Probability of Winning in Risky Choices

Vikas Chaudhary

Abstract

Media reports say that high earners and syndicates buy lottery tickets in bulk. Experimental evidence shows that agents aggressively bid in auctions and contests. Do people try to trade-off probability of winning with other basic risk dimensions (for example, cost) to achieve a subjective threshold probability of winning (in environments they can) even when such choices are second-order stochastic dominated? The literature on risky choices suggests so. In the main design of this experiment, we deconstruct the expected value with variance and skewness of a lottery with Bernoulli distribution to examine the decision-making process. Based on the results, a proportion is classified as expected utility maximizer (EUM)[1] while another proportion seems to achieve a subjective threshold probability of winning (termed as target probability of winning (TPW)). More TPWs prefer higher probabilities compared to EUMs in a constant value lottery set which may explain the preference for negative skewness in experiments. Additionally, we test two contest designs and find TPWs in the population which may explain the puzzle of equilibrium effort more than risk-neutral Nash equilibrium in experiments.

1 Introduction

The purpose of this chapter is to find experimental evidence with a clearer design for target-based decision-making in risky choices where subjects trade-off cost with the probability of winning to reach their desirable chance of winning.

The idea of target-based decision-making is found in the literature with levels of income as the main focus. Camerer et al. (1997) find that cab drivers keep daily targets on earning, driving fewer hours on a good day and more hours on a bad day. The authors attribute this driving behavior to bracketed thinking

[1] In this thesis whenever we say expected utility theory (EUT) or maximization (EUM) we mean any continuous and smooth utility function for which second-order stochastic dominance holds.

combined with aspirations. Similarly, studies show that gamblers tend to shift bets toward long shots in the last race in an attempt to "break even" on the day (McGlothlin, 1956). Here, breaking even is a clear and significant reference point. Such mechanisms (and their combination) of decision-making can give rise to behavior that is qualitatively different from what is predicted by standard models.

However, in some settings choices are over probabilities of success, not levels. For example, buying lottery tickets when a prize is fixed. Anecdotal evidence suggests they might be trading off the probability of winning with either cost or size of the prize to achieve a target probability of winning. In a two-outcome probabilistic game, a sufficiently favorable probability of winning each game (one at a time in case these are repeated) can serve as an aspiration. In this case, only after winning can one achieve payoffs above endowment as a reference point when there is no explicit need-based reference point on the (net) amount to be won.

The objective of this chapter is to answer the following questions. A) Do subjects target a probability of winning in risky choices? B) Do subjects prefer negative skewness relatively over positive skewness in risky choices? C) Do subjects target a probability of winning in contests? To help answer these questions, TPW decision-making will first be described; then, some real-life examples of the behavior it predicts will be given. Subsequently, the TPW decision rule (Section 3) will be introduced and some predictions it makes with that of EUMs will be compared (Section 7). Following this, lab experiments will be used to test the predictions and explore different aspects of behavior (Section 8).

TPW, target probability of winning, emphasizes that the probability of winning in any decision/game could be an independently important determinant of decision making. If feasible, subjects will base their decision to engage with a choice set on the relative probability of winning. This means that they can also choose an option that is second-order stochastic dominated. This is different from the probability weighting function (CPT) where subjects perceive the objective probabilities subjectively and a decision is a function of the product of this subjective probability with the possible subjective value to be gained.

In the real world, people may have to "win" (complete task within constraints) multiple games rather than trying to achieve the highest expected utility with a low probability of winning in each game. Some intuitive real-life examples can be as follows: addressing an acceptable research problem for your thesis (or tenure track) which can be completed in the designated time rather than putting forward the best ideas you can, given the low probability of getting it completed within the time frame in the latter scenario; in congested cities trying to reach a nearby hospital in an emergency rather than the best hospital whose location in the city is less accessible; doctoral students may not even apply to higher-ranking universities for the position of assistant professors even when these applications require minimal effort.

In these situations, if there is a possibility of changing the chance of success by changing the cost/effort, some people may make such a trade-off to reach a more desirable chance of winning. Some intuitive real-life examples can be: doctoral students extend their thesis by a year or take up a post-doc to improve their chance of getting a position of assistant professor; students take up a full-time research assistantship after their undergraduate studies to improve their chance of getting into a good doctoral program, among other reasons; differences in long-term investment decisions—at later age, people choose a lower proportion of equities in their portfolio to increase the chances of the net return on the investment to be above risk-free return at the time of retirement even though equities would give the highest expected value.

