490	2.03
6	M	0.167	0.001	0.580	1.002	-0.093	-0.501	0.024	0.315	3.18
7	M	0.078	0.012	0.436	1.027	-0.061	0.000	0.444	0.999	1.03
8	M	0.094	-0.003	0.126	0.994	0.585	-1.416	0.550	0.038	25.88
16	M	-0.082	-0.325	0.113	0.473	-0.075	-0.309	0.143	0.491	0.96
17	M	-0.011	-0.027	0.008	0.940	0.181	0.031	0.322	1.073	0.88
18	M	0.061	0.026	0.217	1.061	-0.015	-0.373	0.004	0.423	2.51
19	M	0.136	-0.072	0.222	0.847	-0.071	-0.101	0.062	0.792	1.07
22	M	0.105	-0.018	0.233	0.960	-0.120	-0.069	0.265	0.853	1.13
101	F	0.315	-0.022	0.586	0.950	-0.196	-0.654	0.166	0.222	4.28
102	F	0.022	-0.025	0.040	0.945	-0.533	-0.816	0.497	0.153	6.18
103	F	0.402	0.036	0.904	1.086	-0.023	-0.602	0.005	0.250	4.34
104	F	-0.142	-0.100	0.094	0.794	-0.146	-0.296	0.038	0.506	1.57
105	F	0.020	0.005	0.039	1.013	0.072	-0.013	0.119	0.970	1.04
106	F	-0.002	-0.055	0.000	0.882	-0.100	-0.241	0.046	0.574	1.54
107	F	0.073	-0.003	0.148	0.992	-0.048	-0.040	0.077	0.913	1.09
108	F	0.174	-0.119	0.068	0.761	-0.238	-0.336	0.549	0.461	1.65
109	F	-0.044	0.015	0.071	1.034	0.161	-0.749	0.033	0.178	5.80
110	F	-0.162	0.049	0.132	1.120	0.380	-0.448	0.325	0.357	3.14
111	F	0.359	-0.519	0.030	0.303	-0.087	-1.500	0.013	0.032	9.59
112	F	0.122	0.041	0.768	1.100	-0.113	-0.490	0.257	0.324	3.40
113	F	-0.065	-0.128	0.022	0.745	-0.185	-0.586	0.465	0.259	2.87
114	F	0.004	-0.006	0.003	0.985	0.051	-0.049	0.274	0.894	1.10
115	F	0.020	0.000	0.036	1.001	-0.024	-0.035	0.015	0.922	1.09
Mean		0.069	-0.048	0.205	0.923	-0.055	-0.397	0.205	0.529	3.49
SE		0.027	0.024	0.048	0.036	0.042	0.078	0.035	0.062	0.98

Note: Dependent Variable: Log C_L/C_R, Predictors: (Constant), Payoffs (Log R_L/R_R)
Sensitivity (c) and bias (k) estimates for each participant under no-punishment and punishment conditions.

APPENDIX D

Table D1

Experiment 1: Asymmetry Of Gains And Losses – Gender Differences (Means and SEs)

Model	Gender		No Punishment Slope (c)	No Punishment Intercept Log (k)	No Punishment R^2	No Punishment Antilog (k)	Punishment Slope (c)	Punishment Intercept Log (k)	Punishment R^2	Punishment Antilog (k)	Gain/ Loss Ratio
	Male	*M*	0.064	-0.037	0.218	0.917	-0.035	-0.315	0.223	0.484	1.89
		SE	0.022	0.03	0.05		0.072	0.121	0.052		
Rassmussen & Newland											
Procedure	Female	*M*	0.073	-0.055	0.196	0.88	-0.069	-0.457	0.192	0.349	2.52
NPModel		*SE*	0.044	0.036	0.077		0.052	0.102	0.049		
BL/BR=(RL)/(RR)											
	M and F	*M*	0.069	-0.048	0.205	0.896	-0.055	-0.397	0.205	0.401	2.23
		SE	0.027	0.024	0.048		0.042	0.078	0.035		
	Male	*M*	0.064	-0.039	0.055	0.915	0.061	-0.321	0.004	0.477	1.92
		SE	0.027	0.014	0.137		0.096	0.047	0.465		
Standard Procedure											
NPModel	Female	*M*	-0.053	-0.053	0.005	0.886	0.035	-0.448	0.002	0.356	2.49
BL/BR=(RL/RR)		*SE*	0.051	0.03	0.346		0.074	0.039	0.45		
	M and F	*M*	0.057	-0.047	0.01	0.898	0.049	-0.394	0.003	0.403	2.23
		SE	0.037	0.018	0.276		0.059	0.03	0.459		

Note: Dependent Variable: Log C_L/C_R . Predictors: (Constant), Payoffs (Log R_L/R_R) * If we eliminate participant Sensitivity (c) and bias (k) estimates for each participant under no-punishment and punishment conditions. Participant 8 seems to be an outlier the gain/loss ratio will change to 2.025.

APPENDIX E

Table E1

Experiment 1: Asymmetry of Gains and Losses – Risk Differences (Means and SEs)

				No Punishment				Punishment				
Risk	Gender	ID	Risk Sc.	Slope (c)	Intercept Log (k)	R^2	Antilog (k)	Slope (c)	Intercept Log (k)	R^2	Antilog (k)	Gain/ Loss Ratio
RA	M	2	43	0.052	0.005	0.204	1.011	-0.211	-0.303	0.274	0.497	2.033
RA	M	6	44	0.167	0.001	0.58	1.002	-0.093	-0.501	0.024	0.315	3.178
RA	M	7	46	0.078	0.012	0.436	1.027	-0.061	0	0.444	0.999	1.028
RA	M	8	49	0.094	-0.003	0.126	0.994	0.585	-1.416	0.55	0.038	25.884
RA	F	102	53	0.022	-0.025	0.04	0.945	-0.533	-0.816	0.497	0.153	6.181
RA	F	103	52	0.402	0.036	0.904	1.086	-0.023	-0.602	0.005	0.25	4.344
RA	F	106	49	-0.002	-0.055	0	0.882	-0.1	-0.241	0.046	0.574	1.536
RA	F	109	43	-0.044	0.015	0.071	1.034	0.161	-0.749	0.033	0.178	5.801
RA	F	110	47	-0.162	0.049	0.132	1.12	0.38	-0.448	0.325	0.357	3.141
RA	F	111	44	0.359	-0.519	0.03	0.303	-0.087	-1.5	0.013	0.032	9.591
RA	F	112	48	0.122	0.041	0.768	1.1	-0.113	-0.49	0.257	0.324	3.399
RA	F	113	45	-0.065	-0.128	0.022	0.745	-0.185	-0.586	0.465	0.259	2.87
RS	M	1	38	0.115	-0.008	0.224	0.983	-0.212	-0.112	0.243	0.772	1.273
RS	M	4	33	-0.008	-0.002	0.031	0.995	-0.297	-0.31	0.125	0.49	2.032
RS	M	16	42	-0.082	-0.325	0.113	0.473	-0.075	-0.309	0.143	0.491	0.964
RS	M	17	36	-0.011	-0.027	0.008	0.94	0.181	0.031	0.322	1.073	0.876
RS	M	18	28	0.061	0.026	0.217	1.061	-0.015	-0.373	0.004	0.423	2.506
RS	M	19	29	0.136	-0.072	0.222	0.847	-0.071	-0.101	0.062	0.792	1.069
RS	M	22	40	0.105	-0.018	0.233	0.96	-0.12	-0.069	0.265	0.853	1.125
RS	F	101	42	0.315	-0.022	0.586	0.95	-0.196	-0.654	0.166	0.222	4.278
RS	F	104	31	-0.142	-0.1	0.094	0.794	-0.146	-0.296	0.038	0.506	1.57
RS	F	105	35	0.02	0.005	0.039	1.013	0.072	-0.013	0.119	0.97	1.043
RS	F	107	36	0.073	-0.003	0.148	0.992	-0.048	-0.04	0.077	0.913	1.087
RS	F	108	31	0.174	-0.119	0.068	0.761	-0.238	-0.336	0.549	0.461	1.65
RS	F	114	35	0.004	-0.006	0.003	0.985	0.051	-0.049	0.274	0.894	1.102
RS	F	115	37	0.02	0	0.036	1.001	-0.024	-0.035	0.015	0.922	1.086
Mean				0.069	-0.048	0.205	0.923	-0.055	-0.397	0.205	0.529	3.486
SE				0.027	0.024	0.048	0.036	0.042	0.078	0.035	0.062	0.983

Table E2

Experiment 1: Asymmetry of Gains and Losses – Risk Differences Mediated by Gender (Means and SEs)

				No Punishment				Punishment				
Risk Category	ID	Gender	Risk Score	Slope (c)	Intercept Log (k)	R^2	Antilog (k)	Slope (c)	Intercept Log (k)	R^2	Antilog (k)	Gain/ Loss Ratio
RA	M	2	43	.052	.005	.204	1.011	-.211	-.303	.274	0.497	2.033
RA	M	6	44	.167	.001	.580	1.002	-.093	-.501	.024	0.315	3.178
RA	M	7	46	.078	.012	.436	1.027	-.061	.000	.444	0.999	1.028
RA	M	8	49	.094	-.003	.126	0.994	.585	-1.416	.550	0.038	25.884
RA	M	16	42	-.082	-.325	.113	0.473	-.075	-.309	.143	0.491	0.964
RA	F	102	53	.022	-.025	.040	0.945	-.533	-.816	.497	0.153	6.181
RA	F	103	52	.402	.036	.904	1.086	-.023	-.602	.005	0.250	4.344
RA	F	106	49	-.002	-.055	.000	0.882	-.100	-.241	.046	0.574	1.536
RA	F	110	47	-.162	.049	.132	1.120	.380	-.448	.325	0.357	3.141
RA	F	111	44	.359	-.519	.030	0.303	-.087	-1.500	.013	0.032	9.591
RA	F	112	48	.122	.041	.768	1.100	-.113	-.490	.257	0.324	3.399
RA	F	113	45	-.065	-.128	.022	0.745	-.185	-.586	.465	0.259	2.870
RS	M	1	38	.115	-.008	.224	0.983	-.212	-.112	.243	0.772	1.273
RS	M	4	33	-.008	-.002	.031	0.995	-.297	-.310	.125	0.490	2.032
RS	M	17	36	-.011	-.027	.008	0.940	.181	.031	.322	1.073	0.876
RS	M	18	28	.061	.026	.217	1.061	-.015	-.373	.004	0.423	2.506
RS	M	19	29	.136	-.072	.222	0.847	-.071	-.101	.062	0.792	1.069
RS	M	22	40	.105	-.018	.233	0.960	-.120	-.069	.265	0.853	1.125
RS	F	101	42	.315	-.022	.586	0.950	-.196	-.654	.166	0.222	4.278
RS	F	104	31	-.142	-.100	.094	0.794	-.146	-.296	.038	0.506	1.570
RS	F	105	35	.020	.005	.039	1.013	.072	-.013	.119	0.970	1.043
RS	F	107	36	.073	-.003	.148	0.992	-.048	-.040	.077	0.913	1.087
RS	F	108	31	.174	-.119	.068	0.761	-.238	-.336	.549	0.461	1.650
RS	F	109	43	-.044	.015	.071	1.034	.161	-.749	.033	0.178	5.801
RS	F	114	35	.004	-.006	.003	0.985	.051	-.049	.274	0.894	1.102
RS	F	115	37	.020	.000	.036	0.985	-.024	-.035	.015	0.894	1.102
Mean				0.069	-0.048	0.205	0.923	-0.055	-0.397	0.205	0.528	3.487
SE				0.027	0.024	0.048	0.036	0.042	0.078	0.035	0.062	0.983

Note: Dependent Variable: Log C_L/C_R . Predictors: (Constant), Payoffs (Log R_L/R_R)

Table E3

Experiment 1: Asymmetry of Gains and Losses – Risk Differences (Means and SEs)

Rassmussen & Newland Procedure			No Punishment				Punishment				
NPModel BL/BR=(RL)/(RR)			Slope (c)	Intercept Log (k)	R^2	Antilog (k)	Slope (c)	Intercept Log (k)	R^2	Antilog (k)	Gain/ Loss Ratio
Risk Averse	Male	*M*	0.062	-0.062	0.292	0.867	0.029	-0.506	0.287	0.312	2.778
		SE	0.041	0.066	0.092		0.141	0.241	0.096		
	Female	*M*	0.097	-0.086	0.271	0.821	-0.094	-0.669	0.230	0.214	3.831
		SE	0.080	0.076	0.147		0.101	0.153	0.080		
	Male & Female	*M*	0.085	-0.048	0.276	0.896	-0.023	-0.638	0.244	0.230	3.892
		SE	0.047	0.045	0.091		0.083	0.128	0.061		
Risk Seeker	Male	*M*	0.066	-0.017	0.156	0.962	-0.089	-0.156	0.170	0.698	1.378
		SE	0.026	0.013	0.043		0.068	0.063	0.051		
	Female	*M*	0.052	-0.029	0.131	0.936	-0.046	-0.271	0.159	0.535	1.748
		SE	0.049	0.018	0.067		0.049	0.104	0.063		
	Male & Female	*M*	0.056	-0.048	0.144	0.896	-0.081	-0.190	0.172	0.645	1.389
		SE	0.030	0.024	0.041		0.035	0.052	0.040		

Note: Dependent Variable: Log C_L/C_R, Predictors: (Constant), Payoffs (Log R_L/R_R)
Sensitivity (c) and bias (k) estimates for each participant under no-punishment and punishment conditions.

Table E3 – Continuation

Experiment 1: Asymmetry of Gains and Losses – Risk Differences (Means and SEs)

Standard Procedure NPModel BL/BR=(RL/RR)			No Punishment Slope (c)	No Punishment Intercept Log (k)	No Punishment R^2	No Punishment Antilog (k)	Punishment Slope (c)	Punishment Intercept Log (k)	Punishment R^2	Punishment Antilog (k)	Gain/ Loss Ratio
Risk Averse	Male	*M*	0.044	-0.062	0.017	0.866	0.203	-0.532	0.017	0.294	2.95
		SE	0.051	0.024	0.163		0.169	0.017	0.163		
	Female	*M*	0.066	-0.081	0.005	0.83	0.006	-0.649	0.005	0.224	3.70
		SE	0.118	0.061	0.484		0.108	0.057	0.484		
	M and F	*M*	0.059	-0.043	0.006	0.905	0.006	-0.634	0.014	0.232	3.89
		SE	0.071	0.036	0.373		0.108	0.05	0.518		
Risk Seeker	Male	*M*	0.077	-0.019	0.13	0.957	-0.047	-0.149	0.13	0.709	1.35
		SE	0.028	0.015	0.108		0.069	0.032	0.108		
	Female	*M*	0.033	-0.028	0.01	0.938	0.061	-0.272	0.007	0.534	1.76
		SE	0.04	0.017	-0.004		0.086	0.045	0.375		
	M and F	*M*	0.055	-0.05	0.029	0.892	-0.056	-0.187	0.012	0.65	1.37
		SE	0.029	0.055	0.154		0.046	0.023	0.253		

Note: Dependent Variable: Log C_L/C_R, Predictors: (Constant), Payoffs (Log R_L/R_R)

Sensitivity (c) and bias (k) estimates for each participant under no-punishment and punishment conditions.

APPENDIX F

Table F1

Experiment 2: Asymmetry of Gains and Losses (Points Only) – Individual ratios

		No Punishment				Punishment				
ID	Gender	Slope (c)	Intercept Log (k)	R^2	Antilog (k)	Slope (c)	Intercept Log (k)	R^2	Antilog (k)	Gain/ Loss Ratio
1	M	0.115	-0.008	0.224	0.983	-0.212	-0.112	0.243	0.772	1.27
2	M	0.052	0.005	0.204	1.011	-0.211	-0.303	0.274	0.497	2.03
4	M	-0.008	-0.002	0.031	0.995	-0.297	-0.310	0.125	0.49	2.03
6	M	0.167	0.001	0.580	1.002	-0.093	-0.501	0.024	0.315	3.18
7	M	0.078	0.012	0.436	1.027	-0.061	0.000	0.444	0.999	1.03
8	M	0.094	-0.003	0.126	0.994	0.585	-1.416	0.55	0.038	25.88
16	M	-0.082	-0.325	0.113	0.473	-0.075	-0.309	0.143	0.491	0.96
17	M	-0.011	-0.027	0.008	0.940	0.181	0.031	0.322	1.073	0.88
18	M	0.061	0.026	0.217	1.061	-0.015	-0.373	0.004	0.423	2.51
19	M	0.136	-0.072	0.222	0.847	-0.071	-0.101	0.062	0.792	1.07
22	M	0.105	-0.018	0.233	0.960	-0.120	-0.069	0.265	0.853	1.13
101	F	0.315	-0.022	0.586	0.950	-0.196	-0.654	0.166	0.222	4.28
102	F	0.022	-0.025	0.040	0.945	-0.533	-0.816	0.497	0.153	6.18
103	F	0.402	0.036	0.904	1.086	-0.023	-0.602	0.005	0.25	4.34
104	F	-0.142	-0.100	0.094	0.794	-0.146	-0.296	0.038	0.506	1.57
105	F	0.020	0.005	0.039	1.013	0.072	-0.013	0.119	0.97	1.04
106	F	-0.002	-0.055	0.000	0.882	-0.100	-0.241	0.046	0.574	1.54
107	F	0.073	-0.003	0.148	0.992	-0.048	-0.040	0.077	0.913	1.09
108	F	0.174	-0.019	0.003	0.761	-0.238	-0.336	0.597	0.461	1.65
109	F	-0.044	0.015	0.071	1.034	0.161	-0.749	0.033	0.178	5.80
110	F	-0.162	0.049	0.132	1.120	0.380	-0.448	0.325	0.357	3.14
111	F	0.359	-0.519	0.030	0.303	-0.087	-1.500	0.013	0.032	9.59
112	F	0.122	0.041	0.768	1.100	-0.113	-0.490	0.257	0.324	3.40
113	F	-0.065	-0.128	0.022	0.745	-0.185	-0.586	0.465	0.259	2.87
114	F	0.004	-0.006	0.003	0.985	0.051	-0.049	0.274	0.894	1.10
115	F	0.020	0.000	0.036	1.001	-0.024	-0.035	0.015	0.922	1.09
	Mean	0.064	-0.051	0.203	0.918	-0.054	-0.395	0.207	0.532	3.47
	SE	0.027	0.024	0.049	0.038	0.042	0.078	0.036	0.062	0.98

Note: Dependent Variable: Log C_L/C_R, Predictors: (Constant), Payoffs (Log R_L/R_R)

Sensitivity (c) and bias (k) estimates for each participant under no-punishment and punishment conditions.