Similarly, in real-life scenarios, keeping everything in one basket to achieve the highest second-order dominant choice—even if one can substantially increase the chance of winning by increasing the effort (cost) but can't make it certain—may not be preferred by some as it does not leave them with anything if it is a loss. An intuitive example in real life can be seen in professional choices where very few people opt for taking up a career path that requires long-term focused effort and (irreversible) opportunity cost on multiple fronts even when success can transform their careers in the desired direction.

So far, only intuitive examples that are debatable in terms of whether expected utility or any other mainstream behavioral theory can explain such decisions have been given. It is only the decision-maker who has a true insight into how they make those decisions. The following example is more appropriate for allowing discussion based on only observed behavior. There seems to be a general "strategy" popular among the lottery players that one should buy more tickets to increase the chance of winning. This is when, in general, the expected value of the lottery is negative. There are media reports which claim the following:

1) High earners buy in bulk.
2) People form a syndicate to buy tickets in bulk (and a Wikipedia page suggests that people do it to enhance their chance of winning).
3) Winners tend to follow the strategy of buying in bulk.

Some players find such advice reasonable.[2] It might be the case that when

[2]See Appendix for a screenshot of news cited here (Figure 1.36-1.42).

individually they think they are not able to achieve this then some of them form a syndicate to achieve this. Buying in a syndicate strengthens the belief that they enhance the chance of winning by trading off the size of the prize they will share as a reasonable way to approach this game since the expected value remains the same.

Our main task in this experiment (Part 5) teases out EUMs from possible TPWs and deconstructs the expected value with variance and skewness. Hence, a clearer experiment to address aspects of questions A and B is achieved. Evidence on TPWs may resolve the differences between one set of findings in (finance and psychology) literature—which finds preference for statistical moments (corresponding to some utility maximization) as the underlying approach subjects take when making a decision in risky choices—and another set of findings (psychology and finance) where subjects make a decision based on some contextual behavioral approaches. A possible reason for the two different sets of findings is that these designs (due to their contextual nature) are dominated by one "type" of subjects. This could leave the overall finding confounded which may also be the reason that some experiments show a preference for positive preference and some for negative. The behavior in these studies cannot be distinguished, whether subjects are making choices based on moments (which can be rationalized as expected utility maximization) or the probability of winning (a behavioral approach).

If the probability of winning is an important determinant in decision making (at least for some substantial proportion of the population) in risky choices then, among others, it can contribute to insights into two areas of economics research which are contests and all-pay auctions where a limited discussion has occurred so far. If subjects are using this approach to make a decision, then their decision will reflect qualitatively different choices compared to what is predicted by the standard theory. This motivates us to come up with two (Part 3 and 4) additional tasks to address aspects of question C. In these tasks, the environment is varied including the information available to the subjects. A challenge of testing any decision-making approach is that it is contextual; subjects may use a different approach to decision making depending on how they understand technically the same game presented differently[3]. If TPWs are present in contests then it may give insights into behavioral regularities such as over-dissipation and dropout.

In summary, there are three tasks (Part 5, 4, and 3) to study our questions. In Part 5 (the lottery task) the subjects choose from a set of lotteries that vary in cost and probability of winning for a fixed prize which is the same across all the lottery sets (LS). The purpose of this task is to directly test if subjects make decisions based on EUM or TPW in risky choices. In Part 4 (the response

[3] Framing Effect, Kahneman and Tversky (1979), is a testimonial to this

curve task) subjects play as a second-mover to the pre-populated choices of the opponent. The purpose of this task is to understand the subjects' response curve. In Part 3 (the contest task) group size varies in the contests. The objective of this task is to explore how subjects respond to change in the number of subjects in Tullock contests. These are all one-shot tasks. After quizzes (Part 1), subjects played contests for ten periods (Part 2) with limited feedback. Part 6 measures risk aversion.

A summary of the results is as follows. In Part 1, most of the subjects can calculate the probability of winning if the opponent's bid is given and can calculate the payoffs based on whether they would win or lose. In Part 2, most of the subjects actively participated, responded to the outcome (winning and losing) and the change in the number of subjects in the game. In Part 3, around 33% subjects consistently decreased their probability of winning and bid amount upon an increase in subjects in the game while 55% subjects consistently increased either bid amount or probability of winning. In Part 4, around 15% of subjects behaved as predicted by expected utility theory, 23% subjects behaved as predicted by the target probability of winning. In Part 5, 23% of the subjects' behavior is as predicted by an expected utility theory, 36% as predicted by the target probability of winning. In Part 6, it is found that around 8% of subjects are either risk-neutral or mildly risk-seeking or mildly risk-averse, 92% of subjects are risk-averse.

Contribution: This chapter contributes to the experimental literature on risky choices that investigate the probability of winning as an independent criterion in decision making under laboratory conditions (for example, Edwards, 1953; Edwards, 1954; Slovic and Lichtenstein, 1968; Payne and Braunstein, 1971; Payne, 2005). It implicitly contributes to the literature on bracket-based decision making (for example, Camerer et al. (1997)) and adds to the evidence on non-value-based aspirations. The main contribution is a clearer design (which can tease out EUMs) to test for subjects making trade-offs with basic risk dimensions to achieve their TPW. To our knowledge, there has been no previous study that tries to investigate for heterogeneity of decision making (EUM vs TPW) within one task[4]. It is found that a substantial proportion of subjects can be categorized as EUM while a substantial proportion of the population is TPW. This chapter also contributes to the literature on skewness preference and finds that agents tend to prefer negative skewness over positive skewness. It may resolve an apparent contrast between the finance literature which suggests that subjects

[4]This is in a spirit similar to Harrison and Rutström (2009) who find support for data in the experiment being generated by two types of the decision process with two different underlying theories

are EUMs with a preference for skewness and the psychology literature which suggests that subjects use behavioral approaches to makes decisions which are contextual. This chapter also contributes to finding such behavioral types in contests. To our knowledge, there are no previous attempts[5] to investigate TPW types in contests. Given more of these behavioral types have a high target probability of winning, this could be another possible explanation for the regular finding of over-dissipation in these games. Experiments can be designed to test such behavioral types in all-pay-auction as well.

The remaining chapter is organized as follows. In the *Towards Theoretical Formulation* section, we attempt to come up with a decision rule which can capture the central idea of the behavior conjectured. In the *Related Literature* section, some literature is reviewed on risky choices which suggest that the above behavior is a possibility. In the *Main Design–Features* section, the design aspects of the main design, which can tease out two broad behavior types, are discussed. In *Experimental Design and Procedures* section, the design of whole experiment is explicated. In *Research Questions*, the important questions we would like to obtain an answer for from this experiment are listed. In the *Results* section, the insights from the experimental data are discussed. In the *Discussion* section, further questions and designs to test the robustness and understanding of the findings are considered.

2 Related Literature

There is some evidence in the literature that the probability of winning is important in risky choices suggesting that subjects make a trade-off with cost, wherever feasible, to reach their suitable probability of winning in the decision making (for example, Edwards, 1953; Edwards, 1954; Slovic and Lichtenstein, 1968; Payne and Braunstein, 1971; Payne, 2005). —But these pieces of evidence are either debated due to their design or find their explanation in some mainstream theories. Edwards (1954) puts forward "subjective probability" which now is known as probability weighting to explain Edwards (1953, 54), while Decidue (2008) explains Payne (2005) with a discontinuous value function. Similarly, the evidence on preference for skewness is inconclusive. Both Golec and Tamarkin (1998) and Garret and Sobel (1999) find evidence for positive skewness, whilst

[5]To our knowledge this is the first study that has hypothesized probability of winning as an independent criterion of decision making in winner-take-all competitions. An early version of the current second chapter (with the previous title "Learning in Contests") with these insights was poster-presented in GW4 Game Theory Workshop in May 2016 and in conference Contests: Theory and Evidence in June 2017

Symmonds et al. (2011) and Taleb (2004) find evidence for negative skewness. This could be because skewness is correlated with either expected value or variance or other moments which may also be present in the distribution, thereby finding its explanation in EUM rather than as an independent criterion of decision making. There seems to be no literature which studies evidence for the probability of winning in contests before conducting this experiment. A topic-wise detailed literature review is conducted below.

Suggestive Literature on TPW

The probability of winning can be an important psychological factor of risk. Allais (1952/1979) emphasizes the factors of psychological risk in his example of a traveler who may choose a gamble which gives him the greatest chance of winning an amount equal to the price of the ticket they need to return home. It emphasizes the shape of a utility function, probability weighting, and dispersion as psychological factors of risk and expected utility as a monetary factor of risk. The example suggests that the probability of winning can be another important factor in decision-making in risky choices.