Table F2

Experiment 2: Asymmetry of Gains and Losses (Points + Coin Dispenser) – Individual ratios

		No Punishment				Punishment				
ID	Gender	Slope (c)	Intercept Log (k)	R^2	Antilog (k)	Slope (c)	Intercept Log (k)	R^2	Antilog (k)	Gain/ Loss Ratio
1	M	-0.051	0.100	0.380	1.259	-0.287	-0.148	0.775	0.711	1.77
2	M	0.039	-0.140	0.002	0.724	0.460	-0.617	0.060	0.242	3.00
4	M	-0.027	0.018	0.065	1.042	-0.646	-0.343	0.450	0.454	2.29
6	M	0.367	-0.032	0.827	0.929	0.481	-2.059	0.050	0.009	106.52
7	M	-0.074	0.005	0.747	1.011	-0.003	-0.027	0.001	0.939	1.08
16	M	-0.050	-0.471	0.259	0.338	-0.044	-0.617	0.005	0.242	1.40
17	M	-0.170	-0.082	0.088	0.829	-0.135	-0.162	0.224	0.689	1.20
18	M	-0.028	0.035	0.066	1.083	-0.148	-0.851	0.058	0.141	7.68
19	M	0.035	0.004	0.045	1.009	0.319	-0.416	0.082	0.384	2.63
22	M	0.085	0.088	0.233	1.223	0.087	-0.086	0.277	0.820	1.49
101	F	0.236	-0.023	0.849	0.949	-0.468	-1.505	0.259	0.031	30.36
102	F	0.116	-0.018	0.730	0.960	-0.619	-0.777	0.759	0.167	5.74
103	F	0.088	0.024	0.270	1.057	0.012	-0.658	0.012	0.220	4.80
104	F	0.034	-0.010	0.074	0.976	0.067	-0.334	0.040	0.463	2.11
105	F	0.163	0.052	0.893	1.127	0.073	0.020	0.399	1.047	1.08
106	F	-0.020	-0.024	0.023	0.945	-0.261	-0.615	0.566	0.243	3.89
107	F	0.066	0.087	0.248	1.222	-0.258	-0.318	0.144	0.481	2.54
108	F	0.144	-0.020	0.671	0.955	0.012	-0.937	0.014	0.116	8.26
109	F	-0.076	0.046	0.112	1.111	-0.022	-0.983	0.004	0.104	10.69
110	F	0.254	0.005	0.317	1.012	0.300	-0.116	0.293	0.765	1.32
111	F	0.014	-0.237	0.000	0.579	0.004	-1.455	0.000	0.035	16.51
112	F	0.145	0.086	0.688	1.220	-0.065	-1.014	0.033	0.097	12.60
113	F	0.067	-0.114	0.022	0.769	-0.016	-0.534	0.064	0.293	2.63
114	F	0.003	0.013	0.001	1.030	0.019	-0.231	0.015	0.588	1.75
115	F	0.013	-0.012	0.061	0.972	-0.050	0.005	0.176	1.011	0.96
	Mean	0.049	-0.027	0.282	0.970	-0.048	-0.604	0.182	0.390	9.56
	SE	0.023	0.024	0.059	0.041	0.056	0.101	0.046	0.059	4.26

Note: Dependent Variable: Log C_L/C_R, Predictors: (Constant), Payoffs (Log R_L/R_R)

Sensitivity (c) and bias (k) estimates for each participant under no-punishment and punishment conditions.

Table F3

Experiment 2: Asymmetry of Gains and Losses – Points versus Points + Coin Dispenser (Means and SEs)

Rassmussen & Newland Procedure			No Punishment				Punishment				
NPModel	Points/ Points + CD		Slope	Intercept		Antilog	Slope	Intercept		Antilog	Gain/ Loss
BL/BR=(RL)/(RR)			(c)	Log (k)	R^2	(k)	(c)	Log (k)	R^2	(k)	Ratio
	Points Only	*M*	0.064	-0.037	0.218	0.917	-0.035	-0.315	0.223	0.484	1.895
Male		*SE*	0.022	0.03	0.05		0.072	0.121	0.052		
	Points + CD	*M*	0.013	-0.03	0.271	0.934	0.008	-0.533	0.198	0.293	3.183
		SE	0.045	0.052	0.094		0.11	0.19	0.078		
	Points Only	*M*	0.073	-0.055	0.192	0.88	-0.069	-0.457	0.195	0.349	2.521
Female		*SE*	0.044	0.036	0.077		0.052	0.102	0.051		
	Points + CD	*M*	0.083	-0.01	0.331	0.978	-0.086	-0.63	0.185	0.234	4.172
		SE	0.025	0.021	0.09		0.061	0.129	0.062		
	Points Only	*M*	0.069	-0.048	0.203	0.896	-0.055	-0.397	0.207	0.401	2.234
M and F		*SE*	0.027	0.024	0.049		0.042	0.078	0.036		
	Points + CD	*M*	0.05	-0.018	0.307	0.96	-0.048	-0.591	0.19	0.256	3.744
		SE	0.024	0.024	0.063		0.056	0.105	0.047		

Note: Dependent Variable: Log C_L/C_R, Predictors: (Constant), Payoffs (Log R_L/R_R)

Sensitivity (c) and bias (k) estimates for each participant under no-punishment and punishment conditions.

Table F4

Experiment 2: Asymmetry of Gains and Losses – Points versus Points + Coin Dispenser (Means and SEs)

Rassmussen & Newland Proc.	Points		No Punishment				Punishment				
NPModel	Points /		Slope	Intercept		Antilog	Slope	Intercept		Antilog	Gain/Loss
BL/BR=(RL)/(RR)	+ CD		(c)	Log (k)	R^2	(k)	(c)	Log (k)	R^2	(k)	Ratio
	Points	*M*	0.064	-0.037	0.218	0.917	-0.035	-0.315	0.223	0.484	1.90
Male	Only	*SE*	0.022	0.03	0.05		0.072	0.121	0.052		
	Points	*M*	0.013	-0.03	0.271	0.934	0.008	-0.533	0.198	0.293	3.18
	+ CD	*SE*	0.045	0.052	0.094		0.11	0.19	0.078		
	Points	*M*	0.073	-0.055	0.192	0.88	-0.069	-0.457	0.195	0.349	2.52
Female	Only	*SE*	0.044	0.036	0.077		0.052	0.102	0.051		
	Points	*M*	0.083	-0.01	0.331	0.978	-0.086	-0.63	0.185	0.234	4.17
	+ CD	*SE*	0.025	0.021	0.09		0.061	0.129	0.062		
	Points	*M*	0.069	-0.048	0.203	0.896	-0.055	-0.397	0.207	0.401	2.23
M and F	Only	*SE*	0.027	0.024	0.049		0.042	0.078	0.036		
	Points	*M*	0.05	-0.018	0.307	0.96	-0.048	-0.591	0.19	0.256	3.74
	+ CD	*SE*	0.024	0.024	0.063		0.056	0.105	0.047		

Note: Dependent Variable: Log C_L/C_R, Predictors: (Constant), Payoffs (Log R_L/R_R)

Sensitivity (c) and bias (k) estimates for each participant under no-punishment and punishment conditions.

APPENDIX G

Table G1

Experiment 3: Asymmetry of Gains and Losses – Virtual coins versus Cash Coins (Means and SEs)

ID	Comp.	No Punishment				Punishment				Gain/ Loss
		Slope (c)	Intercept Log (k)	R^2	Antilog (k)	Slope (c)	Intercept Log (k)	R^2	Antilog (k)	Ratio
1	NC	0.115	-0.008	0.224	0.983	-0.212	-0.112	0.243	0.772	1.273
2	NC	0.052	0.005	0.204	1.011	-0.211	-0.303	0.274	0.497	2.033
4	NC	-0.008	-0.002	0.031	0.995	-0.297	-0.31	0.125	0.49	2.032
6	NC	0.167	0.001	0.58	1.002	-0.093	-0.501	0.024	0.315	3.178
7	NC	0.078	0.012	0.436	1.027	-0.061	0	0.444	0.999	1.028
8	NC	0.094	-0.003	0.126	0.994	0.585	-1.416	0.55	0.038	25.884
16	NC	-0.082	-0.325	0.113	0.473	-0.075	-0.309	0.143	0.491	0.964
17	NC	-0.011	-0.027	0.008	0.94	0.181	0.031	0.322	1.073	0.876
18	NC	0.061	0.026	0.217	1.061	-0.015	-0.373	0.004	0.423	2.506
19	NC	0.136	-0.072	0.222	0.847	-0.071	-0.101	0.062	0.792	1.069
22	NC	0.105	-0.018	0.233	0.96	-0.12	-0.069	0.265	0.853	1.125
31	C	-0.086	-0.011	0.081	0.974	-0.231	-1.138	0.068	0.073	13.393
32	C	0.188	-0.025	0.525	0.944	-0.226	-0.286	0.146	0.517	1.826
33	C	-0.346	-0.058	0.562	0.874	-0.187	-0.265	0.239	0.543	1.608
34	C	0.29	-0.021	0.657	0.952	0.296	-0.586	0.541	0.259	3.67
35	C	-0.016	0.023	0.015	1.053	-0.254	-0.107	0.654	0.781	1.348
36	C	-0.017	0.013	0.008	1.03	-0.465	-0.757	0.207	0.175	5.883
37	C	0.071	0.011	0.64	1.025	-0.066	-0.058	0.234	0.875	1.171
38	C	-0.046	0.062	0.048	1.152	-0.041	-0.028	0.046	0.938	1.228
39	C	0.04	-0.029	0.036	0.936	0.122	-0.092	0.104	0.809	1.157
40	C	0.121	-0.011	0.238	0.975	0.086	-0.132	0.066	0.738	1.322
41	C	-0.04	0.009	0.571	1.022	-0.085	-0.035	0.306	0.923	1.107
	M	0.039	-0.02	0.262	0.965	-0.065	-0.316	0.23	0.608	3.44
	SE	0.027	0.016	0.049	0.027	0.047	0.079	0.039	0.065	1.22

Note: Dependent Variable: Log C_L/C_R , Predictors: (Constant), Payoffs (Log R_L/R_R)

Sensitivity (c) and bias (k) estimates for each participant under no-punishment and punishment conditions.

Table G2

Experiment 3: Asymmetry of Gains and Losses – No Competition versus Competition (Means and SEs)

			No Punishment				Punishment				
Model	Comp		Slope (c)	Intercept Log (k)	R^2	Antilog (k)	Slope (c)	Intercept Log (k)	R^2	Antilog (k)	Gain/Loss Ratio
Rassmussen & Newland	NC	*M*	0.064	-0.037	0.218	0.917	-0.035	-0.315	0.223	0.484	1.895
Procedure		*SE*	0.022	0.030	0.050		0.072	0.121	0.052		
NPModel											
BL/BR=(RL)/(RR)	C	*M*	0.014	-0.004	0.307	0.992	-0.095	-0.317	0.237	0.482	2.057
		SE	0.050	0.010	0.085		0.063	0.109	0.060		
Standard Procedure	NC	*M*	0.064	-0.039	0.055	0.915	0.061	-0.321	0.004	0.477	1.917
NPModel		*SE*	0.027	0.014	0.137		0.096	0.047	0.465		
BL/BR=(RL/RR)											
	C	*M*	0.045	-0.007	0.036	0.984	-0.030	-0.311	0.001	0.489	2.014
		SE	0.023	0.012	0.121		0.084	-0.030	0.409		

Note: Dependent Variable: Log C_L/C_R, Predictors: (Constant), Payoffs (Log R_L/R_R)

Sensitivity (c) and bias (k) estimates for each participant under no-punishment and punishment conditions.

CHAPTER 4: Behavioral Measurement of an Unselfish Act

Experiment 4

The classical economic view of individual decision making emphasizes rationality and self-interest (Yamagishi, Li, Haruto Takagishi, Matsumoto, & Kiyonari, 2014) as essential for the maximization of subjective utility. Unselfish or altruistic behavior has been defined, in economic terms, as "…costly acts that confer economic benefits on other individuals" (Fehr & Fischbacher, 2003). Such costly acts expose an anomaly in the utilitarian perspective. The *Homo economicus* described by Korn and Ziesecke (2013) or the Econ of Thaler and (2009) is consistent with Bentham's orthodoxy (1775/1988) that utility maximization is the fundamental motive in individual behavior. According to Thales and Sustein (2009), "Econs do not have passions; they are cold-blooded optimizers" (p. 7). The altruist, however, will forego optimizing her or his utility for the benefit of others' utility. Working from a different perspective, Rachlin and Locey (2011a) observed that the "individual altruistic act apparently has no reinforcer; if it did, it would not be altruistic. Altruism thus seems to defy behavioral analysis" and further suggested that the assumption of the maximization goal of *Homo economicus* might be erroneous.

Rachlin and Locey (2011a) provided three potential explanations for altruistic behavior. The first assumes that such behavior allows a person to avoid being a free-loader within her or his society. The second explanation is that altruists maximize reward over a series of choices and not necessarily in individual choices. The third explanation "assumes that people's altruism is based on a straightforward balancing of undiscounted costs to themselves against discounted benefits to others (social discounting)" (p. 25).

Fehr and Fischbacher (2003) proposed a different account of altruistic actions. First, they recognized that social norms can clearly influence altruistic behavior. In the ultimatum game (Guth, Schmittberger, & Schwarze, 1982), for instance, the two participants have to agree on how to divide a fixed sum of money that has been assigned to one of them. That person proposes the amount, and the other person accepts or rejects it. Most people will reject the proposed amount if they consider it unfair even though they will receive nothing. In doing so, they punish the proposer's perceived unfair behavior. Fehr and Fischbacher explained that such rejections in the ultimatum game can be viewed as altruistic punishment, because most people view the equal split as the fair outcome, and, thus, a rejection of a lower offer punishes the proposer for violating a social norm. Fehr and Fischbacher also reported that:

> Recent results on the neurobiology of cooperation in the prisoners' dilemma [another social game widely used for the study of reciprocity] support the view that individuals experience particular subjective rewards from mutual cooperation. If subjects achieve the mutual cooperation outcome with another human subject, the brain's reward circuit (components of the mesolimbic dopamine system including the striatum and the orbitofrontal cortex) is activated relative to a situation in which subjects achieve mutual cooperation with a programmed computer. Moreover, there is also evidence indicating a negative response of the dopamine system if a subject cooperates but the opponent defects (p. 788).

In the experiment, the question I sought to answer was: Would individuals behave differently if the gains they received were transferred to a charity of their choice rather than being retained personally? Higher asymmetry ratios were expected from participants when they profited personally than when they made donations to charity. Moreover, in this experiment, I administered a questionnaire to each participant that assessed their level of risk aversion and risk seeking. I predicted that those who were risk-averse would display a greater asymmetry between gains and losses that those who were risk-seeking.

In this experiment the principal hypothesis (BEH6) was that higher asymmetry ratios were expected from participants when they profited personally than when they made donations to charity.

Method

Experiment 4 utilized the methods and data analytic procedures previously described aided by the coin dispenser/collector that was also used in experiment 3. The experiment consisted of two phases with four sessions in phase 1 and six in phase 2. The participants were randomly assigned in two groups—Profit and Charity—for phase 1. The first phase of the experiment is a comparison between both groups (profit and charity). The net gains that participants in the Profit group obtained per session were paid to them. In the Charity group, the participants donated the net gains to a charitable organization of their choice. In phase 2, both groups were exposed to alternating sessions in which they either received net gains directly or donated the gains to a charity of their choice. The experiment was designed to compare the behavior of participants in punished and unpunished conditions and in conditions in which they either received money personally or donated it to charity. Also, I nested gender within the risk variable.

In sum, I studied gender differences in risk taking in relation to performance in the video game where personal winnings were either received directly or donated to the charity of one's choice. This latter distinction represented self-interest versus altruism, respectively.

Participants

The participants were 10 students (five females) that did not participate in previous experiments related to gain/loss asymmetry. They were invited to play the video game in a series of 36-min sessions in which they could earn money. The in-session earnings were delivered to each participant at the end of a session. In addition, they received a $30 bonus at the completion of the study. Participants were also asked to complete a risk questionnaire at the beginning of the first session.

Data Analysis Plan

The analysis plan included: a linear mixed, asymmetry ratios, and linear regressions. The experiment included 10 sessions, but the data from only the first session were dropped rather than those in the first three sessions as in experiments 1 to 3.

Results

Phase 1: Group, Condition, and Gender Comparison

Table 13 displays an abridged summary of fixed effect" for Phase 1 (a complete table—H1— is provided in the Appendix H at the end of the chapter). Both Punishment and Gender were significant at the 0.05 level. However, there was a significant interaction between Punishment and Gender. Group (Profit vs. Charity) was not significant, but its interactions with Gender was close significance (0.064). Table H2 also appears in Appendix H2 and lists the corresponding estimated marginal means.

Table 13

Experiment 4: Phase 1 Summary of Tests of Fixed Effects Punishment, Group, and Gender Comparison (Sessions 2-4)

$df_{Num} = 1; df_{Den} = 161$

Source	*F*	*p*
Intercept	71.672	0.000
Punishment	44.836	0.000
Group	0 .498	0.481
Gender	24.287	0.000
Log (R_L / R_R)	2.644	0.106
Punishment * Gender	5.171	0.024
Group * Gender	3.480	0.064
Group * Log (R_L / R_R)	4.859	0.029
Punishment * Group * Gender	3.392	0.067

In Appendix H, Table H3 for the unpunished condition and Table H4 for the punishment conditions summarize each participant's mean responses, obtained reinforcers, obtained punishers, and changeovers for each alternative under the concurrent VI-VI schedules and categorized as Gender, Charity, and Profit, as well as their corresponding standard deviations.

Table 14 shows the means of the ratios that are displayed for each participant in Tables H5 and H6 in Appendix H Table H5 shows the slopes (c), intercepts (log k), R^2 for the linear regressions, and the correspondent gain/loss ratios, as well as, the standard errors of the estimate, for participant. The data are organized by Punishment and No punishment conditions, Group, and Gender. Table H6 is organized similarly; however, it displays the results summarized by category.

The asymmetry ratio for the Profit group (1.94) was nearly the same as for the Charity group (1.86) However, within the Profit Group, the female participants (3.07) were 2.24 more sensitive to losses than the male participants (1.37). Within the Charity group, males (1.73) and females (1.88) were close to being the same.

Table 14

Experiment 4: Phase 1 Summary Mean Asymmetry Ratios for Group and Gender (Sessions 2-4)

	Profit	Charity
Male	1.37	1.73
Female	3.07	1.88
Male & Female	1.94	1.86

Female participants displayed a loss aversion when they were playing the game for charity that was approximately two-thirds (0.63) of the loss aversion they displayed when playing for themselves. By contrast, the males in the Charity Group displayed a loss aversion approximately one-fifth (0.21) that of the males in the Profit group.

Phase 2: Group, Session, and Risk Comparison

Table 15 displays an abridged summary for phase 2; the complete table (I1) appears in Appendix I. The effects of Punishment and Risk were significant. However, there was also a significant interaction between the two. Group and Sessions were not significant. Table I2 also appears in Appendix I and includes the estimated marginal means.

Table 15

Experiment 4: Phase 2 Summary of Tests of Fixed Effects, Punishment, Group, Sessions, and Risk - Comparison (Sessions 5-10)

$df_{Num} = 1; df_{Den} = 161$

Source	*F*	*p*
Intercept	197.863	0.000
Punishment	142.161	0.000
Group	0.555	0.457
Sessions (Profit or Charity)	0.090	0.765
Risk (Risk Averse or Risk Seeking)	81.266	0.000
Log (R_L/R_R)	14.588	0.000
Punishment * Risk	48.555	0.000
Punishment * Log (R_L/R_R)	16.394	0.000
Punishment * Group * Risk	5.272	0.022
Punishment * Sessions * Log (R_L/R_R)	4.479	0.035
Punishment * Risk * Log (R_L/R_R)	5.715	0.017
Group * Risk * Log (R_L/R_R)	10.130	0.002
Group * Gender * Log (R_L / R_R)	7.938	0.005

Table I3 and I4 (see Appendix I) displays the data for each participant in sessions 5-10. Table I3 in Appendix I summarizes the mean responses, obtained reinforcers, obtained punishers, and changeovers under the concurrent VI-VI schedules for the No punished condition and I4 for the punished condition. The categories appearing in the table are Group (Profit and

Charity), Sessions (Paid and Not-paid), Gender (Male and Female), and Risk (Averse and Seeking). Sessions 5, 7, and 9 were paid and sessions 6, 8 and 10 were not paid.

Table 16 summarizes the mean asymmetry ratios that are displayed in Table I5 (see Appendix I). Table I5 displays the values of sensitivity (c), (log k), and R^2 as well as the loss/gain ratios and the standard error of the estimate.

Table 16

Experiment 4: Comparison of Asymmetry Ratios Between Groups and Session Types

	Group	
Session Type	Profit	Charity
Not paid	2.01	1.88
Paid	1.84	1.91

The mean ratios for the Profit group were similar: 2.01 (Not paid) and1.84 (paid). Those for the Charity group were nearly identical: 1.88 (Not Paid) and 1.91 (Paid).

Table 17 summarizes the asymmetry ratios found in Table I6 (see appendix I) for Risk nested within the Group and Session categories. In every case, the ratio for the Risk-averse was higher than that for Risk-seeking participants. It is also the case that, within both groups (Profit and Charity) and Session types (Not Paid and Paid), the Risk-averse participants produced a higher asymmetry ratio than the Risk-seeking participants did.

Table 17

Experiment 4: Mean Asymmetry Ratios between Risk-Averse and Risk-Seeking Participants in Each Group and Session

Session	Risk	Group	
		Profit	Charity
Not Paid	Averse	4.44	2.34
	Seeker	1.22	1.38
Paid	Averse	3.12	2.34
	Seeker	1.36	1.36

Phase 2: Gender, Group, Session, and Risk

Table 18

Experiment 4: Phase 2 Tests of Fixed Effects of Punishment and Gender (Sessions 5-10);

$df_{Num} = 1$, $df_{Den} = 296$

Source	*F*	*p*
Intercept	142.337	0.000
Punishment	119.140	0.000
Gender	43.765	0.000
Log (R_L / R_R)	12.393	0.000
Punishment * Gender	38.510	0.000
Punishment * Log (R_L / R_R)	15.731	0.000
Punishment * Gender * Log (R_L / R_R)	5.814	0.017

Table 18 displays an abridged summary of the analysis of phase 2 by gender. The complete set of data appears in Table J1 (Appendix J). The table shows that both Punishment and Gender were significant, as was their interaction. Table J2 in Appendix J shows the corresponding estimated marginal means.

Table 19

Experiment 4: Mean Asymmetry Ratios as a Function of Gender

Session	Risk	Gender	Profit	Charity
Not Paid	Averse	Male	1.31	1.22
		Female	6.2	
	Seeker	Male	1.17	1.51
		Female	3.52	2.34
Paid	Averse	Male	1.26	1.27
		Female	2.91	
	Seeker	Male	1.41	1.44
		Female	3.39	2.34

Table 19 is a summary of Table J3 and shows the asymmetry ratios for Gender nested within Profit, Session, and Risk. In every case, the asymmetry ratio for females exceeded that for males. Due to we used a risk median for male and female and the small number of participants there were not RA females in the charity group

Discussion

Higher asymmetry ratios were expected from participants when they profited personally than when they made donations to charity (Hypothesis BEH6). No significant differences were found between the profit and the charity group and between the paid and unpaid sessions. The utilitarian approach would have forecasted that participants would have traded one alternative for the other or substituted one for the other opting for the one that provides the highest utility. Hypothesis BEH6 was rejected. However, the results contradicted the utilitarian perspective. Significant differences were found between male and female participants and between risk averse and risk seekers.

APPENDIX H

Table H1

Experiment 4: Phase 1 – Tests of Fixed Effects Group and Gender Comparison – (Sessions 2-4)

$df_{Num} = 1; df_{Den} = 161$

Source	*F*	*p*
Intercept	71.672	0.000
Punishment	44.836	0.000
Group	0.498	0.481
Gender	24.287	0.000
Log (R^L / R^R)	2.644	0.106
Punishment * Group	0.423	0.516
Punishment * Gender	5.171	0.024
Punishment * Log (R^L / R^R)	2.105	0.149
Group * Gender	3.480	0.064
Group * Log (R^L / R^R)	4.859	0.029
Gender * Log (R^L / R^R)	1.295	0.257
Punishment * Group * Gender	3.392	0.067
Punishment * Group * Log (R^L / R^R)	0.794	0.374
Punishment * Gender * Log (R^L / R^R)	0.186	0.667
Group * Gender * Log (R^L / R^R)	3.028	0.084
Punishment * Group * Gender * Log (R^L / R^R)	3.058	0.082

a. Dependent Variable: Log (C^L / C^R)

Table H2

Estimated Marginal Means – Experiment 4: Phase 1 – Profit versus Charity Comparison – (Sessions 2-4)

$df_{Num} = 1; df_{Den} = 161$

			95% CI	
	M	*SE*	Lower Bound	Upper Bound
Grand Mean [a]	-0.179	0.021	-0.221	-0.137
No Punished	-0.037	0.030	-0.096	0.021
Punished	-0.320	0.030	-0.380	-0.260
Male	-0.073	0.030	-0.133	-0.014
Female	-0.284	0.030	-0.343	-0.225
No Punished * Male	0.020	0.042	-0.063	0.103
No Punished * Female	-0.095	0.042	-0.178	-0.011
Punished * Male	-0.167	0.043	-0.252	-0.081
Punished * Female	-0.473	0.042	-0.556	-0.390
Profit * Male	-0.130	0.038	-0.206	-0.055
Profit * Female	-0.260	0.046	-0.351	-0.168
Charity * Male	-0.016	0.047	-0.109	0.076
Charity * Female	-0.308	0.038	-0.383	-0.234
No Punished * Profit * Male	-0.062	0.053	-0.166	0.043
No Punished * Profit * Female	-0.019	0.065	-0.148	0.110
No Punished * Charity * Male	0.102	0.065	-0.027	0.231
No Punished * Charity * Female	-0.170	0.054	-0.277	-0.064
Punished * Profit * Male	-0.199	0.055	-0.307	-0.090
Punished * Profit * Female	-0.500	0.066	-0.630	-0.371
Punished * Charity * Male	-0.134	0.067	-0.267	-0.002
Punished * Charity * Female	-0.446	0.053	-0.551	-0.342

Note: Dependent Variable: Log (C_L / C_R)

Table H3

Experiment 4: No Punished Condition – Mean Responses, Obtained Reinforcers, Punishers, and Switches For Each Alternative of the Concurrent VI VI Schedules Categorized By Group, Sessions, Gender, and ID

Group	Sessions	Gender	ID		Clicks Left	Clicks Right	Payoff Left	Payoff Right	Penalty Left	Penalty Right	Switches Left	Switches Right
Profit	Paid	Male	1001	*M*	567.67	600.44	10.22	10.44	0.00	0.00	22.67	22.67
				SD	56.32	44.38	5.61	6.11	0.00	0.00	5.83	6.38
			1002	*M*	469.78	463.56	12.33	11.00	0.00	0.00	18.67	18.33
				SD	26.61	26.43	6.16	5.20	0.00	0.00	2.65	2.74
			1003	*M*	369.33	524.56	6.44	8.33	0.00	0.00	4.56	4.78
				SD.	113.42	98.80	4.28	6.10	0.00	0.00	1.74	2.22
		Female	1101	*M*	580.78	569.89	10.33	11.89	0.00	0.00	15.56	15.44
				SD	115.21	130.73	5.85	7.17	0.00	0.00	5.88	5.98
			1102	*M*	190.56	228.33	7.22	8.56	0.00	0.00	3.89	3.78
				SD	39.29	57.03	3.90	5.27	0.00	0.00	0.78	0.67
Charity	No paid	Male	1004	*M*	613.56	527.33	8.56	9.67	0.00	0.00	18.00	17.56
				SD	238.17	250.75	4.07	3.67	0.00	0.00	2.96	3.40
			1005	*M*	565.22	473.56	9.11	7.11	0.00	0.00	9.67	9.56
				SD	168.20	151.37	4.59	4.14	0.00	0.00	5.07	4.72
		Female	1103	*M*	358.78	643.33	6.00	6.22	0.00	0.00	4.56	4.44
				SD	126.19	175.10	5.74	5.09	0.00	0.00	1.67	1.59
			1104	*M*	252.22	288.89	10.67	11.44	0.00	0.00	19.00	18.89
				SD	87.36	97.42	6.34	6.00	0.00	0.00	8.20	7.70
			1105	*M*	418.22	649.11	8.78	9.44	0.00	0.00	14.89	15.11
				Std. Dev.	160.96	100.43	5.02	5.55	0.00	0.00	7.36	7.72

Note: Dependent Variable: Log C_L/C_R, Predictors: (Constant), Payoffs (Log R_L/R_R)
Sensitivity (c) and bias (k) estimates for each participant under no-punishment and punishment conditions.

Table H4

Experiment 4: Punished Condition – Mean Responses, Obtained Reinforcers, Punishers, and Switches for Each Alternative of The Conc VI VI Schedules Categorized by Group, Gender, and ID

Group	Gender	ID		Clicks Left	Clicks Right	Payoff Left	Payoff Right	Penalty Left	Penalty Right	Switches Left	Switches Right
Profit	Male	1001	*M*	414.33	583.89	8.11	11.11	8	0	17	16.78
			SD	84.48	56.05	4.26	5.99	3.46	0	8.49	8.12
		1002	*M*	368.11	422.78	11	10.56	10.89	0	18.33	18.44
			SD	52.65	66.73	6.2	5.81	4.4	0	5.79	5.88
		1003	*M*	246	663.22	5.33	8.44	6.78	0	5.78	5.78
			SD.	132.43	165.15	3	6.65	3.46	0	1.92	1.56
	Female	1101	*M*	196.56	829.78	5.67	6.33	4.78	0	10.22	10.44
			SD	111.33	194.76	3.5	4.12	2.68	0	3.19	2.74
		1102	*M*	129.89	273.22	7.78	7.33	7.22	0	5.44	5.56
			SD	49.05	47.77	3.31	5.02	2.91	0	1.13	1.13
Charity	Male	1004	*M*	398.11	724.33	6.22	7.78	7.56	0	18.89	19.33
			SD	234.88	267.91	3.11	5.43	2.4	0	3.41	3.24
		1005	*M*	563.22	430.33	10.11	8.22	10.67	0	8.67	8.78
			SD	225.66	167.54	5.6	5.54	4.3	0	4.12	4.18
	Female	1103	*M*	235.11	689.22	3.56	5.56	5.56	0	3.67	3.89
			SD	169.01	172.22	1.24	4.8	2.65	0	1.87	1.36
		1104	*M*	215.89	293.67	10.33	10	9.44	0	18.11	18.44
			SD	70.08	49.33	4.77	5.48	4.95	0	8.67	9.06
		1105	*M*	240.44	807.89	7.33	7.56	7.78	0	13.22	13.33
			SD	144.3	164.84	4.8	5.61	3.96	0	7.07	6.56

Note: Dependent Variable: Log $C_L/C_{R,}$ Predictors: (Constant), Payoffs (Log R_L/R_R)
Sensitivity (c) and bias (k) estimates for each participant under no-punishment and punishment conditions.

Table H5

Experiment 4: Individual Asymmetry Ratios

				No Punishment				Punishment				
Group	Gender	ID		Slope (c)	Intercept Log (k)	R^2	Antilog(k)	Slope (c)	Intercept Log (k)	R^2	Antilog(k)	Gain/loss Ratio
Profit	Male	1001		0.004	-0.025	0.002	0.943	-0.074	-0.165	0.138	0.684	1.379
			SE	0.032	0.017	0.051		0.070	0.034	0.099		
		1002		0.004	0.005	0.016	1.013	0.075	-0.061	0.131	0.374	2.705
			SE	0.011	0.006	0.017		0.073	0.038	0.115		
		1003		0.115	-0.152	0.316	0.705	-0.029	-0.427	0.003	0.459	1.536
			SE	0.064	0.036	0.105		0.205	0.117	0.304		
	Female	1101		0.159	0.023	0.320	1.056	-0.214	-0.665	0.063	0.989	1.067
			SE	0.088	0.050	0.149		0.311	0.114	0.343		
		1102		0.275	-0.056	0.559	0.879	-0.249	-0.338	0.151	0.715	1.230
			SE	0.092	0.044	0.131		0.223	0.085	0.253		
Charity	Male	1004		-1.060	0.012	0.883	1.027	-0.701	-0.309	0.789	0.490	2.094
			SE	0.146	0.052	0.153		0.137	0.074	0.223		
		1005		0.333	0.051	0.208	1.125	0.086	-0.005	0.395	0.989	1.138
			SE	0.246	0.108	0.307		0.043	0.018	0.050		
	Female	1103		-0.103	-0.224	0.070	0.597	-0.554	-0.606	0.577	0.248	2.409
			SE	0.153	0.086	0.240		0.179	0.081	0.241		
		1104		0.036	-0.056	0.022	0.878	-0.057	-0.146	0.105	0.715	1.228
			SE	0.092	0.050	0.149		0.063	0.031	0.092		
		1105		-0.163	-0.230	0.069	0.589	0.253	-0.626	0.143	0.236	2.490
			SE	0.226	0.097	0.290		0.234	0.141	0.422		

Note: Dependent Variable: Log C_L/C_R, Predictors: (Constant), Payoffs (Log R_L/R_R)

Sensitivity (c) and bias (k) estimates for each participant under no-punishment and punishment conditions.

Table H6

Experiment 4: Group and Gender Asymmetry Ratios

			No Punishment				Punishment				
Group	Gender	ID	Slope (c)	Intercept Log (k)	R^2	Antilog (k)	Slope (c)	Intercept Log (k)	R^2	Antilog (k)	Gain/loss Ratio
Profit	Male	*M*	0.061	-0.061	0.107	0.869	0.046	-0.198	0.011	0.633	1.37
		SE	0.035	0.019	0.100		0.089	0.047	0.233		
	Female	*M*	0.205	-0.016	0.386	0.963	-0.207	-0.503	0.058	0.314	3.07
		SE	0.064	0.034	0.143		0.209	0.078	0.330		
	M & F	*M*	0.113	-0.046	0.203	0.899	-0.074	-0.333	0.013	0.464	1.94
		SE	0.034	0.018	0.124		0.101	0.048	0.314		
Charity	Male	*M*	-0.220	0.099	0.062	1.255	-0.391	-0.140	0.298	0.725	1.73
		SE	0.214	0.086	0.361		0.155	0.076	0.312		
	Female	*M*	-0.078	-0.171	0.031	0.674	-0.009	-0.446	0.000	0.358	1.88
		SE	0.089	0.046	0.233		0.142	0.074	0.384		
	M & F	*M*	-0.108	-0.063	0.027	0.866	-0.131	-0.333	0.030	0.464	1.86
		SE	0.101	0.048	0.316		0.116	0.059	0.392		

Note: Dependent Variable: Log C_L/C_R, Predictors: (Constant), Payoffs (Log R_L/R_R)
Sensitivity (c) and bias (k) estimates for each participant under no-punishment and punishment conditions.

APPENDIX I

Table H1

Experiment 4: Tests of Fixed Effects - Phase 2 Punishment Cat., Group, Sessions and Risk Comparison– Sessions
5 to 10. $df_{Num} = 1; df_{Deno} = 320$

Source	*F*	*P*
Intercept	197.863	0.000
Punishment Cat.	142.161	0.000
Group	0.555	0.457
Sessions (paid and unpaid)	0.09	0.765
Risk (RA and RS)	81.266	0.000
Log (R^L/R^R)	14.588	0.000
Punishment Cat * Group	3.038	0.082
Punishment Cat * Sessions	0.319	0.572
Punishment Cat * Risk	48.555	0.000
Punishment Cat * Log (R^L/R^R)	16.394	0.000
Group * Sessions	0.499	0.481
Group * Risk	0.843	0.359
Group * Log (R^L/R^R)	1.177	0.279
Sessions * Risk	0.779	0.378
Sessions * Log (R^L/R^R)	1.165	0.281
Risk Log (R^L/R^R)	1.21	0.272
Punishment Cat * Group * Sessions	0.251	0.617
Punishment Cat * Group * Risk	5.272	0.022
Punishment Cat * Group * Log (R^L/R^R)	2.453	0.118
Punishment Cat * Sessions * Risk	0.946	0.332
Punishment Cat * Sessions * Log (R^L/R^R)	4.479	0.035
Punishment Cat * Risk * Log (R^L/R^R)	5.715	0.017
Group * Sessions * Risk	0.892	0.346
Group * Sessions * Log (R^L/R^R)	0.037	0.848
Group * Risk * Log (R^L/R^R)	10.13	0.002
Paid * Risk * Log (R^L/R^R)	0.235	0.628
Punishment Cat * Group * Sessions * Risk	1.07	0.302
Punishment Cat * Group * Sessions * Log (R^L/R^R)	0.163	0.687
Punishment Cat * Group * Risk * Log (R^L/R^R)	3.518	0.062
Punishment Cat * Sessions * Risk * Log (R^L/R^R)	0.422	0.517
Group * Sessions * Risk * Log (R^L/R^R)	0.049	0.825
Punishment Cat * Group * Sessions * Risk * Log (R^L/R^R)	0.044	0.834

Note: Dependent Variable: Log (C^L / C^R)

Table I2

Experiment 4: Phase 2 –Estimated Marginal Means
Punishment Cat., Group, Sessions and Risk Comparison
Sessions 5 to 10, df = 320

	M	*SE*	95% CI Lower Bound	95% CI Upper Bound
No Punished	-0.027	0.017	-0.061	0.008
Punished	-0.325	0.018	-0.36	-0.29
Averse	-0.288	0.018	-0.323	-0.253
Seeking	-0.064	0.017	-0.098	-0.029
No Punished*Averse	-0.051	0.025	-0.1	-0.003
No Punished*Seeking	-0.002	0.025	-0.051	0.047
Punished*Averse	-0.524	0.025	-0.574	-0.474
Punished*Seeking	-0.126	0.025	-0.174	-0.077
No Punished*Profit*Averse	0.02	0.038	-0.055	0.095
No Punished*Profit*Seeking	-0.01	0.031	-0.072	0.052
No Punished*Charity*Averse	-0.123	0.031	-0.184	-0.061
No Punished*Charity*Seeking	0.006	0.039	-0.069	0.082
Punished*Profit*Averse	-0.555	0.039	-0.632	-0.478
Punished*Profit*Seeking	-0.12	0.031	-0.182	-0.058
Punished*Charity*Averse	-0.493	0.032	-0.557	-0.43
Punished*Charity*Seeking	-0.132	0.038	-0.206	-0.057

Note: Dependent Variable: Log (C^L / C^R)

Table I3 Continuation

Experiment 4 – No Punished Schedules – Mean Responses, Obtained Reinforcers, Punishers, and Switches for Each Alternative of the Conc VI VI Schedules Categorized by Group, Gender, ID, and Type of Session

Group	Gender	ID	Risk Score	Sessions		Clicks Left	Clicks Right	Payoff Left	Payoff Right	Penalty Left	Penalty Right	Switches Left	Switche s Right
Profit	Male	10 01	38	No paid	*M*	600.11	617.22	11.44	10.78	0	0	22.67	22.33
					SD	58.88	54.8	6.13	5.7	0	0	4.85	5
				Paid	*M*	551.33	584.89	11.11	12.56	0	0	22.33	22.56
					SD	69.7	65.76	6.33	6.25	0	0	3.16	2.88
		10 02	35	No paid	*M*	542.11	525.67	11.67	10.89	0	0	12.78	12.56
					SD	48.48	66.56	6.12	4.99	0	0	3.38	3.43
				Paid	*M*	562.56	533.56	12.22	10.67	0	0	13.67	13.89
					SD	75.83	41.81	6.14	6.42	0	0	2.65	2.8
		10 03	31	No paid	*M*	410.56	548.89	10.67	8.78	0	0	16.33	16.78
					SD	166.22	262.72	6.61	5.76	0	0	11.09	10.92
				Paid	*M*	459.22	502.44	11.22	9.67	0	0	15	15.11
					SD	64.83	58.71	5.49	3.46	0	0	8.28	8.54
	Female	11 01	43	No paid	*M*	552.78	508.44	10.11	10.67	0	0	13.33	13.22
					SD	72.83	60.46	4.14	4.42	0	0	4.42	4.76
				Paid	*M*	567.33	519.78	11.78	10.22	0	0	12.44	12.44
					SD	58.52	73.35	4.58	5.17	0	0	2.65	3.17
		11 02	42	No paid	*M*	229.11	215	7.89	8	0	0	3.78	3.89
					SD	52	42.21	4.48	5.72	0	0	0.67	0.78
				Paid	*M*	208.89	212.67	8.22	9	0	0	5	4.44
					SD	38.88	23.94	3.96	5	0	0	1.12	1.13

Table I3 Continuation

Experiment 4 – No Punished Schedules

Mean Responses, Obtained Reinforcers, Punishers, and Switches for Each Alternative of the Conc VI VI Schedules Categorized by Group, Gender, ID, and Type of Session