There is some suggestive evidence from zero expected value lottery tickets, in a lab experiment, that agents have a preference for the probability of winning. Edwards (1953) designed the lotteries which have the same expected value to understand what makes subjects deviate from the expected value. A set of gambles is designed with a monotonically increasing probability of winning and decreasing prize value such that the expected value of all the gambles remained the same[6]. Three such sets are designed. The first is in the domain of gain having a positive expected value. The second is in the domain of losses having the negative expected value. The third is neutral having an expected value as close to zero. Each set of gambles had three parts, Part A, B, and C. Part A is based just on imagining. Part B is based on worthless-chip. Part C is based on real gambling. The choices of all the parts are highly correlated. In the real gambling choices based on the choice distribution of all the subjects it is concluded that in positive and zero expected value gamble sets, subjects have a preference for the probability of winning. The middle gambles (with probability 3/8, 4/8, and 5/8) are chosen more than other gambles. In the negative expected value set, the choices generally decreased as the probability of winning increased.

Similar suggestive evidence is found in the non-zero expected value gamble experiment in the lab. Edwards (1954), following Edwards (1953), designed an experiment to identify variables that determine choices among bets which differ from one another in expected value. Three sets of gambles are

[6] One of the lottery sets in the main design in our experiment is similar to this

designed—positive, negative, and near zero. Based on the results, it can be concluded that subjects do not consistently prefer bets with higher expected values to bets with lower expected values and part of the variation can be predicted by probability preferences. Edwards (1954) gives subjective probability as a possible explanation for the probability preference; that is, the objective probabilities stated in the gambles are perceived subjectively by the subjects and the subjects are trying to maximize "subjective" (weighted probability) expected utility[7].

Subjects may use an alternative approach to understand and take gambles which can make choices qualitatively different from EUT. They may evaluate a gamble using some basic independent dimensions and seek a preferred trade-off between those. Slovic and Lichtenstein (1968) characterize a gamble as a multidimensional stimulus with four basic risk dimensions—the probability of winning, amount to win, probability of losing, and amount to lose. This design approach focuses on the relative importance of the basic risk dimensions and how people use them. It gives an alternative explanation of subjects preferring low probability of winning gambles in Coombs and Pruitt (1960), possibly because these (zero expected value) gambles have the higher winning amount or lower losing amount (their argument does not apply for the preference for gambles with a high probability of winning). They use the same explanation (amount of winning and amount of losing) to explain variance preference. Their results show that subjects' bids were influenced considerably more by variation in the probability of winning and amount of losing than by variation in the amount of winning or probability of losing when subjects have to choose between the duplex gamble. It is seen that subjects' ratings or bids monotonically increased as the probability of winning increases and monotonically decreases as the probability of losing increases. These results are attributed to an information processing model where subjects believe the probability of winning is more important than other risk dimensions rather than subject having specific preference[8] for probability.

Similarly, Tversky (1969, 3/33) argued that "one subject may conceptualize (two-outcome) gambles in terms of odds and stakes, while another may view them in terms of their expectation, variance, and skewness." Tversky used specially constructed sets of gambles to demonstrate that subjects use a choice process termed as "lexicographic semiorder" (LS) that is qualitatively incompatible with expected utility maximization. Payne and Braunstein (1971) explore

[7]In our main design, behavior in three lottery sets can help to gauge the possibility of such an explanation

[8]Preference here means the intrinsic preference across the games (e.g., risk preferences). To avoid such confusion of terminology we preferred to use the abbreviation 'TPW' (i.e., target probability of winning)

the relative merit of the basic risk dimensions and the underlying distributions as explanations for decisions. Their study involves the use of pairs of gambles that display different values for the risk dimensions, but which are equal in their underlying distributions[9]. To explain the results, they propose an information processing model in which subjects first examine probability information and use it to exclude gambles having an unacceptable probability of winning.

Some known behavior effects could be specific examples suggesting that the probability of winning does matter for some in decision-making in risky choices. Kahneman and Tversky (1979) show "possibility effect" (no chance of winning less preferred to some chance of winning) and "certainty effect" (some chance of losing less preferred to no chance of losing) in decision making where subjects choose the option with lower mathematical expectation. It possibly reflects (in two extreme cases) that the probability of winning and losing can be an important factor in decision making and if subjects can trade-off expected value/cost with (substantial) increased chance of winning, they do so.