Group	Gender	ID	Risk Score	Sessions		Clicks Left	Clicks Right	Payoff Left	Payoff Right	Penalty Left	Penalty Right	Switches Left	Switches Right
Charity	Male	1004	34	No paid	*M*	565.78	602.89	12.11	12.44	0	0	34.56	34.44
					SD	123.34	98.96	6.55	6.04	0	0	4.61	4.22
				Paid	*M*	575.89	587.89	11.11	11.44	0	0	33.44	33.44
					SD	106.88	109.88	6.35	4.98	0	0	7.3	7.4
		1005	39	No paid	*M*	581.33	419.44	10.22	8.67	0	0	10.33	10.44
					SD	111.72	180.81	4.58	4.27	0	0	4.5	4.5
				Paid	*M*	531.44	525.56	11.78	11.11	0	0	14.44	14.33
					SD	32.45	39.53	5.85	4.14	0	0	2.4	2.29
	Female	1103	42	No paid	*M*	389.89	367.44	6.44	4.78	0	0	3.67	2.89
					SD	158.92	114.83	4.95	4.6	0	0	2.4	2.32
				Paid	*M*	333.22	478	5.22	3.78	0	0	3.78	3.56
					SD	158.72	282.58	4.97	2.95	0	0	2.77	2.7
		1104	40	No paid	*M*	205.56	277.67	11	10.44	0	0	13.22	13.11
					SD	60.86	72.86	3.84	5.13	0	0	2.33	1.9
				Paid	*M*	258.22	342	11.56	10.33	0	0	15.89	15.56
					SD	81.52	103.39	5.77	5.34	0	0	4.34	4.36
		1105	40	No paid	*M*	303.11	453.33	7.56	7.78	0	0	8	8
					SD	45.17	105.55	3.81	5.47	0	0	3.28	2.92
				Paid	*M*	375	514.22	8.44	10.11	0	0	10.78	10.56
					SD	122.16	101.37	3.21	5.23	0	0	4.35	4.28

Table I4

Experiment 4 – Punished Schedules

Mean Responses, Obtained Reinforcers, Punishers, and Switches for Each Alternative of the Conc VI VI Schedules Categorized by Group, Gender, ID, and Type of Session

Group	Gender	ID	Risk Score	Sessions		Clicks Left	Clicks Right	Payoff Left	Payoff Right	Penalty Left	Penalty Right	Switches Left	Switches Right
Profit	Male	1001	38	No paid	*M*	502.89	672.56	9.22	9.44	9.33	0	13.67	14.22
					SD	72.31	89.69	4.12	5	3.2	0	4.12	3.83
				Paid	*M*	458.78	615	10.89	9.89	9.33	0	15	15
					SD	91.36	75.82	4.48	5.4	3.2	0	3.74	3.5
		1002	35	No paid	*M*	462.56	496.67	10.44	10.56	9.33	0	11.44	11.67
					SD	48.97	54.84	6.02	7.04	3.71	0	3.54	3.54
				Paid	*M*	452.89	536.89	10.22	9.56	9.56	0	16.22	16
					SD	53.28	77.78	4.97	5.22	4.03	0	3.19	3.39
		1003	31	No paid	*M*	487	466.78	10.11	8.11	10.22	0	16.44	16
					SD	273.56	191.82	5.51	4.62	3.8	0	8.59	8.82
				Paid	*M*	332.22	620	8.67	8.56	8.44	0	17.56	17.78
					SD	56.41	165.3	3.91	5.48	2.55	0	9.8	9.67
	Female	1101	43	No paid	*M*	200.25	674.5	5.13	9.75	5.75	0	9.38	9.63
					SD	153.05	154.36	2.03	4.83	1.83	0	4.78	4.34
				Paid	*M*	259.67	695.33	6.56	8.22	6	0	11.22	11.22
					SD	160.37	223.55	2.79	6.44	3.04	0	4.06	3.56
		1102	42	No paid	*M*	100.22	328.78	7.44	6.67	7.22	0	6.22	6.33
					SD	47.15	62.71	2.01	4.09	3.6	0	1.72	1.22
				Paid	*M*	97	305.44	7.11	9	6.33	0	6.33	6.89
					SD	35.46	48.94	2.26	5.12	2.87	0	1.8	2.03

Table I4 Continuation

Experiment 4 – Punished Schedules

Mean Responses, Obtained Reinforcers, Punishers, and Switches for Each Alternative of the Conc VI VI Schedules Categorized by Group, Gender, ID, and Type of Session

Group	Gender	ID	Risk Score	Sessions		Clicks Left	Clicks Right	Payoff Left	Payoff	Penalty	Penalty	Switches	Switches
Charity	Male	1004	34	No paid	*M*	421	678.33	10.56	10.78	8.78	0	34.67	34.78
					SD	141.51	128.34	4.33	5.65	3.46	0	5.1	5.43
				Paid	*M*	434.78	676.44	10.44	10.67	8.89	0	33.11	33.11
					SD	144.43	148.36	4.19	6.32	3.33	0	6.53	6.47
		1005	39	No paid	*M*	452.22	465.89	8.22	10	9.11	0	10.78	10.67
					SD	92.93	108.41	4.41	6.22	3.79	0	3.6	3.39
				Paid	*M*	465.89	584.22	9.78	11.11	10	0	13.56	13.89
					SD	92.85	149.08	3.27	5.6	4.24	0	2.79	2.67
	Female	1103	42	No paid	*M*	122.56	682.78	3.11	2.56	3.89	0	3.11	3.89
					SD	85.69	103.96	2.93	2.13	1.76	0	1.05	1.17
				Paid	*M*	175.89	650.33	3.22	4.22	4.89	0	3.22	3.56
					SD	78.79	216.58	2.33	2.49	1.9	0	1.92	2.01
		1104	40	No paid	*M*	142.44	348.33	7.78	10	7.67	0	10.67	10.78
					SD	72.59	78.03	3.77	6.34	1.66	0	0.87	0.97
				Paid	*M*	214.78	369.33	8.78	10.56	9.11	0	14.56	14.78
					SD	59.7	112.7	3.67	5.66	2.37	0	3.54	3.6
		1105	40	No paid	*M*	286.22	480.22	6.67	4.56	6.78	0	6.56	6.56
					SD	117.39	215.83	3.28	2.19	4.68	0	2.4	2.74
				Paid	*M*	190.89	640.56	4.89	8.67	6.44	0	7.33	7.67
					SD	130.69	205.25	3.22	6.95	3.28	0	2.35	2.35

Table I5

Experiment 4 – No Paid And Paid Sessions Asymmetry Ratios

Group	Sessions		No Punishment				Punishment				
			Slope c	Intercept Log (k)	R^2	Antilog (k)	Slope c	Intercept Log (k)	R^2	Antilog (k)	Gain/Loss Ratio
Profit	No paid	*M*	0.034	0.008	0.022	1.019	-0.099	-0.295	0.018	0.507	2.01
		SE	0.035	0.016	0.105		0.115	0.055	0.363		
	Paid	*M*	0.086	-0.006	0.244	0.987	-0.170	-0.271	0.086	0.536	1.84
		SE	-0.006	0.011	0.072		0.085	0.039	0.260		
Charity	No paid	*M*	-0.086	-0.056	0.027	0.880	-0.067	-0.330	0.006	0.468	1.88
		SE	0.080	0.035	0.228		0.130	0.061	0.396		
	Paid	*M*	-0.003	-0.081	0.000	0.830	-0.242	-0.362	0.103	0.435	1.91
		SE	0.081	0.037	0.249		0.109	0.050	0.331		

Note: Dependent Variable: Log (C^L / C^R)
Sensitivity (c) and bias (k) estimates for each participant under no-punishment and punishment conditions.

Table I6

Experiment 4 – Risk averse and Risk seeking asymmetry ratios

Group	Sessions Paid	Risk Category		No Punishment Slope (c)	No Punishment Intercept Log (k)	No Punishment R^2	No Punishment Antilog (k)	Punishment Slope (c)	Punishment Intercept Log (k)	Punishment R^2	Punishment Antilog (k)	Asymmetry Ratio
Profit	No paid	RA	*M*	0.124	0.029	0.153	1.07	-0.302	-0.618	0.151	0.241	4.44
			SE	0.073	0.031	0.13		0.185	0.091	0.373		
		RS	*M*	-0.011	-0.004	0.005	0.99	-0.015	-0.09	0.005	0.812	1.22
			SE	0.031	0.015	0.076		0.044	0.021	0.107		
	Paid	RA	*M*	0.155	0.008	0.411	1.019	-0.509	-0.486	0.412	0.327	3.12
			SE	0.046	0.02	0.084		0.157	0.061	0.248		
		RS	*M*	0.049	-0.016	0.173	0.963	-0.095	-0.149	0.114	0.709	1.36
			SE	0.022	0.011	0.055		0.053	0.027	0.138		
Charity	No paid	RA	*M*	0.015	-0.11	0.001	0.777	0.036	-0.479	0.002	0.332	2.34
			SE	0.117	0.05	0.254		0.186	0.087	0.433		
		RS	*M*	-0.217	0.021	0.332	1.05	-0.234	-0.119	0.276	0.76	1.38
			SE	0.08	0.035	0.144		0.095	0.044	0.188		
	Paid	RA	*M*	0.117	-0.136	0.036	0.731	-0.236	-0.506	0.08	0.312	2.34
			SE	0.122	0.057	0.295		0.16	0.069	0.345		
		RS	*M*	-0.181	-0.005	0.55	0.987	-0.382	-0.139	0.735	0.725	1.36
			SE	0.041	0.018	0.078		0.057	0.028	0.119		

Note: Dependent Variable: Log (C^L / C^R)

Sensitivity (c) and bias (k) estimates for each participant under no-punishment and punishment conditions.

APPENDIX J

Table J1

Experiment 4 – Phase 2

Tests of Fixed Effects: Punishment Cat., Group, Sessions, Risk and Gender Comparison– Sessions 5 to 10, $df_{Num} = 1$; $df_{Den} = 296$

Source	*F*	*P*
Intercept	142.337	0.000
Punishment Cat. (Punished - No Punished)	119.140	0.000
Group (Profit - Charity)	0.008	0.929
Sessions (Paid - No-Paid)	0.025	0.874
RiskSep (Risk Averse - Risk Seeking)	1.145	0.285
Gender (Male and Female)	43.765	0.000
Log (R^L/R^R)	12.393	0.000
Punishment Cat. * Group	1.040	0.309
Punishment Cat. * Sessions	0.927	0.336
Punishment Cat. * RiskSep	0.010	0.920
Punishment Cat. * Gender	38.510	0.000
Punishment Cat. * Log (R^L/R^R)	15.731	0.000
Group * Sessions	0.087	0.768
Group * RiskSep	2.643	0.105
Group * Gender	0.016	0.900
Group * Log (R^L/R^R)	1.348	0.247
Sessions * RiskSep	0.335	0.563
Sessions * Gender	0.786	0.376
Sessions * Log (R^L/R^R)	1.136	0.287
RiskSep * Gender	0.003	0.954
RiskSep * Log (R^L/R^R)	0.031	0.860
Gender * Log (R^L/R^R)	0.210	0.647
Punishment Cat. * Group * Sessions	0.000	0.998
Punishment Cat. * Group * RiskSep	0.251	0.617
Punishment Cat. * Group * Gender	3.057	0.081
Punishment Cat. * Group * Log (R^L/R^R)	0.238	0.626
Punishment Cat. * Sessions * RiskSep	0.980	0.323
Punishment Cat. * Sessions * Gender	1.281	0.259
Punishment Cat. * Sessions * Log (R^L/R^R)	2.363	0.125
Punishment Cat. * RiskSep * Gender	0.372	0.542
Punishment Cat. * RiskSep * Log (R^L/R^R)	0.068	0.794
Punishment Cat. * Gender * Log (R^L/R^R)	5.814	0.017
Group * Sessions * RiskSep	1.061	0.304
Group * Sessions * Gender	0.473	0.492
Group * Sessions * Log (R^L/R^R)	0.510	0.476
Group * RiskSep * Gender		
Group * RiskSep * Log (R^L/R^R)	2.772	0.097
Group * Gender * Log (R^L/R^R)	7.938	0.005
Sessions * RiskSep * Gender	0.815	0.367
Sessions * RiskSep * Log (R^L/R^R)	0.982	0.323
Sessions * Gender * Log (R^L/R^R)	0.566	0.452
RiskSep * Gender * Log (R^L/R^R)	1.224	0.270

Table J1 Continuation

Experiment 4: Phase 2 – Tests of Fixed Effects

Punishment Cat., Group, Sessions, Risk and Gender Comparison– Sessions 5 to 10, $df_{Num} = 1; df_{Den} = 296$

Source	*F*	*P*
Punishment Cat. * Group * Sessions * RiskSep	0.202	0.653
Punishment Cat. * Group * Sessions * Gender	0.186	0.666
Punishment Cat. * Group * Sessions * Log (R^L/R^R)	0.118	0.731
Punishment Cat. * Group * RiskSep * Gender		
Punishment Cat. * Group * RiskSep * Log (R^L/R^R)	0.07	0.791
Punishment Cat. * Group * Gender * Log (R^L/R^R)	2.189	0.14
Punishment Cat. * Sessions * RiskSep * Gender	0.554	0.457
Punishment Cat. * Sessions * RiskSep * Log (R^L/R^R)	0.4	0.528
Punishment Cat. * Sessions * Gender * Log (R^L/R^R)	0.695	0.405
Punishment Cat. * RiskSep * Gender * Log (R^L/R^R)	0.299	0.585
Group * Sessions * RiskSep * Gender		
Group * Sessions * RiskSep * Log (R^L/R^R)	0.637	0.426
Group * Sessions * Gender * Log (R^L/R^R)	0.356	0.551
Group * RiskSep * Gender * Log (R^L/R^R)		
Sessions * RiskSep * Gender * Log (R^L/R^R)	0.172	0.678
Punishment Cat. * Group * Sessions * RiskSep * Gender		
Punishment Cat. * Group * Sessions * RiskSep * Log (R^L/R^R)	0.304	0.582
Punishment Cat. * Group * Sessions * Gender * Log (R^L/R^R)	0.722	0.396
Punishment Cat. * Group * RiskSep * Gender * Log (R^L/R^R)		
Punishment Cat. * Sessions * RiskSep * Gender * Log (R^L/R^R)	0.017	0.896
Group * Sessions * RiskSep * Gender * Log (R^L/R^R)		
Punishment Cat. * Group * Sessions * RiskSep * Gender * Log (R^L/R^R)		

Table J2

Experiment 4: Phase 2 – Punishment Cat., Group, Sessions, Risk, and Gender Comparison– Sessions 5 to 10

df = 296

			95% CI	
	M	*SE*	Lower Bound	Upper Bound
Grand Average	-0.159	0.013	-0.185	-0.132
Punished	-0.014	0.019	-0.051	0.023
No Punished	-0.304	0.019	-0.341	-0.266
Male	-0.065	0.018	-0.101	-0.029
Female	-0.284	0.02	-0.324	-0.244
No Punished * Male	-0.005	0.026	-0.055	0.046
No Punished * Female	-0.026	0.028	-0.081	0.029
Punished * Male	-0.125	0.025	-0.175	-0.075
Punished * Female	-0.541	0.029	-0.599	-0.483

Note: Dependent Variable: Log (C^L/C^R)

Covariates appearing in the model are evaluated at the following values: Log (R^L/R^R) = 0.0075.

Table J3

Experiment 4: Male and Female - Risk Averse and Risk Seeking Asymmetry Ratios

					No Punishment				Punishment				
Group	Sessions	Risk	Gender		Slope (c)	Intercept Log (k)	*R2*	Antilog (k)	Slope (c)	Intercept Log (k)	*R2*	Antilog (k)	Gain/ Loss Ratio
Profit	No paid	RA	M	*M*	-0.052	-0.011	0.166	0.976	-0.007	-0.127	0.001	0.747	1.307
				SE	0.044	0.021	0.064		0.088	0.037	0.11		
			F	*M*	0.048	0.037	0.025	1.09	-0.465	-0.755	0.28	0.176	6.202
				SE	0.113	0.036	0.107		0.304	0.162	0.419		
		RS	M	*M*	0.011	-0.002	0.004	0.996	-0.019	-0.071	0.009	0.849	1.173
				SE	0.043	0.02	0.083		0.052	0.026	0.107		
			F	*M*	0.158	0.018	0.235	1.041	-0.291	-0.529	0.141	0.296	3.519
				SE	0.108	0.054	0.16		0.271	0.12	0.344		
	Paid	RA	M	*M*	0.02	-0.025	0.306	0.944	-0.087	-0.125	0.189	0.749	1.259
				SE	0.012	0.006	0.019		0.068	0.029	0.086		
			F	*M*	0.046	0.035	0.055	1.085	-0.709	-0.428	0.521	0.373	2.905
				SE	0.073	0.03	0.088		0.278	0.105	0.295		
		RS	M	*M*	0.069	-0.014	0.203	0.969	-0.098	-0.161	0.106	0.69	1.405
				SE	0.034	0.015	0.065		0.071	0.038	0.161		
			F	*M*	0.237	-0.005	0.793	0.988	-0.349	-0.536	0.393	0.291	3.392
				SE	0.046	0.02	0.06		0.164	0.065	0.192		

Note: Dependent Variable: Log (C^L / C^R)

Sensitivity (c) and bias (k) estimates for each participant under no-punishment and punishment conditions.

Table J3 Continuation

Experiment 4: Male and female - Risk Averse and Risk Seeking Asymmetry Ratios

Group	Sessions Paid	Risk	Gender		No Punishment				Punishment				Gain/Loss Ratio
					Slope (c)	Intercept Log (k)	*R2*	Antilog (k)	Slope (c)	Intercept Log (k)	*R2*	Antilog (k)	
Charity	No paid	RA	M	*M*	0.013	0.075	0.001	1.188	-0.027	-0.012	0.013	0.973	1.22
				SE	0.224	0.062	0.172		0.088	0.044	0.133		
		RS	F	*M*	-0.284	-0.04	0.897	0.913	-0.496	-0.217	0.899	0.607	1.504
				SE	0.036	0.02	0.059		0.063	0.027	0.081		
			F	*M*	0.015	-0.11	0.001	0.777	0.036	-0.479	0.002	0.332	2.342
				SE	0.117	0.05	0.254		0.186	0.087	0.433		
	Paid	RA	M	*M*	-0.043	0.006	0.523	1.013	-0.363	-0.098	0.705	0.798	1.269
				SE	0.016	0.006	0.019		0.089	0.038	0.113		
		RS	M	*M*	-0.274	-0.022	0.779	0.95	-0.383	-0.181	0.787	0.66	1.44
				SE	0.055	0.027	0.081		0.075	0.041	0.123		
			F	*M*	0.117	-0.136	0.036	0.731	-0.236	-0.506	0.08	0.312	2.342
				SE	0.122	0.057	0.295		0.16	0.069	0.345		

Note: Dependent Variable: Log (C^L / C^R)

Sensitivity (c) and bias (k) estimates for each participant under no-punishment and punishment conditions.

CHAPTER 5: Analyzing Gain-Loss Asymmetry Using Behavioral and Electrophysiological Measures

Experiment 5

This chapter reports an experiment in which participants played the SubSearch game while the electroencephalogram (EEG) was recorded from their scalp. Thus, the behavior-analytic data from the game could be related to the corresponding electrophysiological data. There were 16 male subjects (age mean=23), who were recruited from undergraduate students at Brigham Young University. The experiment consisted of eight sessions in which the game was synchronized with the Emotive Epoc® software. Evoked-response potential (ERP) recording was continuous during the 36-min session. Following filtering, amplifying, and averaging the ERP record, the data analysis was focused on the 1 s before and the 2 s following each onscreen presentation of a gain or a loss. Amplitude and latency were measured for each peak of the averaged, within-participant ERP components: N50, P100, N100, P200, N200, and P300. The experiment involved four distinctive phases. The behavioral-analytic results will be presented before the electrophysiological results.

Behavioral-analytic Results

Table K1 in Appendix K displays the results of the analysis using the Linear Mixed Methods (LMM) model described in Chapter 3. The model included four factors: Participants (ID), gains and losses (GainLoss), risk (RiskCat), and sessions (SessionNum). The dependent variable was *log* (C_L/C_R) that is the logarithm of total mouse clicks in the left panel of the monitor screen divided by total clicks in the right panel. The covariate was *log* (R_L/R_R), the logarithm of the total number of left reinforcers divided by the total number of right reinforcers.

Hypothesis EEG1, EEG2, and EEG3. Gain and Loss, Sessions, and Risk

It was expected an asymmetry of gains and losses between 2:1 or 3:1 (EEG1), significant differences between sessions due to a learning effect (EEG2), significant difference between Risk Averse and Risk Seekers (EEG3)

The application of the model showed only a significant outcome for GainLoss at 0.01 level $F_{(1, 583)} = 378.703$, $p = .000$. The other factors Risk, $F_{(6, 583)} = .100$, $p = .751$and Session $F_{(1, 583)} = 2.043$, $p = .058$ were not significant nor were there significant interactions. The estimates of the covariance parameters were residual = 0.096783, *SE* = .005669, and the estimated marginal grand mean was -0.306, *SE* = .014, *df* =583, 95% CI [-.333,-.2.79].

Table 20

Experiment 5: Overall Gain/Loss Ratio Gain/Loss Ratios and for Risk Categories (Risk Averse and Risk Seeking) in Sessions 1-7

Session	Gain/Loss Ratio	Gain/Loss Ratio Risk Category	
		Risk Averse	Risk Seeking
1	3.13	2.36	4.14
2	2.69	2.57	2.79
3	4.22	5.02	3.54
4	3.98	3.95	4.03
5	2.75	3.11	2.44
6	3.91	4.20	3.62
7	3.46	4.95	2.42
Mean	3.40	3.60	3.21

Table 20 contains the mean gain-loss ratios for each session and overall, and also the ratios for participants in the two categories of risk in sessions 1-7. The ratios of gains and losses were higher than most of those obtained in previous experiments, loss amplitudes are higher than gain amplitudes (3.40). The difference in gain/loss ratios for participants in the two risk categories was typically lower. Tables K2 and K3 in Appendix K show the mean responses, obtained reinforcers, punishers, and switches for the punished and for the unpunished alternatives respectively. Table K4 in Appendix K shows the individual gain/loss ratios for all participants. In addition, Table K5 displays the calculation of the overall ratio, Table K6 the calculation of the gain/loss ratios for risk-averse and risk-seeking participants, Table K7 the calculations of the gain/loss ratios per session, and Table K8 the gain/loss ratios for the interaction of session and risk. Hypothesis EEG1 was partially accepted. Loss amplitudes were higher than gains, but the ratio of 3.40:1 was larger than 2:1 or 3:1 that was expected. There were not significant differences in Risk and Sessions consequently both hypothesis EEG2 and EEG 3 were rejected. Note, however that the trend in the risk aversion group is positive and in the risk seekers group is negative. Risk averse tend to increase risk aversion and risk seekers tend to decrease risk aversion.

Hypothesis EEG4. The Use of Different Stimuli for Gains and Losses in Sessions 7 and 8: Behavioral Measures.

Table L1 displays the results of the application of the LMM. As in the previous six sessions, both an auditory stimulus and a visual stimuli signaled gains and losses in session 7. In session 8, however, only visual stimuli were used. Fifteen participants completed session 7, and 12 completed session 8. The dependent variable was $log\ (C_L/C_R)$, the covariate was $log\ (R_L/R_R)$, and the factors were: ID, gain/loss (GainLoss), and sessions 7 and 8 (SessionNum). The results included a significant difference for GainLoss, $F_{(1,\ 151)} = 129.614$, $p = 0.000$. SessionNum was not significant $F_{(1,\ 151)} = 2.301$, $p = 0.131$ was not significant. The estimates of the covariance parameters were for the covariate residual = 0.112098, SE= 0.012901 and the estimated marginal grand mean -0.305, *SE* = 0.027 *df* =151, 95% CI [-0.358,-0.252]. The gain-loss asymmetry in session 7 was 4.08, which is 1.30 times higher than in session 8 that was 3.14. Tables L2 and L3 in the Appendix L show the mean responses, obtained reinforcers, punishers, and switches for the unpunished and punished conditions respectively for Session 7 and similar information for session 8 in tables L4 and L5. Table L6 and L7 in the appendix show the gain/loss ratios with their respective means, *SE*s, *CI*s, *df*, and antilogs for session 7 and session 8 respectively. Hypothesis EEG4 behaviorally measured was rejected.

Electrophysiological Results

The hypotheses regarding the asymmetry of gains and losses were tested electro-physiologically by measuring the amplitudes in microvolts (μV) of the ERP components corresponding to the gain and loss events in the SubSearch game.

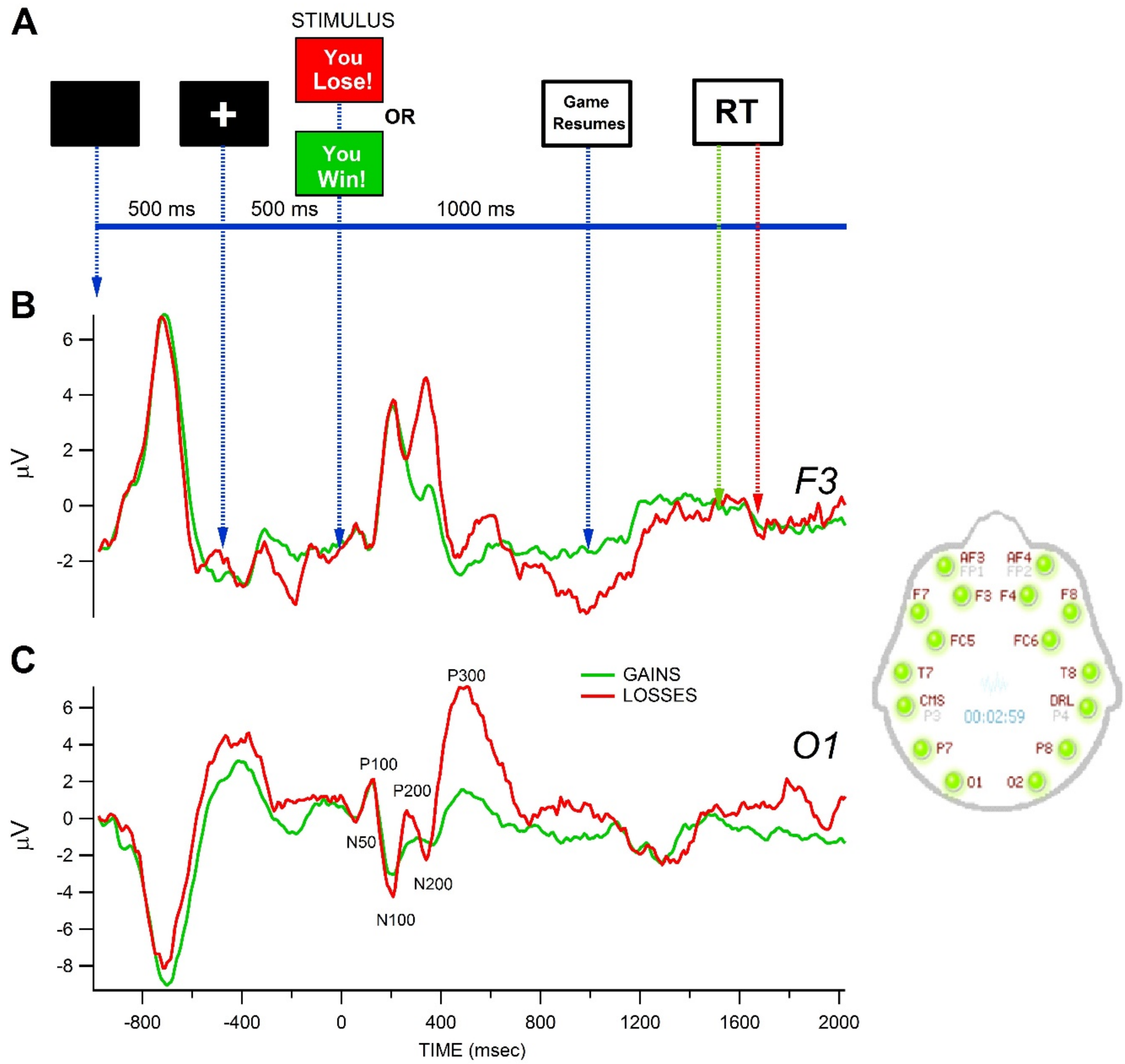

Figure 7. P300 waveform for gains and losses.

Figure 7 shows the averaged P300 waveform with the N50, P100, N100, P200, N200, and P300 components for electrodes F3 and O1. In addition, the figure shows the time windows for the on-screen stimulus and response (RT = response time) that resumed the game.

Hypothesis EEG1

Table 21

Experiment 5: Gain/Loss Ratios for P100, N100, P200, N200, and P300 Waves and the Accompanying Fixed Effects Analysis

$df_{Num} = 1; df_{Den} = 14$

Components	Amplitude (µV)					Type 3 Tests of Fixed Effects GainLoss Effect	
	Gain		Loss		Gain/Loss	*F*	
	M	*SE*	*M*	*SE*	Ratio	Value	*p* >*F*
P100	2.162	0.204	4.286	0.203	1.98	87.94	< 0.0001
N100	4.184	0.474	7.29	0.474	1.74	31.8	< 0.0001
P200	3.77	0.387	7.419	0.387	1.97	64.3	< 0.0001
N200	2.033	0.325	4.596	0.325	2.26	40.84	< 0.0001
P300	7.351	0.667	14.619	0.667	1.99	82.81	< .0001

It was expected an asymmetry of gains and losses between 2:1 or 3:1 (EEG1), significant differences between sessions due to a learning effect (EEG2). Table 21 shows the P100, N100, P200, N200, and P300 means, standard errors (*SE*s), gain/loss ratios, and the corresponding degrees of freedom (*df*), degrees of freedom numerator (df_{num}), degrees of freedom denominator(df_{den}), F values (*F*), and p values (*p*) of the LMM analysis. There were significant differences for all components. The amplitude of the P300 component was 1.99 greater for losses than for gains $F_{(1, 14)} = 82.81$, $p < 0.0001$. A similar pattern was observed in all other components. Hypothesis EEG1 measured electro physiologically was accepted.

Table 22

Experiment 5: Mean Overall Latencies in Each Component for Gains and Losses and the Accompanying Fixed Effects Analysis

$df_{Num} = 1; df_{Den} = 14$

	Latency (msec)				Type 3 Tests of Fixed Effects GainLoss Effect	
Components	Gain		Loss		F	
	M	*SE*	*M*	*SE*	Value	*p* > *F*
N50	107.19	4.2056	106.56	4.2056	0.71	0.4137
P100	143.13	3.2865	145.84	3.2865	0.13	0.7213
N100	191.05	3.8994	194.54	3.8994	1.2	0.2911
P200	230.76	4.4199	238.51	4.4199	0.13	0.7257
N200	270.43	5.3163	282.36	5.3163	2.74	0.1201
P300	442.45	7.0643	455.03	7.0643	0.02	0.8835

Table 22 shows the latencies for the P300 component when gains or losses occurred. The differences in latencies were not significant $F(1, 14) = 0.02$, $p = 0.8835$.

Gain/Loss Ratio Differences by Electrode Site

Table 23 shows the overall gain/loss ratios for the P100, N100, P200, N200, and P300 at Front, Middle, and Back electrodes sites. Appendix M: Tables M1, M2, and M3 exhibit detailed information about the estimated mean amplitudes, SEs, and ratios for the early components (P_{100}, N_{100}, and P_{200}) and the termed event-related potentials N200 and P300. For the interaction between GainLoss and FrontBack.

Table 23

Experiment 5: Overall Gain/Loss Ratios for Different Electrode Locations and the Accompanying Fixed Effects Analysis

$df_{Num} = 2; df_{Den} = 28$

Components	Sets of Electrodes Gain/Loss Ratios			Type 3 Tests of Fixed Effects GainLoss Effect	
	Front	Middle	Back	*F* Value	*P* >*F*
P100	1.91	2.16	1.93	30.49	< .0001
N100	1.63	2.00	1.67	27.74	< .0001
P200	1.83	1.84	2.17	14.42	< .0001
N200	2.15	2.06	2.52	15.16	< .0001
P300	2.10	1.92	1.96	16.68	< .0001
Mean	1.92	2.00	2.05		

Table 24 shows the averaged latencies for the components N50, P100, N100, P200, N200, and P300. The Frontal electrodes recorded a faster response compared to those in the Middle and Back sites. The latencies in the Front and Middle are larger for losses than gains, however, slower for losses in the Back compared to the gains.

Table 24

Experiment 5: Mean Latencies for Gain and Loss Signals at Three Different Electrode Sites

$df_{Num} = 2; df_{Den} = 2.349$

Components	Latencies (msec) Gain			Loss			Type 3 Tests of Fixed Effects GainLoss * FrontBack Interaction	
	Front	Middle	Back	Front	Middle	Back	*F* Value	*p* > *F*
N50	81.6	123.92	116	82.07	133.24	104.36	4.85	0.0079
P100	115.72	156.79	15688	121.02	166.82	149.67	4.16	0.0157
N100	159.98	201.52	211.64	163.35	215.75	204.53	5.25	0.0053
P200	185.79	247.54	258.95	203.98	255.72	255.82	3.37	0.0347
N200	217.53	293.1	300.64	238.8	306.71	301.56	2.08	0.1246
P300	360.28	485.65	481.4	394.71	491.77	478.61	5.65	0.0036
Mean	186.82	251.42	281.9	200.66	261.67	249.09		

Hypothesis EEG2

The participants played the game under identical conditions for seven sessions. I compared the overall amplitudes and latencies for gains and losses in order to determine whether the longitudinal data displayed an acquisition effect. It was hypothesized that differences in ERPs corresponding to differences in the behavioral gain/loss ratio would appear with participants' increased exposure to the SubSearch game (for example, comparing the data from session 1 to those from session 7) and which has been traditionally known as a learning curve. Figure 8 displays the mean electrophysiological gain/loss ratios for the P100, N100, P200, N200, and P300 components in each session. A visible pattern consistent with a learning curve was observed for all but the P300 component. Tables N1, N2, N3, and N4 in Appendix N display the mean amplitudes, *SE*s and gain/loss ratios that are summarized in Table 25.

Table 25

Experiment 5: Gain/Loss Amplitude Ratios Per Session and T3TFE for GainLoss and Session

Components	Sessions ratios								Type 3 Tests of Fixed Effects GainLoss * Session Interaction Effect			
	1	2	3	4	5	6	7	*M*	df_{Num}	df_{Den}	*F* Value	p > *F*
P100	1.53	1.99	1.64	1.69	2.31	2.29	2.87	2.05	6	2270	3.98	0.0006
N100	1.36	1.70	1.42	1.87	1.96	2.02	1.99	1.76	6	2258	4.42	0.0002
P200	1.64	1.75	1.88	2.11	2.13	1.98	2.38	1.98	6	2252	1.77	0.1021
N200	2.06	2.39	2.15	2.14	2.41	2.52	2.21	2.27	6	2266	1.07	0.3804
P300	1.65	2.17	2.14	2.12	1.74	2.14	2.03	2.00	6	2268	3.49	0.0019
Mean	1.65	2.00	1.85	1.99	2.11	2.19	2.30	2.01				

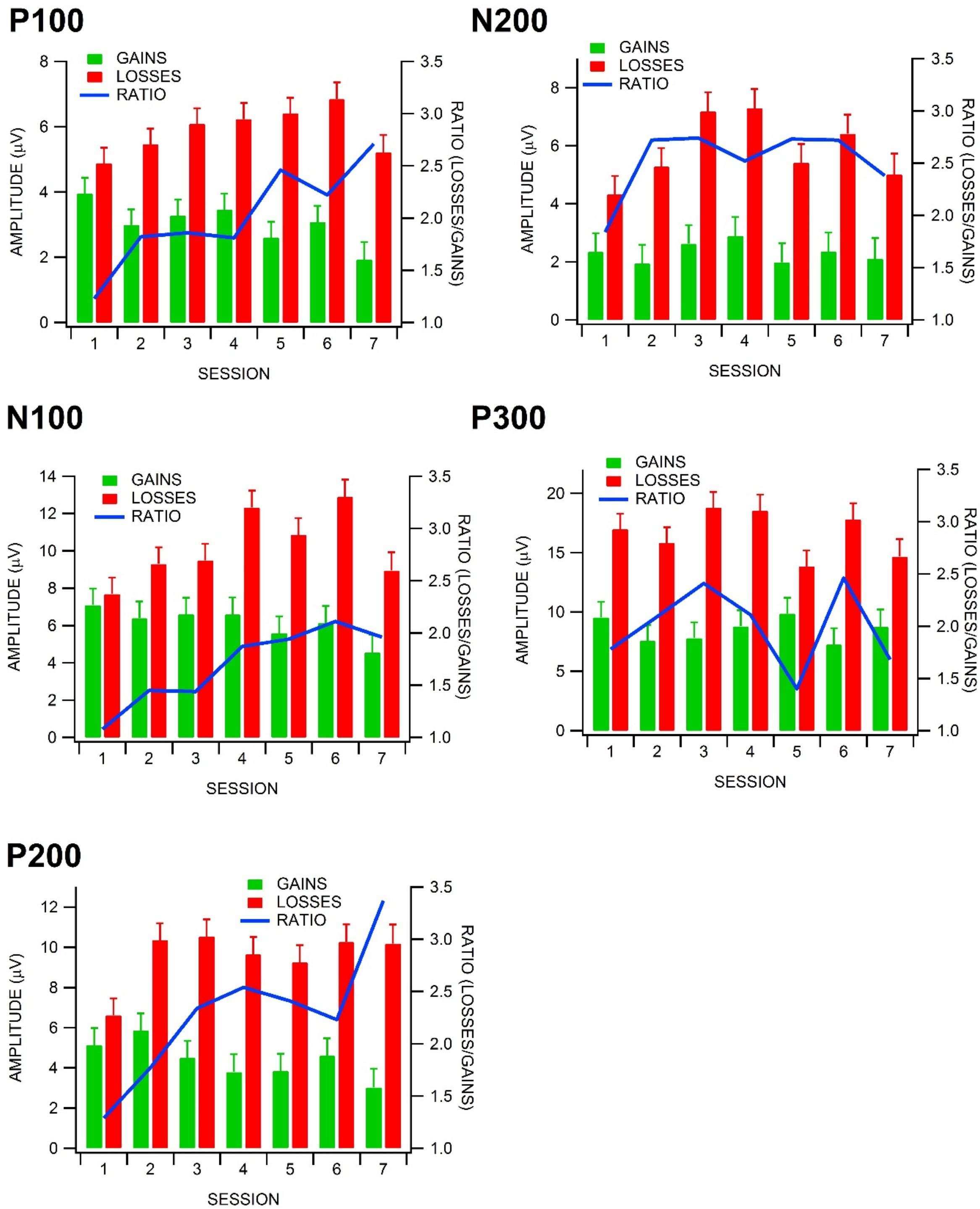

Figure 8. Mean electrophysiological gain/loss ratios for the P300 waveform per session

Table 26 shows the mean gain/loss ratios for the ERP latencies in each session and for each component. The LMM analysis produced significant differences for the N50, P100, and N100 components only. N50 and P100 show significant differences across sessions at 0.01 level and N100 at 0.05 level. Tables N5, N6, N7 and N8 in Appendix N show the mean latencies for gains and losses, *SE*s, and the LMM results for each session and component.

Table 26

Experiment 5: Mean Gain/Loss Ratios for Latencies Per Session and the Accompanying Fixed Effects Analysis

$df_{Num} = 6; df_{Den} = 2349$

Components	Sessions								Type 3 Tests of Fixed Effects GainLoss * Session Interaction Effect	
	1	2	3	4	5	6	7	*M*	*F* Value	*p* > *F*
N50	0.73	1.03	1.01	1.06	0.99	1.09	1.14	1.01	4.23	0.0003
P100	0.81	0.97	0.99	1.06	0.97	1.03	1.06	0.98	3.81	0.0009
N100	0.88	0.96	0.99	1.02	0.96	1	1.07	0.98	2.43	0.0241
P200	0.88	0.96	0.96	1	0.95	1.02	1.01	0.97	1.72	0.112
N200	0.86	0.95	0.95	0.98	0.93	1	1.04	0.96	2.05	0.0564
P300	0.93	0.96	0.95	0.94	0.99	1.02	1.01	0.97	1.65	0.1298
Mean	0.85	0.97	0.97	1.01	0.96	1.03	1.06	0.98		

Hypothesis EEG3

In the earlier-reported study of risk. Risk averse participants displayed significantly higher gain/loss ratios than risk-seeking participants did. The EEG3 hypothesis predicted the same pattern for ERP components.