Lopes (1981) questions the interpretation of expected utility theory by von Neumann and Morgenstern regarding whether subjects combine values (utilities) and probabilities ever, except in the long run. She discusses the idea of whether the only rational measure of the worth of a gamble is its expected value (utility). She argues that in decision making it is reasonable to consider the probability of success in the short-run compared to expectation-based decision-making in long-run situations. Lopes (1987, 1996, 1995, 1999) cites multiple experimental studies conducted after Lopes (1981) which confirm the difference between the choices made by the subjects when they playing a one-shot game compared to the same game being played repeatedly. It concludes that an adequate descriptive theory of risk-taking will need to be a dual criterion theory. It formulates the SP/A theory that combines a decumulative weighting process with a process that maximizes the probability of achieving an aspiration level. It claims that the dual criterion theory does a creditable job of describing both preferences and reasoning patterns across a wide variety of behavioral phenomena.

Some more recent evidence confirms that the probability of winning can drive the decision-making in risky choices. Payne (2005) does a simple test of the expected utility model, the original prospect theory, and cumulative prospect theory in a value allocation task. Subjects are provided with an opportunity to improve a gamble (for example: $100, 0.20; $50, 0.20; $0, 0.20; -$25, 0.20; -$50, 0.20) such that they can change the overall probability of gain or loss. Subjects are given a value (say $38) and must choose one of the two options (say $100 and $ 0 from the above gamble) they would like to add to this value. The experi-

[9]Note, a tradeoff between EV and probability of winning is not tested in this design but is present in our main design

ment finds that subjects were highly sensitive to changes in outcome values that either increased the overall probability of a strict gain or decreased the overall probability of a strict loss. It is concluded that the experimental result supports the hypothesis that subjects focus on the overall probability of success, which is in contrast with expected utility and prospect theory. Venkatraman, Payne, and Huettel (2014) use the value allocation task in multi-outcome gambles involving possibilities of both gains and losses and find that subjects often maximize the overall probability of winning. Zeisberger (2016), in a series of experiments, finds that people pay explicit attention to the probability of losing and their willingness to take risks and choice behavior is considerably influenced by loss probabilities, while performance feedback seems unable to mitigate this effect.

EUM and Skewness

The economics approach to decision-making in risky choices is the expected utility maximization which depends on the curvature of the utility function (Pratt, 1964). The finance approach to decision-making in risky choices is based on statistical moments of the underlying distribution. Markowitz (1952) shows that the approach of mean-variance is the expected utility maximization if the distribution is normal. Roy (1952) defines the "safety first" principle that calculates the probability of returns of the portfolio going below the desired threshold as a measure of downside risk. The optimum portfolio will be the one that minimizes this probability. Such a measure of downside risk has been further generalized as a probability loss risk measure for making risky choices. The major problem with probability loss risk measure is its failure to distinguish increasing downside risk from other properties of distributions (e.g., mean, variance, skewness).[10]

Tsiang (1972) asserts that as the ratio of risk (standard deviation) to the mean value of total wealth increases, the accuracy of mean-variance analysis decreases, and higher-order central moments in a particular third would have to be taken into consideration for an appropriate utility function for a risk-averse individual.[11] It shows that subjects with such utility functions will have

[10]The main design (Part 5) of this experiment does indeed distinguish it from the first two moments.

[11]As mentioned in Tsiang (1972), according to Arrow an appropriate utility function for a risk-averse individual should have the following essential properties: (a) $U'(y) > 0$, i.e., the marginal utility of wealth is positive; (b) $U''(y) < 0$, i.e., the marginal utility of wealth decreases with an increase of wealth; (c) $d[-U''(y)/U'(y)]/dy < 0$, i.e., marginal absolute risk-aversion should, if anything, decrease with an increase in wealth; (d) $d[-yU''(y)U'(y)]/dy > 0$, i.e., marginal relative (proportional) risk-aversion should, if anything, increase with an increase in wealth. These properties are satisfied by a negative exponential function, constant elasticity utility function,

a preference for positive skewness ($U''' > 0$) if the phenomenon of increasing absolute risk aversion is regarded as absurd. Scott and Horvath (1980) show that investors exhibiting positive marginal utility of wealth for all wealth levels, consistent risk aversion at all wealth levels, and strict consistency of moment preference will have a positive preference for positive skewness (i.e. $U''' > 0$)

In the wide range of economic models (e.g., gambles, auctions, and contests) individuals' decisions under risk can be understood as trade-offs between mean, variance, and skewness. Chiu (2010) establishes a skewness-comparability condition on probability distributions that is necessary and sufficient for any decision-makers preferences over the distributions to depend on their means, variances, and third moments only. The study generalizes the condition for two distributions to be comparable in terms of downside risk, establishing that all Bernoulli distributions are mutually skewness comparable. The degree of skewness is determined only by the probability of the lower possible outcome. The utility preferences can be described by the preference over three moments.

Evidence on Preference for Skewness

In the below papers there is differing evidence on preference for skewness in lab experiments as well as natural empirical data. The evidence ranges from a preference for positive skewness to negative skewness and a preference for skewness to no skewness. Coombs and Bowen (1971) construct gambles with the same underlying mathematical expectation and variance but different skewness. The choices made by the subjects show that their decision (perceived risk) was a function of skewness as well as mathematical expectation and variance even under multiple plays.

Some studies (Arditti, 1967; Levy and Sarnat ,1972; Krauss and Litzenberger, 1976) have found the coefficient for the second moment to be positive and statistically significant. This was interpreted to mean that a higher return tends to go together with prospects with a higher variance [12] and investors prefer a positive asymmetry. The coefficient for the fourth moment was significant only in few cases, and the coefficient for higher moments was always insignificant.

Golec and Tamarkin (1998) find that betting behavior at horse tracks is explained by expected utility functions which consider mean, variance, and skewness of the returns. It finds that bettors are risk-averse, but are attracted to the positive skewness of returns offered by low probability, high variance bets. Garret and Sobel (1999) find that lottery players are also risk-averse but favor

log function, among others. Polynomials as utility functions cannot satisfy these requirements at the same time.

[12] In the main design higher mean are separated with higher variance for two sets of choices

positive skewness. In contrast with risk-measures focusing only on the chance of poor outcomes, Symmonds et al. (2011) use a multi-outcome gamble to test preference for statistical moments. The study finds the mean-variance-skewness model as the best fit. The majority of subjects were variance averse and seeking negative skewness. In line with this conclusion from the perspective of financial markets, Taleb (2004) also lists the areas where traders have a preference for negative skewness.

Brunner, Levinsky and Qiu (2011) experimentally test skewness preference at the individual level. The experimental approach allows to directly control the payoff distributions faced by the subjects. Their definition of skewness preferences follows the definition of Tsiang (1972) that an expected utility maximizer reveals skewness preferences if the third derivative of the utility function is positive. The subjects choose one of the two gambles provided each time. The researchers find that skewness of the distribution has a significant impact on the decisions. Around 40% prefer skewness (positive and negative) and around 10% avoid skewness.

Astebro, Mata, and Santos-Pinto (2015) study how the presence of skewness influences the risk attitudes of experimental subjects. Using three sets (with different non-negative skewness) of ten pairs of choices (similar to Holt and Laury, 2002) each with multiple outcomes, they find that when the choice task includes a positively skewed lottery, subjects make riskier choices. Additionally, estimated parameters of power utility (crra) function find no evidence for risk-loving; rather, skew seeking is attributed to optimism and likelihood sensitivity.

One-Shot vs Multi-Period Games

Even if subjects are expected to be utility maximizers, they can behave differently in the one-shot game to how they would in a repeated game. Ross (1999) shows that there is a large class of utility functions (including crra utility functions, but excluding exponential and risk-neutral utility functions) that accepts a long enough sequence of independent good bets due to the law of large numbers, any one of which considered individually would be rejected. This motivates us to prefer a one-shot design as our starting point of investigation. In our design, subjects play lotteries and raffles which have more choices than simply accepting or rejecting: they can choose their bid amount.