Table 27 shows the mean amplitudes, *SE*s, gain/loss ratios, and the LMM results for risk averse and risk-seeking participants. No significant difference was found in the P300 component $F_{(1, 2268)} = 0$, $p = 0.96$ or in the other components. In addition, no significant difference was found for the P300 interaction between GainLoss and Risk $F_{(1, 2268)} = 0.22$, $p = 0.6421$ or for the other components.

Table 27

Experiment 5: Overall Means for Amplitude, SE, Gain/Loss Ratio, and the Accompanying Fixed Effects Analysis per ERP Component for Risk-Averse and Risk-Seeking Participants

Components	Risk Averse (RA)		Risk Seeking (RS)		Ratio	Type 3 Tests of Fixed Effects Risk Effect			
	M	*SE*	*M*	*SE*	RA/RS	df_{Num}	df_{Den}	*F* Value	p > *F*
P100	3.161	0.241	3.287	0.2371	0.96	1	2270	0.14	0.709
N100	5.688	0.548	5.7848	0.5417	0.98	1	2258	0.02	0.901
P200	5.876	0.447	5.3136	0.4396	1.11	1	2252	0.81	0.370
N200	3.260	0.364	3.3685	0.3588	0.97	1	2266	0.05	0.832
P300	10.962	0.763	11.0078	0.7487	1.00	1	2268	0.00	0.966

Table 28, shows the gain/loss ratios (amplitudes) for the interaction between Risk, FrontBack, and GainLoss. A significant difference at 1% level was found at that P300, $F_{(2, 2268)}$ =

6.28, p = 0.0019, and the N200, $F_{(2, 2266)} = 4.71$, p = 0.0091. P100 was also significant at 0.003 level, $F_{(2, 2270)} = 3.52$, p = 0.0299. Appendix M displays the amplitudes means, ratios, and LMM analysis categorized by sets of electrodes for the RA and RS. Tables O1 for the front electrodes, O2 for middle electrodes, and O3 for the back electrodes.

Table 28

Experiment 5: Gain/Loss ratios- Amplitudes - for RA and RS Segmented by Location of Electrodes

Components	Gain/Loss Ratios						Type 3 Tests of Fixed Effects			
	Risk Averse			Risk Seekers			Risk Effect			
	Front	Middle	Back	Front	Middle	Back	df_{Num}	df_{Den}	F Value	$p > F$
P100	1.73	2.41	1.71	2.12	1.95	2.17	2	2270	3.52	0.029
N100	1.56	1.82	1.48	1.71	2.21	1.87	2	2258	1.99	0.136
P200	1.69	1.65	2.21	2.01	2.07	2.14	2	2252	1.55	0.212
N200	1.97	2.04	1.86	2.37	2.09	3.54	2	2266	4.71	0.009
P300	2.13	1.97	1.72	2.07	1.88	2.22	2	2268	6.28	0.002
Mean	1.81	1.98	1.8	1.06	2.04	2.39				

Table 29 supplements the information of table 28 and displays the ratios of RA/RS. The ratio in the back set of electrodes is 0.53 in the N200 suggests that processes of attention, detection, and classification are more prevalent in risk seekers and the back electrodes (N2c) that is thought to reflect a sub process of classification tasks reacts to a loss that is more prominent for the risk seekers subjects.

Table 29

Experiment 5: Gain/Loss Ratios Comparing RA and RS Per Location of Electrodes and Their Correspondent T3TFE for the P300 Components

Components	Risk Averse / Risk Seeking Gain / Loss Ratios			Type 3 Tests of Fixed Effects Risk*Gain Loss*FrontBack Effect			
	Front	Middle	Back	df_{Num}	df_{Den}	F Value	$p > F$
P100	0.81	1.24	0.79	2	2270	3.52	0.0299
N100	0.91	0.82	0.79	2	2258	1.99	0.1363
P200	0.84	0.8	1.03	2	2252	1.55	0.2121
N200	0.83	0.98	0.53	2	2266	4.71	0.0091
P300	1.03	1.04	0.77	2	2268	6.28	0.0019

Hypothesis EEG4

When a gain or a loss message was displayed on the monitor screen, a distinctive sound accompanied each message. Sessions 1 to 7 included both the visual and auditory stimuli. In session 8, only the visual stimulus was present. I hypothesized that the amplitudes of the P300 components corresponding to gains and losses would be greater in session 7 than in session 8.

Table 30 includes the overall mean amplitudes and *SE*s of the gain and losses in each component for sessions 7 and 8. Though the Gain/Loss ratios were significantly different for all components between sessions 7 and 8 and they are significant different at 0.01 level, the predicted direction of effect did not appear for N100 nor P300. In addition, Table 30 displays the gain/loss ratio per component and the LMM analysis for the two sessions. Table P1 in Appendix P supplements Table 31 shows the mean amplitudes, *SE*s or all components that corresponds to the gain/loss ratios of Table 31.

Table 30

Experiment 5: Overall Mean Gain/Loss Ratios of Each Component for Sessions 7 and 8 and the Accompanying Fixed Effects Model

$df_{Num} = 6; df_{Den} = 2349$

Components	Gain/Loss Ratios		Type 3 Tests of Fixed Effects Gain-Loss Effect	
	Session 7	Session 8	*F* Value	$p > F$
P100	2.98	1.72	51.16	<.0001
N100	1.99	2.07	70.14	<.0001
P200	2.40	1.85	46.76	<.0001
N200	2.28	1.84	13.92	0.0033
P300	2.03	2.13	108.22	<.0001
Mean	2.34	1.92		

The ratios that appear in Table 31 were calculated by dividing the gain/loss ratios for amplitude in session 7 by those in session 8 for the three sets of electrodes (front, middle, and back). Tables P2, P3, and P4 display the amplitudes and ratios that were summarized in table 32. A significant difference was found for the P300 interaction GainLoss*FrontBack*Session ($p < 0.02$). The overall mean Gain/Loss ratio difference for the P300 component was substantially lower for the Back electrodes than for the other two locations. This finding suggests that the absence of the auditory stimulus in session 8 caused a redistribution of the amplitudes, increasing the amplitudes for the Back signals and reducing those of the Front and Middle.

Table 31

Experiment 5: Overall Mean Differences between Gain/Loss Ratios of Amplitude in Sessions 7 and 8 by Electrode Location and the Accompanying Fixed Effects Analysis

Components	Session 7 and 8 Differences Gain/Loss Ratios			Type 3 Tests of Fixed Effects GainLoss*FrontBack*Session			
	Front	Middle	Back	df_{Num}	df_{Den}	*F Value*	$p > F$
P100	2.01	1.43	1.76	2	528	0.77	0.4646
N100	0.78	1.19	0.97	2	525	0.73	0.4815
P200	1.41	0.78	1.82	2	522	3.18	0.0425
N200	1.28	1.1	1.32	2	525	0.11	0.9002
P300	1.19	1.21	0.65	2	529	4.39	0.0129

Table 32 shows the overall mean Gain/Loss ratios of latencies in those sessions and the SMM analysis. There were no significant results. Table P5 in Appendix P supplements Table 32 with the correspondent latencies means and *SE*s.

Table 32

Experiment 5: Overall Means of Gain/Loss Ratios of Latencies Per Component in Sessions 7 and 8 and the Accompanying Fixed Effects Analysis

Components	Gain/Loss Ratio		Type 3 Tests of Fixed Effects Gain-Loss Effect			
	Session 7	Session 8	df_{Num}	df_{Den}	*F* Value	$p > F$
N50	1.15	0.96	1	545	3.48	0.0627
P100	1.06	0.97	1	545	1.62	0.203
N100	1.07	0.98	1	544	2.11	0.1469
P200	1.01	1.02	1	544	0.03	0.8559
N200	1.04	1.04	1	544	0.02	0.8798
P300	1.01	1.04	1	544	0.68	0.4084
Mean	1.06	1.00				

Hypothesis EEG5

The event that triggered the ERP, including the P300 component, was the 1-s gain or loss message displayed on the monitor screen. Immediately following the offset of the message, a blinking button appeared at the bottom of the screen, indicating that the game could be resumed. To do so, participants moved the cursor to the button and clicked. The resumption of the game was accompanied by a distinctive ERP component that appeared similar to the original P300 component, enough so that I labeled it 2P300. It appears approximately 1300 msec following the onset of the gain or loss message. Preceding it were components corresponding to the original P300's precursors Table 33 displays the overall mean amplitude of the gains and losses and gain/loss ratios for these components and the results of the LMM analysis. Note that the gain/loss ratios were nearly identical to those of the earlier-occurring components all of which were also significant ($p < 0.0001$).

Table 33

Experiment 5: Mean Overall Gain/ Loss Ratios and Results of the Accompanying Fixed Effects Analysis for the Later-developing ERP Components,
dfNum = 1; dfDen = 14

Components	Amplitude (µv) Gain *M*	Gain *SE*	Loss *M*	Loss *SE*	Gain/Loss Ratio	Type 3 Tests of Fixed Effects GainLoss Effect *F* Value	$p > F$
P100	2.518	0.3	4.777	0.3	1.9	39.49	<.0001
N100	4.428	0.42	7.792	0.42	1.76	41.57	<.0001
P200	4.187	0.41	7.892	0.41	1.88	64.44	<.0001
N200	1.536	0.14	3.298	0.14	2.15	115.22	<.0001
P300	7.274	0.51	13.249	0.51	1.82	101.3	<.0001

Table 34 displays the overall mean latencies of the second set of components for gains and losses and the accompanying LMM analysis. Note that, like the latencies of the earlier-occurring components (see Table 23), none of gain-loss differences for the later-occurring components were significant. The latencies of the later-occurring components (2P300 waveform) are twice the value of the first P300 waveform.

Table 34

Experiment 5 Mean Overall Latencies (msec) for Gains and Losses of the Later-Occurring Components and the Accompanying Fixed Effects Analysis.

$df_{Num} = 1; df_{Den} = 14$

Components	Latencies				Type 3 Tests of Fixed Effects GainLoss Effect	
	Gain		Loss		*F*	
	M	*SE*	*M*	*SE*	Value	$p > F$
N50	879.92	15.1149	875.53	15.1149	0.69	0.4209
P100	958.98	15.4058	954.68	15.4058	0.13	0.7194
N100	1047.6	15.7639	1034.69	15.7639	0.12	0.7381
P200	915.95	21.5283	923.37	21.5283	0.02	0.8949
N200	963.05	22.1205	971.11	22.1205	1.66	0.2188
P300	1307.35	23.9916	1304.09	23.9916	1.85	0.1949

Response time

An exploratory analysis of the response time (only in electrode O1) showed that the brain response to a gain took 1512 msec as an average after the message was displayed on the screen. However, it took 1665 msec when the stimulus was a loss. The response time to losses was delayed 10% more than the response to gains. Indicating the possibility (to be confirmed in a future study) that the brain uses more resources to process a loss than a gain.

Discussion

The behavior-analytic gain/loss ratios in experiment 5 were higher (3.40) than those in the previous experiments (overall mean = 1.92). A similar differential, the electrophysiological gain/loss ratios were also larger in experiment 5 (3.40 versus 1.99).

Considering that the experiments shared the SubSearch game, it is reasonable to conclude that there were other factors that influenced the value of the behavioral ratio in experiment 5. The primary difference was the use of the Emotive Epoc device to record the EEG. That its use required additional preparation and possibly imposed discomfort during the sessions (as, for instance, asking participants to avoid unnecessary movements so as to prevent the loss of the Bluetooth interconnectivity or to reduce noise in the EEG) might have influenced the results.

APPENDIX K

Table K1

Experiment 5: Type III Tests of Fixed Effects. Behavioral Measures Gain/loss , Risk (Risk Averse and Risk Seeking), and sessions (1 – 7)

Source	df_{Num}	df_{Den}	F	p
Intercept	1	583	483.644	0.000
GainLoss	1	583	378.703	0.000
RiskCat	1	583	0.100	0.751
SessionNum	6	583	2.043	0.058
Log R_L/R_R	1	583	8.371	0.004
GainLoss * RiskCat	1	583	0.778	0.378
GainLoss * SessionNum	6	583	1.168	0.322
GainLoss * Log R_L/R_R	1	583	3.553	0.060
RiskCat * SessionNum	6	583	1.839	0.089
RiskCat * Log R_L/R_R	1	583	0.759	0.384
SessionNum * Log R_L/R_R	6	583	0.499	0.809
GainLoss * RiskCat * SessionNum	6	583	10.302	0.254
GainLoss * RiskCat Log R_L/R_R	1	583	0.010	0.921
GainLoss * SessionNum * Log R_L/R_R	6	583	.099	.997
RiskCat * SessionNum * Log R_L/R_R	6	583	.540	.778
GainLoss * RiskCat * SessionNum * Log R_L/R_R	6	583	.634	.703

Note: Dependent Variable: Log C_L/C_R.

Table K2

Experiment 5: No Punished Schedules Mean Responses, Obtained Reinforcers, Punishers, and Switches for the Punished Alternative (Sessions 1 to 7)

ID	Risk Score		Clicks Left	Clicks Right	Payoff Left	Payoff Right	Penalty Left	Penalty Right	Switches Left	Switches Right
1	43	*M*	338.4	394.8	7.4	8.0	0.0	0.0	4.7	4.3
		SD	73.2	74.2	4.7	4.3	0.0	0.0	1.3	1.4
2	40	*M*	500.9	472.2	8.3	8.7	0.0	0.0	6.5	6.4
		SD	130.2	115.3	4.1	5.5	0.0	0.0	1.8	1.7
3	37	*M*	354.4	330.3	7.4	7.3	0.0	0.0	4.0	4.0
		SD	163.5	191.8	4.5	5.0	0.0	0.0	1.5	1.6
4	45	*M*	583.6	589.9	9.1	9.8	0.0	0.0	14.1	14.0
		SD	178.0	125.2	3.4	3.7	0.0	0.0	6.1	6.0
5	42	*M*	219.2	315.7	5.8	6.2	0.0	0.0	3.6	3.4
		SD	80.5	106.3	3.5	4.2	0.0	0.0	1.5	1.6
6	42	*M*	313.1	265.6	10.0	8.8	0.0	0.0	7.3	7.2
		SD	92.8	88.4	6.2	4.2	0.0	0.0	2.5	2.6
7	47	*M*	659.6	650.3	9.1	7.4	0.0	0.0	8.1	7.8
		SD	86.5	69.6	4.1	3.5	0.0	0.0	1.8	1.9
8	43	*M*	396.4	477.5	6.6	8.4	0.0	0.0	7.2	7.0
		SD	166.3	174.7	3.7	4.1	0.0	0.0	2.8	2.6
9	37	*M*	669.1	640.1	10.4	10.9	0.0	0.0	12.9	12.7
		SD	138.7	115.7	5.7	4.8	0.0	0.0	2.3	2.5
10	42	*M*	478.7	775.1	8.7	8.7	0.0	0.0	9.6	9.7
		SD	195.3	231.5	4.2	4.1	0.0	0.0	3.9	3.6
11	38	*M*	568.6	447.9	10.1	9.6	0.0	0.0	9.6	9.5
		SD	191.6	127.9	5.3	5.0	0.0	0.0	2.8	2.7
12	35	*M*	539.1	703.0	7.8	8.5	0.0	0.0	6.7	6.6
		SD	202.1	202.1	4.8	4.8	0.0	0.0	2.3	2.1
13	50	*M*	499.1	504.8	9.5	7.5	0.0	0.0	6.9	6.6
		SD	150.6	160.8	5.3	4.0	0.0	0.0	1.9	2.0
14	38	*M*	290.7	319.5	7.1	8.4	0.0	0.0	7.2	7.0
		SD	83.4	112.1	3.5	4.3	0.0	0.0	1.8	1.7
15	40	*M*	326.9	354.4	9.6	9.3	0.0	0.0	8.1	8.0
		SD	121.1	97.0	5.8	4.7	0.0	0.0	1.5	1.8
16	42	*M*	346.8	295.9	6.3	6.9	0.0	0.0	4.0	3.9
		SD	162.3	68.9	4.4	3.5	0.0	0.0	1.4	1.5

Table K3

Experiment 5: Punished Schedules Mean Responses, Obtained Reinforcers, Punishers, and Switches for the Punished Alternative (Sessions 1 to 7)

ID	RiskScore		Clicks Left	Clicks Right	Payoff Left	Payoff Right	Penalty Left	Penalty Right	Switches Left	Switches Right
1	43	*M*	115.9	502.0	4.2	4.7	4.7	0.0	3.7	4.1
		SD	47.7	94.0	2.9	4.0	3.0	0.0	1.4	1.4
2	40	*M*	218.3	740.0	5.2	6.0	5.9	0.0	5.0	5.3
		SD	169.1	232.7	3.9	5.1	4.3	0.0	2.4	2.2
3	37	*M*	130.9	494.8	3.3	4.8	5.4	0.0	3.7	3.8
		SD	104.4	178.6	3.3	4.5	3.7	0.0	1.6	1.3
4	45	*M*	288.2	734.4	6.6	7.9	8.4	0.0	10.0	10.2
		SD	177.4	158.3	4.9	4.9	4.7	0.0	4.4	4.3
5	42	*M*	152.1	368.9	6.2	5.8	8.7	0.0	4.0	4.0
		SD	53.5	50.1	3.9	3.7	3.2	0.0	1.7	1.5
6	42	*M*	143.8	555.7	5.3	7.1	7.0	0.0	6.7	6.9
		SD	77.9	148.2	2.8	3.9	3.3	0.0	2.1	2.2
7	47	*M*	230.8	1053.1	4.0	7.3	4.6	0.0	5.8	6.3
		SD	181.9	227.3	2.2	6.1	2.3	0.0	2.7	2.8
8	43	*M*	197.3	525.1	6.8	7.0	8.4	0.0	6.7	6.9
		SD	79.7	150.8	3.7	6.1	3.4	0.0	4.4	4.4
9	37	*M*	218.3	1023.3	7.9	9.7	6.9	0.0	10.0	10.3
		SD	120.8	177.0	2.3	5.8	2.6	0.0	1.9	2.1
10	42	*M*	328.5	874.8	6.9	8.8	8.7	0.0	9.2	9.2
		SD	160.8	171.1	3.4	4.7	3.9	0.0	3.2	3.0
11	38	*M*	209.6	769.8	3.7	5.3	4.7	0.0	5.4	5.7
		SD	201.8	264.4	3.5	5.7	4.2	0.0	2.8	2.7
12	35	*M*	305.6	915.2	6.0	5.8	8.4	0.0	8.7	8.9
		SD	187.3	219.0	2.6	3.9	2.2	0.0	3.5	3.8
13	50	*M*	204.1	747.3	6.4	7.9	7.2	0.0	7.7	7.9
		SD	113.2	225.6	4.1	5.0	3.4	0.0	2.4	2.5
14	38	*M*	104.6	470.9	6.1	6.8	6.8	0.0	7.2	7.5
		SD	70.6	91.6	4.0	4.5	3.6	0.0	2.9	2.7
15	40	*M*	124.9	516.7	7.9	9.2	8.9	0.0	9.3	9.2
		SD	36.6	161.8	3.1	6.5	3.1	0.0	3.0	2.9
16	42	*M*	171.8	383.7	5.4	6.8	7.4	0.0	4.0	4.2
		SD	125.4	103.4	3.2	6.0	3.1	0.0	1.9	2.0

Note: Dependent Variable: Log C_L/C_R.

Table K4

Experiment 5: Individual Gain/Loss Ratios (Sessions 1 - 7)

ID	No Punishment				Punishment				Gain/ Loss Ratio
	Slope c	Intercept Log (k)	R^2	Antilog (k)	Slope c	Intercept Log (k)	R^2	Antilog (k)	
1	0.122	-0.061	0.206	0.868	0.231	-0.644	0.230	0.227	3.83
2	0.212	0.022	0.420	1.053	-0.199	-0.507	0.048	0.311	3.38
3	0.489	0.006	0.519	1.014	0.215	-0.591	0.049	0.256	3.95
4	0.068	-0.020	0.008	0.954	0.317	-0.381	0.195	0.416	2.30
5	0.190	-0.117	0.114	0.764	0.009	-0.402	0.001	0.396	1.93
6	0.321	0.069	0.624	1.172	-0.180	-0.655	0.042	0.221	5.30
7	-0.026	0.007	0.014	1.017	-0.267	-0.741	0.121	0.182	5.60
8	0.160	-0.105	0.101	0.785	-0.035	-0.452	0.004	0.353	2.22
9	0.198	0.025	0.315	1.059	0.034	-0.717	0.002	0.192	5.52
10	-0.029	-0.240	0.001	0.575	-0.026	-0.480	0.001	0.331	1.74
11	0.313	0.088	0.535	1.224	-0.083	-0.885	0.003	0.130	9.40
12	-0.147	-0.156	0.050	0.698	-0.121	-0.526	0.021	0.298	2.34
13	0.160	-0.015	0.400	0.967	0.046	-0.610	0.006	0.246	3.94
14	-0.155	-0.054	0.089	0.882	0.187	-0.691	0.090	0.204	4.33
15	0.224	-0.049	0.439	0.894	0.059	-0.616	0.020	0.242	3.69
16	0.103	0.052	0.074	1.128	0.163	-0.408	0.130	0.391	2.89

Table K5

Experiment 5: Behavioral Measures Sessions 1 To 7. Calculation of the Overall Ratio. Unpunished and Punished Conditions, Means, SEs, CI, Antilog(s), and Gain/Loss Ratio

No Punishment					Punishment						
M	*SE*	95% CI			*M*	*SE*	95% CI			*df*	Gain/Loss
		Lower Bound	Upper Bound	Antilog			Lower Bound	Upper Bound	Antilog		Ratio
-0.041	.019	-.078	-.004	0.91	-0.572	.020	-.611	-.533	0.27	583	3.40

Note: Dependent Variable: Log CL / CR.
Covariates appearing in the model are evaluated at the following values: Log RL / RR = -.0422.

Table K6

Experiment 5: Behavioral Measures Sessions 1 to 7. Risk Averse versus Risk Seeking for the Unpunished and Punished Conditions Means, SEs, CI, Antilog(s) and Gain/Loss Ratio

	No Punishment					Punishment						
Risk	*M*	*SE*	95% CI		Antilog	*M*	*SE*	95% CI		Antilog	*df*	Gain/Loss
			Lower Bound	Upper Bound				Lower Bound	Upper Bound			Ratio
RA	-0.034	0.021	-0.075	0.007	0.92	-0.59	0.021	-0.632	-0.548	0.26	583	3.60
RS	-0.048	0.031	-0.109	0.014	0.9	-0.554	0.034	-0.62	-0.488	0.28	583	3.21

Note: Dependent Variable: Log CL / CR.
Covariates appearing in the model are evaluated at the following values: Log RL / RR = -.0422.

Table K7

Experiment 5: Behavioral Measures Sessions 1 to 7. GainLoss Ratios per Session - Means, SEs, CI, Antilog(s), and Gain/Loss Ratio

Session	No Punishment					Punishment					*df*	Gain/Loss Ratio
	M	*SE*	95% CI			*M*	*SE*	95% CI				
			Lower Bound	Upper Bound	Antilog			Lower Bound	Upper Bound	Antilog		
1	0.03	0.050	-0.068	0.128	1.07	-0.465	0.051	-0.564	-0.365	0.34	583	3.13
2	-0.071	0.049	-0.168	0.025	0.85	-0.5	0.052	-0.601	-0.398	0.32	583	2.69
3	-0.072	0.050	-0.171	0.026	0.85	-0.697	0.059	-0.812	-0.582	0.20	583	4.22
4	-0.05	0.047	-0.143	0.043	0.89	-0.65	0.051	-0.751	-0.550	0.22	583	3.98
5	-0.055	0.050	-0.154	0.043	0.88	-0.495	0.051	-0.595	-0.395	0.32	583	2.75
6	-0.027	0.049	-0.123	0.068	0.94	-0.619	0.050	-0.717	-0.520	0.24	583	3.91
7	-0.04	0.053	-0.145	0.065	0.91	-0.579	0.055	-0.687	-0.470	0.26	583	3.46

Note: Dependent Variable: Log C_L / C_R.

Covariates appearing in the model are evaluated at the following values: Log R_L / R_R. = -.0422.

Table K8

Experiment 5: Behavioral Measures Sessions 1 to 7. Session and Risk Comparison - Means, SEs, CI, Antilog(s), and Gain/Loss Ratio

Session		No Punishment					Punishment						
		M	*SE*	95% CI			*M*	*SE*	95% CI			*df*	Gain/Loss
				Lower Bound	Upper Bound	Antilog			Lower Bound	Upper Bound	Antilog		Ratio
Risk	1	0.027	0.055	-0.081	0.134	1.06	-0.345	0.055	-0.453	-0.237	0.45	583	2.36
Averse	2	-0.036	0.056	-0.146	0.075	0.92	-0.446	0.055	-0.554	-0.338	0.36	583	2.57
	3	-0.02	0.054	-0.127	0.086	0.95	-0.721	0.057	-0.834	-0.609	0.19	583	5.02
	4	-0.084	0.054	-0.191	0.023	0.82	-0.681	0.059	-0.796	-0.566	0.21	583	3.95
	5	-0.039	0.054	-0.146	0.068	0.91	-0.532	0.057	-0.644	-0.420	0.29	583	3.11
	6	-0.029	0.054	-0.135	0.077	0.94	-0.652	0.055	-0.761	-0.543	0.22	583	4.20
	7	-0.056	0.055	-0.165	0.053	0.88	-0.751	0.058	-0.865	-0.636	0.18	583	4.95
Risk	1	0.033	0.083	-0.131	0.197	1.08	-0.584	0.085	-0.750	-0.418	0.26	583	4.14
Seeker	2	-0.107	0.080	-0.265	0.051	0.78	-0.553	0.088	-0.726	-0.381	0.28	583	2.79
	3	-0.124	0.085	-0.290	0.042	0.75	-0.673	0.102	-0.874	-0.471	0.21	583	3.54
	4	-0.015	0.078	-0.168	0.137	0.97	-0.62	0.084	-0.784	-0.456	0.24	583	4.03
	5	-0.071	0.084	-0.237	0.094	0.85	-0.458	0.084	-0.623	-0.293	0.35	583	2.44
	6	-0.026	0.081	-0.184	0.133	0.94	-0.585	0.083	-0.749	-0.422	0.26	583	3.62
	7	-0.024	0.091	-0.203	0.155	0.95	-0.407	0.094	-0.591	-0.222	0.39	583	2.42

Note: Dependent Variable: Log C_L / C_R

Covariates appearing in the model are evaluated at the following values: Log. R_L / R_R = -.0422.

APPENDIX L

Table L1

Experiment 5: Behavioral Measures Sessions 7 and 8. Type III Tests of Fixed Effects

$df_{Num} = 1; df_{Den} = 151$

Source	*F*	*p*
Intercept	129.614	0.000
GainLoss	106.207	0.000
SessionNum	2.301	0.131
Log R_L / R_R	3.542	0.062
GainLoss * SessionNum	1.151	0.285
GainLoss * Log R_L / R_R	1.519	0.220
SessionNum * Log R_L / R_R	0.259	0.611
GainLoss * SessionNum * Log R_L / R_R	0.411	0.522

Note: Dependent Variable: Log C_L / C_R

Table L2

Experiment 5: No Punished Schedules Mean Responses, Obtained Reinforcers, Punishers, and Switches for the Punished Alternative (Session 7)

ID	Risk Score		Clicks Left	Clicks Right	Payoff Left	Payoff Right	Penalty Left	Penalty Right	Switches Left	Switches Right
1	43	*M*	348.0	362.0	10.3	7.7	0.0	0.0	5.0	4.3
		SD	128.1	48.5	6.7	5.5	0.0	0.0	1.0	0.6
2	40	*M*	469.3	490.7	9.7	7.7	0.0	0.0	6.3	6.0
		SD	49.6	40.4	2.9	6.5	0.0	0.0	1.0	0.9
3	37	*M*	326.7	317.7	9.7	7.7	0.0	0.0	4.7	4.3
		SD	131.5	106.5	4.7	6.0	0.0	0.0	1.2	2.3
4	45	*M*	624.7	617.0	10.3	7.3	0.0	0.0	9.3	9.0
		SD	111.5	68.6	4.0	3.2	0.0	0.0	1.2	1.0
5	42	*M*	283.7	241.3	8.0	4.7	0.0	0.0	4.7	4.3
		SD	8.5	37.9	7.8	1.5	0.0	0.0	0.6	1.2
7	47	*M*	626.7	613.7	9.3	9.3	0.0	0.0	8.0	7.3
		SD	19.1	59.6	6.0	4.9	0.0	0.0	1.0	1.5
8	43	*M*	499.3	521.3	7.3	8.3	0.0	0.0	8.7	8.3
		SD	91.5	66.3	5.1	6.7	0.0	0.0	2.5	2.9
9	37	*M*	656.7	655.0	12.3	10.7	0.0	0.0	14.0	14.7
		SD	239.9	216.4	7.4	7.6	0.0	0.0	1.7	2.1
10	42	*M*	387.7	890.3	8.0	9.0	0.0	0.0	13.0	13.3
		SD	180.8	180.6	4.4	5.2	0.0	0.0	6.6	5.7
11	38	*M*	442.3	476.3	8.7	11.0	0.0	0.0	11.7	11.7
		SD	206.5	109.8	3.5	6.6	0.0	0.0	2.5	1.5
12	35	*M*	501.7	778.7	8.0	9.3	0.0	0.0	6.3	6.0
		SD	136.7	95.6	2.6	7.8	0.0	0.0	0.6	1.0
14	38	*M*	287.7	253.0	6.7	9.7	0.0	0.0	8.3	8.0
		SD	32.1	13.7	3.1	4.5	0.0	0.0	1.5	2.0
15	40	*M*	398.7	415.3	10.7	8.0	0.0	0.0	8.0	8.0
		SD	114.7	148.0	10.8	6.6	0.0	0.0	2.0	3.0
16	42	*M*	349.3	256.0	7.0	6.7	0.0	0.0	5.3	5.3
		SD	45.0	17.1	2.6	2.1	0.0	0.0	0.6	1.2

Table L3

Experiment 5: Punished Schedules Mean Responses, Obtained Reinforcers, Punishers, and Switches for the Punished Alternative (Session 7)

ID	Risk Score		Clicks Left	Clicks Right	Payoff Left	Payoff Right	Penalty Left	Penalty Right	Switches Left	Switches Right
1	43	*M*	138.7	330.7	4.3	3.7	4.0	0.0	4.0	4.0
		SD	22.0	30.0	2.1	3.5	2.6	0.0	0.0	1.0
2	40	*M*	225.3	654.7	7.0	5.7	9.0	0.0	6.7	6.3
		SD	58.5	28.4	2.4	3.1	2.4	0.0	2.3	2.3
3	37	*M*	179.7	474.0	4.7	7.3	7.3	0.0	4.0	5.0
		SD	97.3	60.8	2.1	4.5	3.1	0.0	1.0	1.0
4	45	*M*	183.3	772.7	3.7	11.3	5.0	0.0	8.7	9.3
		SD	135.4	120.6	2.1	9.0	3.5	0.0	6.0	6.1
5	42	*M*	232.0	225.0	8.7	3.7	10.3	0.0	4.0	4.3
		SD	64.4	60.9	4.2	1.5	5.8	0.0	1.0	0.6
7	47	*M*	1.3	1374.3	0.0	3.3	0.0	0.0	0.3	0.7
		SD	2.3	26.8	0.0	5.8	0.0	0.0	0.6	0.6
9	37	*M*	101.3	1168.3	7.0	10.0	4.7	0.0	7.7	8.0
		SD	54.2	82.8	3.6	9.2	2.5	0.0	3.2	3.6
10	42	*M*	291.7	1024.0	7.0	10.3	8.0	0.0	14.3	14.7
		SD	76.5	88.1	2.6	7.6	2.0	0.0	4.2	4.7
11	38	*M*	541.3	717.3	8.3	8.3	10.3	0.0	9.0	9.0
		SD	167.3	244.8	6.0	4.5	7.5	0.0	2.6	2.6
12	35	*M*	241.0	892.3	7.0	5.7	9.0	0.0	12.3	12.7
		SD	126.6	167.0	1.0	4.6	1.7	0.0	1.5	1.5
14	38	*M*	177.7	386.3	8.7	7.0	11.0	0.0	8.0	8.3
		SD	45.3	93.2	4.0	4.6	3.6	0.0	1.0	0.6
15	40	*M*	111.3	689.7	8.7	6.3	8.3	0.0	11.7	12.3
		SD	26.5	165.7	1.2	5.5	1.2	0.0	0.6	0.6

Table L4

Experiment 5: No Punished Schedules Mean Responses, Obtained Reinforcers, Punishers, and Switches for the Punished Alternative (Session 8)

ID	Risk Score		Clicks Left	Clicks Right	Payoff Left	Payoff Right	Penalty Left	Penalty Right	Switches Left	Switches Right
1	43	*M*	422.3	304.3	7.3	6.0	0.0	0.0	3.0	3.3
		SD	149.9	143.5	5.1	1.0	0.0	0.0	1.0	1.2
2	40	*M*	570.7	389.0	10.3	7.7	0.0	0.0	10.7	10.7
		SD	69.5	100.2	7.2	4.0	0.0	0.0	1.4	1.9
3	37	*M*	348.3	365.7	9.0	9.7	0.0	0.0	5.7	4.7
		SD	76.3	117.6	6.2	9.0	0.0	0.0	2.1	2.1
4	45	*M*	545.7	561.3	10.0	9.7	0.0	0.0	8.3	8.0
		SD	110.3	51.4	6.2	5.0	0.0	0.0	1.5	1.0
5	42	*M*	165.3	345.0	5.0	8.3	0.0	0.0	4.0	4.0
		SD	17.1	22.1	3.0	4.2	0.0	0.0	1.0	1.0
7	47	*M*	639.3	623.0	10.3	10.0	0.0	0.0	7.7	7.3
		SD	1.5	21.0	9.0	9.5	0.0	0.0	1.2	1.5
9	37	*M*	612.7	712.3	12.3	10.0	0.0	0.0	12.0	12.0
		SD	241.7	300.0	6.0	7.0	0.0	0.0	0.0	1.0
10	42	*M*	419.7	998.7	8.7	10.7	0.0	0.0	11.3	11.3
		SD	206.8	234.1	5.7	6.1	0.0	0.0	4.9	4.9
11	38	*M*	635.0	670.0	9.0	11.0	0.0	0.0	7.7	7.7
		SD	265.5	217.6	8.7	8.5	0.0	0.0	0.6	0.6
12	35	*M*	555.3	638.3	8.3	8.7	0.0	0.0	8.0	7.7
		SD	105.2	51.4	6.7	5.0	0.0	0.0	0.0	0.6
14	38	*M*	348.7	226.7	9.3	8.0	0.0	0.0	6.3	6.3
		SD	165.2	41.2	4.9	3.5	0.0	0.0	0.6	0.6
15	40	*M*	432.0	418.3	11.7	7.3	0.0	0.0	9.3	8.7
		SD	58.6	49.2	9.0	6.5	0.0	0.0	2.3	2.9

Table L5

Experiment 5: Punished Schedules Mean Responses, Obtained Reinforcers, Punishers, and Switches for the Punished Alternative

ID	Risk Score		Clicks Left	Clicks Right	Payoff Left	Payoff Right	Penalty Left	Penalty Right	Switches Left	Switches Right
1	43	*M*	138.7	330.7	4.3	3.7	4.0	0.0	4.0	4.0
		SD	22.0	30.0	2.1	3.5	2.6	0.0	0.0	1.0
2	40	*M*	225.3	654.7	7.0	5.7	9.0	0.0	6.7	6.3
		SD	58.5	28.4	2.4	3.1	2.4	0.0	2.3	2.3
3	37	*M*	179.7	474.0	4.7	7.3	7.3	0.0	4.0	5.0
		SD	97.3	60.8	2.1	4.5	3.1	0.0	1.0	1.0
4	45	*M*	183.3	772.7	3.7	11.3	5.0	0.0	8.7	9.3
		SD	135.4	120.6	2.1	9.0	3.5	0.0	6.0	6.1
5	42	*M*	232.0	225.0	8.7	3.7	10.3	0.0	4.0	4.3
		SD	64.4	60.9	4.2	1.5	5.8	0.0	1.0	0.6
7	47	*M*	1.3	1374.3	0.0	3.3	0.0	0.0	0.3	0.7
		SD	2.3	26.8	0.0	5.8	0.0	0.0	0.6	0.6
9	37	*M*	101.3	1168.3	7.0	10.0	4.7	0.0	7.7	8.0
		SD	54.2	82.8	3.6	9.2	2.5	0.0	3.2	3.6
10	42	*M*	291.7	1024.0	7.0	10.3	8.0	0.0	14.3	14.7
		SD	76.5	88.1	2.6	7.6	2.0	0.0	4.2	4.7
11	38	*M*	541.3	717.3	8.3	8.3	10.3	0.0	9.0	9.0
		SD	167.3	244.8	6.0	4.5	7.5	0.0	2.6	2.6
12	35	*M*	241.0	892.3	7.0	5.7	9.0	0.0	12.3	12.7
		SD	126.6	167.0	1.0	4.6	1.7	0.0	1.5	1.5
14	38	*M*	177.7	386.3	8.7	7.0	11.0	0.0	8.0	8.3
		SD	45.3	93.2	4.0	4.6	3.6	0.0	1.0	0.6
15	40	*M*	111.3	689.7	8.7	6.3	8.3	0.0	11.7	12.3
		SD	26.5	165.7	1.2	5.5	1.2	0.0	0.6	0.6

Table L6

Experiment 5: Individual Gain/Loss Ratios (Sessions 7)

ID	No Punishment				Punishment				Gain/Loss Ratio
	Slope C	Intercept Log (k)	R^2	Antilog (k)	Slope c	Intercept Log (k)	R^2	Antilog (k)	
1	0.341	-0.073	0.979	0.846	0.390	-0.589	1.000	0.257	3.29
2	-0.014	-0.017	0.012	0.961	-0.532	-0.605	0.500	0.248	3.87
3	0.496	-0.091	0.917	0.811					
4	0.341	-0.049	0.969	0.894	0.324	-0.152	0.735	0.705	1.27
5	0.144	0.057	0.961	1.140	-0.092	-0.439	0.879	0.364	3.13
7	-0.051	0.008	0.804	1.018	-0.814	-0.774	1.000	0.168	6.05
8	0.038	-0.020	0.372	0.956	-0.091	-0.280	0.697	0.524	1.82
9	0.462	-0.034	0.984	0.924	0.390	-0.980	0.966	0.105	8.82
10	-0.427	-0.393	0.693	0.404	-0.679	-0.441	0.481	0.362	1.12
11	0.613	-0.014	0.955	0.968	0.997	-1.639	1.000	0.023	42.19
12	-0.083	-0.197	0.056	0.636	-0.411	-0.659	1.000	0.219	2.90
14	-0.122	0.036	0.456	1.085	0.247	-0.710	0.940	0.195	5.57
15	0.172	-0.029	0.365	0.936	-0.193	-0.761	0.929	0.173	5.40
16	0.263	0.131	0.178	1.352	-0.196	-0.566	0.787	0.272	4.97

Note: Dependent Variable: Log C_L / C_R.

Table L7

Experiment 5: Individual Gain/Loss Ratios (Sessions 8)

ID	No Punishment				Punishment				Gain/Loss
	Slope c	Intercept Log (k)	R^2	Antilog (k)	Slope C	Intercept Log (k)	R^2	Antilog (k)	Ratio
1	0.371	0.163	0.345	1.46	0.080	-0.384	1.000	0.41	3.53
2	0.159	0.164	0.376	1.46	-0.232	-0.444	0.522	0.36	4.06
3	0.365	-0.019	0.986	0.96	-0.539	-0.558	0.364	0.28	3.46
4	0.129	-0.017	0.996	0.96	-1.103	-1.111	0.913	0.08	12.41
5	0.060	-0.305	0.199	0.50	0.0318	-0.102	0.261	0.79	0.63
7	0.008	0.011	0.554	1.03					
9	0.700	-0.146	0.981	0.71	0.401	-1.103	0.859	0.08	9.06
10	-0.203	-0.422	0.141	0.38	-0.244	-0.568	0.994	0.27	1.40
11	0.357	-0.005	1.000	0.99	0.442	-0.091	0.974	0.81	1.22
12	-0.010	-0.067	0.029	0.86	-0.730	-0.470	0.932	0.34	2.53
14	0.604	0.123	0.938	1.33	-0.211	-0.304	0.721	0.50	2.67
15	0.046	0.000	0.174	1.00	-0.299	-0.697	0.994	0.20	4.98

Note: Dependent Variable: Log C_L / C_R.