3 Towards Theoretical Formulation

In an attempt to give more clarity to what is being conjectured we formulate a decision rule, stated below, to express the behavior. The domain of the decision rule is an environment where there is a feasibility of probability-cost trade-off with the framing of two-possible outcomes as winning and losing.[13] Given a lottery game, the TPW is taken as exogenous[14]. It possibly depends on various factors like the endowment of the agent, the cost structure of the lottery, and the number of total lotteries and prize money. What we conjecture is that if these factors remain approximately the same then a TPW subject will make a similar choice. Our basic conjecture emphasizes that people try to achieve a threshold probability of winning even if it is a second-order stochastic dominated choice.[15]

This is in no way to claim that the stated decision rule is exactly how people make decisions in risky choices. Not everyone is the same and decision-making also depends on the environment. For example, in the case of a choice between a pair of gamble options, it may not be feasible for subjects to achieve their TPW; in which case, they may decide differently while making a choice. For example, the value of the amount which can be won/lost or a substantial difference/absolute values of probabilities of the two paired gambles may become salient.

Decision Rule: $\min(n)$ s.t. $nP(L) \geq TPW$

where
n is the number of lottery tickets
$P(L)$ is the probability of winning achieved by one lottery (L) ticket
TPW is the target probability of winning agent desires for this lottery game

It is not possible to fully ascertain how exactly subjects arrive at their target probability of winning. Yet, this decision-making can be captured even without such knowledge if an environment is considered that has a possibility of a more continuous trade-off between the two. In such an environment, for a specific game, a simulation of such behavior can be generated as agents try to achieve some minimum chance of winning and see whether they go beyond that as it is costly. Figure 1.0 (x-axis: cost, y-axis: the probability of winning) captures such an environment.

Now, returning to the lottery example, let us discuss the decision rule and

[13] It might apply to limited multi-outcome games and lotteries but will require separate study to investigate.

[14] This is a critical simplification and beyond the scope of this work

[15] As Roy (1952) notes, "a valid objection to much economic theory is that it is set against a background of ease and safety. To dispel this artificial sense of security, theory should take account of the often close resemblance between economic life and navigation in poorly charted waters or man-oeuvres in a hostile jungle. Decisions taken in practice are less concerned with whether a little more of this or of that will yield the largest net increase in satisfaction than with avoiding known rocks of uncertain position or with deploying forces so that, if there is an ambush round the next corner, total disaster is avoided. If economic survival is always taken for granted, the rules of behavior applicable in an uncertain and ruthless world cannot be discovered."

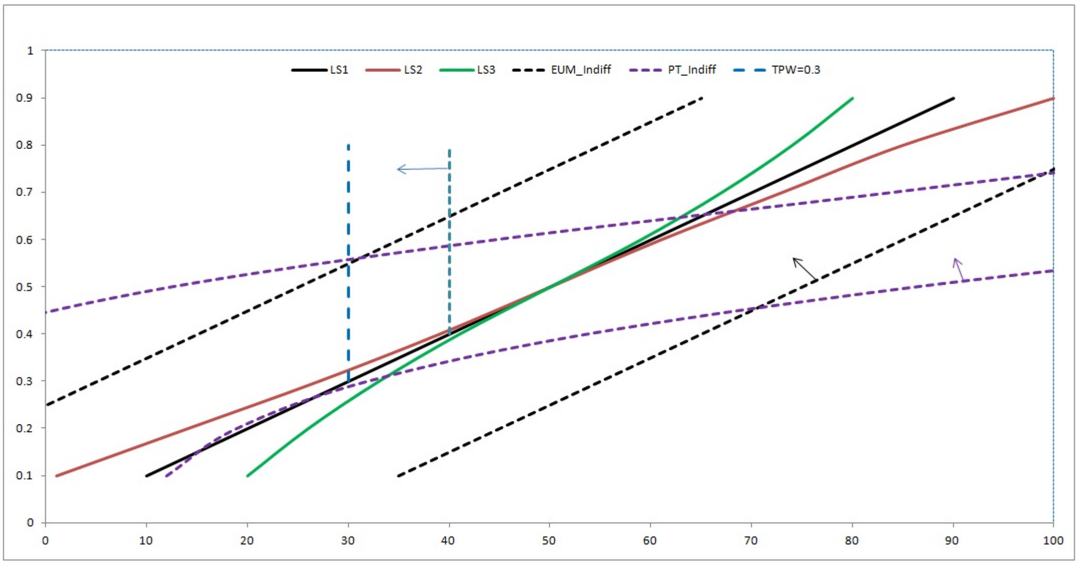

Figure 1.0: Indifference Curves

prediction it makes which is in contrast to two mainstream theories. Can individuals buying lotteries in bulk, but not spending all their spendable income on it, be explained using expected utility maximization (EUM) or cumulative prospect theory (CPT)? It seems that these lottery players make a trade-off decision between cost and chance of winning. Although players may enhance their chance of winning by buying more lottery tickets, at the same time they do not pour all their money into doing that. Hence, in the first-order they seem to value the chance of winning up to a certain threshold and in second-order value the cost. In the case of buying in bulk in a syndicate, the trade-off is between the chance of winning and the size of the prize they will share as an individual.