APPENDIX M

Table M1

Experiment 5: Component Mean Amplitudes, Gain/Loss Ratios, and LMM Analysis: Front Electrodes

Front Electrodes (Amplitudes)						Type 3 Tests of Fixed Effects GainLoss Effect			
Components	Gain		Loss		Gain / Loss Ratio	df_{Num}	df_{Den}	*F* Value	$p > F$
	M	*SE*	*M*	*SE*					
P100	1.8072	0.2716	3.4494	0.2711	1.91	2	28	30.49	<.0001
N100	3.1852	0.5933	5.1902	0.5934	1.63	2	28	27.74	<.0001
P200	3.5205	0.4876	6.4528	0.4866	1.83	2	28	14.42	<.0001
N200	1.5892	0.3788	3.4232	0.3786	2.15	2	28	15.16	<.0001
P300	6.5627	0.7464	13.7896	0.7464	2.10	2	28	16.68	<.0001

Table M2

Experiment 5: Component Mean Amplitudes, Gain/Loss Ratios, and LMM Analysis: Middle Electrodes

Middle Electrodes (Amplitudes)						Type 3 Tests of Fixed Effects GainLoss Effect			
Components	Gain		Loss		Gain / Loss Ratio	df_{Num}	df_{Den}	*F* Value	$p > F$
	M	*SE*	*M*	*SE*					
P100	1.6392	0.2707	3.5371	0.2709	2.16	2	28	30.49	<.0001
N100	3.2336	0.5924	6.4675	0.5924	2.00	2	28	27.74	<.0001
P200	3.3975	0.4859	6.2572	0.4865	1.84	2	28	14.42	<.0001
N200	2.1916	0.3783	4.5237	0.3781	2.06	2	28	15.16	<.0001
P300	6.992	0.7446	13.4478	0.7449	1.92	2	28	16.68	<.0001

Table M3

Experiment 5: Component Mean Amplitudes, Gain/Loss Ratios, and LMM Analysis: Back Electrodes

Back Electrodes (Amplitudes)						Type 3 Tests of Fixed Effects GainLoss Effect			
Components	Gain		Loss		Gain / Loss Ratio	df_{Num}	df_{Den}	*F* Value	$p > F$
	M	*SE*	*M*	*SE*					
P100	3.0387	0.271	5.8721	0.2708	1.93	2	28	30.49	<.0001
N100	6.1323	0.5925	10.2108	0.5931	1.67	2	28	27.74	<.0001
P200	4.3926	0.487	9.548	0.4867	2.17	2	28	14.42	<.0001
N200	2.3179	0.3787	5.8396	0.3788	2.52	2	28	15.16	<.0001
P300	8.4985	0.7458	16.619	0.7454	1.96	2	28	16.68	<.0001

APPENDIX N

Table N1

Experiment 5: Component Mean Amplitudes for Session 1 and 2

Component	Session 1 - Amplitudes					Session 2 – Amplitudes				
	Gain		Loss		Gain/Loss	Gain		Loss		Gain/Loss
	M	*SE*	*M*	*SE*	Ratio	*M*	*SE*	*M*	*SE*	Ratio
P100	2.331	0.345	3.554	0.344	1.53	2.032	0.345	4.049	0.345	1.99
N100	4.284	0.685	5.821	0.685	1.36	4.310	0.686	7.306	0.688	1.70
P200	3.684	0.634	6.035	0.630	1.64	4.040	0.633	7.051	0.632	1.75
N200	1.828	0.506	3.774	0.506	2.06	1.682	0.507	4.019	0.507	2.39
P300	8.076	1.114	13.316	1.114	1.65	6.593	1.117	14.304	1.116	2.17

Table N2

Experiment 5: Component Mean Amplitudes for Session 3 and 4

Component	Session 3 - Amplitudes					Session 4 – Amplitudes				
	Gain		Loss		Gain/Loss	Gain		Loss		Gain/Loss
	M	*SE*	*M*	*SE*	Ratio	*M*	*SE*	*M*	*SE*	Ratio
P100	2.536	0.351	4.171	0.349	1.64	2.567	0.357	4.337	0.356	1.69
N100	4.744	0.687	6.715	0.690	1.42	4.552	0.703	8.511	0.703	1.87
P200	4.197	0.634	7.888	0.638	1.88	3.683	0.655	7.776	0.654	2.11
N200	2.362	0.510	5.068	0.512	2.15	2.489	0.522	5.327	0.522	2.14
P300	7.736	1.116	16.591	1.119	2.14	7.407	1.151	15.671	1.151	2.12

Table N3

Experiment 5: Component Mean Amplitudes for Aession 5 and 6.

Component	Session 5 - Amplitudes					Session 6 – Amplitudes				
	Gain		Loss		Gain/Loss	Gain		Loss		Gain/Loss
	M	*SE*	*M*	*SE*	Ratio	*M*	*SE*	*M*	*SE*	Ratio
P100	1.895	0.348	4.374	0.346	2.31	2.248	0.356	5.144	0.358	2.29
N100	3.685	0.690	7.208	0.688	1.96	4.324	0.705	8.715	0.704	2.02
P200	3.595	0.633	7.667	0.634	2.13	4.036	0.652	8.009	0.649	1.98
N200	1.894	0.509	4.555	0.508	2.41	2.068	0.525	5.208	0.520	2.52
P300	7.863	1.121	13.720	1.118	1.74	6.926	1.149	14.826	1.148	2.14

Table N4

Experiment 5: Component Mean Amplitudes for Session 7

Component	Session 7 - Amplitudes				
	Gain		Loss		Gain/Loss
	M	*SE*	*M*	*SE*	Ratio
P100	1.525	0.385	4.374	0.386	2.87
N100	3.388	0.753	6.751	0.755	1.99
P200	3.157	0.705	7.511	0.706	2.38
N200	1.908	0.562	4.218	0.563	2.21
P300	6.857	1.244	13.904	1.245	2.03

Table N5

Experiment 5: Latencies and Latency Gain/Loss Ratio Session 1 and 2 and LMM Analysis

$df_{Num} = 6$, $df_{Den} = 2349$

Component	Session 1 - Latencies			LatRatio	Session 2 - Latencies			LatRatio		
	Gain	Loss	*SE*	Gain/Loss	Gain	Loss	*SE*	Gain/Loss	*F* Value	*p* > *F*
N50	84.514	115.24	6.577	0.73	101.97	99.286	6.577	1.03	4.23	0.0003
P100	122.19	151.29	5.456	0.81	137.41	141.81	5.456	0.97	3.81	0.0009
N100	172.32	196.17	5.952	0.88	186.36	193.44	5.952	0.96	2.43	0.0241
P200	208.95	237.83	7.139	0.88	225.26	235.68	7.139	0.96	1.72	0.112
N200	241.94	281.13	8.776	0.86	260.58	273.68	8.776	0.95	2.05	0.0564
P300	426.76	458.01	10.839	0.93	437.66	454.96	10.839	0.96	1.65	0.1298
Mean	209.45	239.95	7.46	0.85	224.87	233.14	7.46	0.97		

Table N6

Experiment 5: Latencies and Latency Gain/Loss Ratio Session 3 And 4 and LMM Analysis

$df_{Num} = 6$, $df_{Den} = 2349$

	Session 1 - Latencies			LatRatio	Session 2 - Latencies			LatRatio	Type 3 Tests of Fixed Effects GainLoss * Session	
Component	Gain	Loss	*SE*	Gain/Loss	Gain	Loss	*SE*	Gain/Loss	*F* Value	Pr > *F*
N50	84.514	115.24	6.577	0.73	101.97	99.286	6.577	1.03	4.23	0.0003
P100	122.19	151.29	5.456	0.81	137.41	141.81	5.456	0.97	3.81	0.0009
N100	172.32	196.17	5.952	0.88	186.36	193.44	5.952	0.96	2.43	0.0241
P200	208.95	237.83	7.139	0.88	225.26	235.68	7.139	0.96	1.72	0.112
N200	241.94	281.13	8.776	0.86	260.58	273.68	8.776	0.95	2.05	0.0564
P300	426.76	458.01	10.839	0.93	437.66	454.96	10.839	0.96	1.65	0.1298
Mean	209.45	239.95	7.46	0.85	224.87	233.14	7.46	0.97		

Table N7

Experiment 5: Latencies and Latency Gain/Loss Ratio Session 5 and 6 and LMM Analysis

dfNum = 6, dfDen = 2349

	Session 5 - Latencies			LatRatio	Session 6 - Latencies			LatRatio	Type 3 Tests of Fixed Effects GainLoss * Session	
Component	Gain	Loss	*SE*	Gain/Loss	Gain	Loss	*SE*	Gain/Loss	*F* Value	Pr > *F*
N50	106.37	107.22	6.577	0.99	108.76	99.771	6.757	1.09	4.23	0.0003
P100	143.11	148.19	5.456	0.97	146.96	143.12	5.615	1.03	3.81	0.0009
N100	190.02	197.15	5.952	0.96	195.67	196.08	6.109	1.00	2.43	0.0241
P200	232.91	245.04	7.139	0.95	236.33	232.05	7.343	1.02	1.72	0.112
N200	271.24	292.81	8.776	0.93	278.9	279.8	9.032	1.00	2.05	0.0564
P300	456.75	461.47	10.839	0.99	457.36	447.73	11.131	1.02	1.65	0.1298
Mean	233.4	241.98	7.46	0.96	237.33	233.09	7.66	1.03		

Table N8

Experiment 5: Latencies and Latency Gain/Loss Ratio Session 7 and LMM Analysis.

dfNum = 6, dfDen = 2349

	Session 7 - Latencies			LatRatio	Type 3 Tests of Fixed Effects GainLoss * Session	
Component	Gain	Loss	*SE*	Gain/Loss	*F* Value	*p*
N50	131.27	114.75	7.305	1.14	4.23	0.0003
P100	160.55	152.03	6.095	1.06	3.81	0.0009
N100	205.27	192.52	6.589	1.07	2.43	0.0241
P200	242.12	238.77	7.961	1.01	1.72	0.112
N200	285.09	274.18	9.809	1.04	2.05	0.0564
P300	453.35	447.6	12.017	1.01	1.65	0.1298
Mean	246.28	236.64	8.3	1.06		

APENDIX O

Table O1

Experiment 5: Component Mean Amplitudes, Gain/Loss Ratios, and LMM Analysis: Front Electrodes for RA and RS

Front Electrodes										
	Risk Averse					Risk Seeker				
Component	Gain		Loss		Gain / Loss	Gain		Loss		Gain / Loss
	M	*SE*	*M*	*SE*	ratio	*M*	*SE*	*M*	*SE*	ratio
P100	1.94	0.39	3.35	0.39	1.73	1.68	0.38	3.55	0.38	2.12
N100	3.33	0.84	5.19	0.84	1.56	3.04	0.84	5.19	0.83	1.71
P200	3.95	0.70	6.68	0.69	1.69	3.09	0.68	6.22	0.68	2.01
N200	1.71	0.54	3.37	0.54	1.97	1.47	0.53	3.48	0.53	2.37
P300	6.97	1.06	14.82	1.06	2.13	6.15	1.05	12.76	1.05	2.07

Table O2

Experiment 5: Component Mean Amplitudes, Gain/Loss Ratios, and LMM Analysis: Middle Electrodes for RA and RS

Middle Electrodes										
	Risk Averse					Risk Seeker				
Component	Gain		Loss		Gain / Loss	Gain		Loss		Gain / Loss
	M	*SE*	*M*	*SE*	ratio	*M*	*SE*	*M*	*SE*	Ratio
P100	1.49	0.39	3.59	0.39	2.41	1.79	0.38	3.48	0.38	1.95
N100	3.47	0.84	6.32	0.84	1.82	3.00	0.83	6.62	0.83	2.21
P200	3.71	0.69	6.12	0.69	1.65	3.09	0.68	6.39	0.68	2.07
N200	2.11	0.54	4.32	0.54	2.04	2.27	0.53	4.73	0.53	2.09
P300	6.60	1.06	12.99	1.06	1.97	7.38	1.04	13.90	1.05	1.88

Table O3

Experiment 5: Component Mean Amplitudes, Gain/Loss Ratios, and LMM Analysis: Back Electrodes for RA and RS

Back Electrodes										
	Risk Averse					Risk Seeker				
Component	Gain		Loss		Gain / Loss	Gain		Loss		Gain / Loss
	M	*SE*	*M*	*SE*	ratio	*M*	*SE*	*M*	*SE*	ratio
P100	3.17	0.39	5.43	0.39	1.71	2.91	0.38	6.32	0.38	2.17
N100	6.40	0.84	9.44	0.84	1.48	5.87	0.83	10.99	0.83	1.87
P200	4.61	0.70	10.18	0.70	2.21	4.17	0.68	8.92	0.68	2.14
N200	2.82	0.54	5.24	0.54	1.86	1.82	0.53	6.44	0.53	3.54
P300	8.97	1.06	15.42	1.06	1.72	8.03	1.05	17.82	1.05	2.22

APPENDIX P

Table P1

Experiment 5: Mean Amplitudes, SEs, and Gain/Loss Ratios for Sessions 7 and 8

Components	Session 7					Session 8				
	Gain		Loss		Gain/loss	Gain		Loss		Gain/loss
	M	SE	*M*	SE	Ratio	*M*	Gain/loss	*M*	SE	Ratio
P100	1.496	0.336	4.459	0.337	2.98	1.645	Gain/loss	2.829	0.339	1.72
N100	3.578	0.578	7.127	0.579	1.99	2.602	0.580	5.379	0.581	2.07
P200	3.248	0.565	7.804	0.566	2.40	2.532	0.569	4.689	0.568	1.85
N200	1.983	0.524	4.511	0.525	2.28	1.859	0.527	3.427	0.527	1.84
P300	7.063	0.681	14.308	0.683	2.03	5.837	0.696	12.438	0.689	2.13
Mean	3.474	0.537	7.642	0.538	2.33	2.895	0.593	5.753	0.541	1.922

Table P2

Experiment 5: Amplitudes for Gain and Loss Session 7 and 8 - Front Electrodes

Components	Session 7			Session 8			
	Gain *M*	Loss *M*	Gain/loss Ratio	Gain *M*	Loss *M*	Gain/loss Ratio	Ratio Diff.
P100	1.481	4.224	2.85	1.999	2.841	1.42	2.01
N100	3.407	5.079	1.49	2.202	4.215	1.91	0.78
P200	3.326	6.644	2.00	2.529	3.576	1.41	1.41
N200	1.389	3.076	2.21	1.408	2.441	1.73	1.28
P300	5.869	14.102	2.40	5.610	11.362	2.03	1.19

Table P3

Experiment 5: Amplitudes for Gain and Loss Session 7 and 8 - Middle Electrodes

Components	Session 7			Session 8			
	Gain *M*	Loss *M*	Gain/loss Ratio	Gain *M*	Loss *M*	Gain/loss Ratio	Ratio Diff.
P100	1.221	3.965	3.25	1.284	2.923	2.28	1.43
N100	2.592	7.004	2.70	2.282	5.179	2.27	1.19
P200	3.331	6.347	1.91	1.817	4.451	2.45	0.78
N200	2.309	5.060	2.19	1.649	3.274	1.98	1.10
P300	6.394	13.748	2.15	5.905	10.455	1.77	1.21

Table P4

Experiment 5: Amplitudes for Gain and Loss Session 7 and 8 - Back Electrodes

Components	Session 7			Session 8			
	Gain *M*	Loss *M*	Gain/loss Ratio	Gain *M*	Loss *M*	Gain/loss Ratio	Ratio Diff.
P100	1.787	5.190	2.90	1.654	2.723	1.65	1.76
N100	4.735	9.298	1.96	3.322	6.744	2.03	0.97
P200	3.087	10.421	3.38	3.249	6.038	1.86	1.82
N200	2.251	5.397	2.40	2.520	4.568	1.81	1.32
P300	8.926	15.073	1.69	5.995	15.498	2.59	0.65

Table P5
Experiment 5: Overall Means and SEs of Gain and Loss Latencies for All Components in Sessions 7 and 8

Component	Latency (msec)							
	Session 7				Session 8			
.	Gain		Loss		Gain		Loss	
	M	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
N50	135.140	8.304	117.120	8.304	121.910	8.304	127.140	8.304
P100	163.490	7.102	154.350	7.102	157.850	7.102	162.820	7.102
N100	208.870	7.309	195.440	7.309	200.900	7.309	204.370	7.319
P200	245.750	8.284	242.440	8.284	243.060	8.284	237.260	8.297
N200	288.980	10.288	279.140	10.288	288.820	10.288	276.390	10.303
P300	458.870	12.237	456.040	12.237	465.280	12.237	446.010	12.254
Mean	250.183	8.921	240.755	8.921	246.303	8.921	242.332	8.930

CHAPTER 6: Conclusions

Notable aspects of the research method and data analysis include:

(a) The concurrent-operants procedure made use of six consecutive sub-conditions of reinforcement and punishment within the same session, which is unusual. The data indicated that participants were sensitive to the changes in conditions.

(b) The Subsearch game produced behavioral outcomes in accordance with the matching law.

(c) The indirect model of behavior and its consequences, which was not proposed in the literature, seems to be competitive model with other, previously used models. The model does not take punishers into direct account in order to calculate the gain/loss ratio. Alternative experimental designs might require a different model.

(d) The data analysis was an attempt to bridge traditional methods in behavior analysis with commonly used inferential methods, for instance, the use of linear mixed models.

As already mentioned, normative theories of judgment and decision making posit that the context in which a choice occurs should not affect the choice. A great deal of evidence, however, suggests that individuals deviate from normative behavior (Kahneman, 2011). In that context, the experiments reported here suggest that "ordinary people", in contrast to the Econ, deviate from the normative standard, that is, their decision making depends on the context in which it occurs. Specifically,

Behavioral Measures

(e) The gain/loss ratio calculated as the mean of all of the proposed models was 2.05. For the indirect model alone, it was 2.23.

(f) Risk seeking and risk aversion are dynamic. When internal or external conditions change, the individual's response to gains and losses may also change.

Internal conditions included:

(g) Gender. Women s were more sensitive to losses than men were.

(h) Risk. Risk-averse individuals were more sensitive to losses than risk seekers were.

(i) Generosity. Altruistic behavior, such as donating one's winnings to the charity of one's choice, challenges the traditional view of utility theory.

Among the external conditions I studied were:

(j) Coin dispenser. Loss aversion increased when the game was played using the coin dispenser/collector in addition to onscreen (virtual) points exchangeable for money

(k) Competition. The results suggested that risk-averse individuals became more averse and risk seekers more inclined to take risk when given access to the anonymous outcomes of all participants.

(l) Emotiv Epoc. The use of the Emotiv Epoc may have influenced participants' behavior, specifically, by increasing the gain/loss ratio. It was 3.40 when the Emotiv Epoc was used.

Electrophysiological Measures

(m) That brain activity was correlated with behavioral outcomes was demonstrated by the asymmetry ratio of 1.99 for ERPs. Moreover, the Frontal electrodes recorded a faster response to gains and losses when compared to those at the Middle and Back sites.

(n) A pattern observed in the ERP over consecutive sessions was consistent with that of the traditional learning curve.

(o) No significant differences were found in the ERPs of risk-averse and risk-seeking participants except for, the N200 at the interaction between GainLoss and Frontback.

(p) Visual and auditory stimuli generated higher amplitudes than did auditory stimuli only.

(q) Mean latencies of the 2P300 component were twice those latencies of the P300.

(r) A difference in time response was found between the latencies of gains and losses. It was larger for the losses than the gains.

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