Let us consider these lotteries with a prize value equal to 100 which is equal to the endowment (spendable income). The TPW indifference curve would be a vertical line starting from the point in the lottery curve that gives this probability of winning. The family of curves will be parallel vertical lines on the right. Note, if the cost does not greatly differ across lottery curves then indifference curves for a specific TPW across different lottery curves will be close. [16] The indifference curves (Figure 1.0) for EUMs are inclined straight lines. It is seen that for these lotteries with slightly different cost structures (compared to constant expected value (=100) lottery line LS 1) the choice predictions for LS 2 and 3 are at the extreme opposite end. In general for a family of lottery

[16]This is an approximation in itself. This means that if cost changes substantially players are likely to consider this factor. However, with a small margin of change, they will choose a similar probability of winning.

sets (LS 2 and 3), any point on the curve can be considered as an element of the set of lotteries represented by this curve, the EUM prediction will be one of the endpoints. The indifference curves for prospect theory are based on the convex weighting function with loss aversion equals 2.25 and endowment as the reference point. These predict that the high probability end lotteries will be chosen.

Nonetheless, it is important to note that there can be various qualitatively different indifference curves for PT due to different parametric functionals. Although it is difficult to rule out the possibility that another existing EUM or CPT model can explain this behavior (some of such (non-standard) CPT models and their limitations will be discussed), we find that a CPT model with parametric values of Tversky and Kahneman (1992), as used in the literature on risky choice, with an endowment as the reference point[17] gives a prediction similar to standard EUM. A list of possibility of alternative explanations are discussed in Section 8 of this chapter for the results in the main design.

4 Main Design-Features

As reviewed above, on the one hand, literature in finance suggests that subjects are expected to be utility maximizers, attracted to the first and the third moment and with an aversion towards the second moment. On the other hand, literature in psychology finds subjects having some preference for the probability of winning (equivalent to skewness in Bernoulli distribution), preference for statistical moments, and use of some information processing approach to make decisions.

The main task central to our study is framed such that variance and skewness for any lottery do not vary across the three lottery sets (LS1-LS3) and only expected value changes as shown in Table 1.1-1.3 below. In these tables apart from self-explanatory headers, EV denotes the expected wealth of the gamble (including the endowment of 100), Var denotes variance of wealth and Skew denotes its skewness.

LS 2 and 3 are second-order stochastic dominant lotteries in the respective lottery sets. There is no second-order stochastic dominance among lotteries in LS 1. In this task, between two adjacent lotteries, the "risk dimensions" (probability of winning, probability of losing, winning amount, and losing amount) change gradually over lottery sets with moments varying in a pattern easily detectable even if values are difficult to calculate.

[17] One of the challenges in applying PT is that it is not clear what should be the reference point (Barberis, 2013). In a lottery with only two possible outcomes (single prize), it seems reasonable to take endowment as a reference point.

Lottery Set 1	Probability of Winning	Cost	Prize	EV	Var	Skew
L1	0.1	10.0	100	100	900	2.7
L2	0.2	20.0	100	100	1600	1.5
L3	0.3	30.0	100	100	2100	0.9
L4	0.4	40.0	100	100	2400	0.4
L5	0.5	50.0	100	100	2500	0.0
L6	0.6	60.0	100	100	2400	-0.4
L7	0.7	70.0	100	100	2100	-0.9
L8	0.8	80.0	100	100	1600	-1.5
L9	0.9	90.0	100	100	900	-2.7

Table 1.1: Lottery Set 1

Lottery Set 2	Probability of Winning	Cost	Prize	EV	Var	Skew
L1	0.1	1.0	100	109	900	2.7
L2	0.2	14.0	100	106	1600	1.5
L3	0.3	27.0	100	103	2100	0.9
L4	0.4	39.0	100	101	2400	0.4
L5	0.5	50.0	100	100	2500	0.0
L6	0.6	61.0	100	99	2400	-0.4
L7	0.7	73.0	100	97	2100	-0.9
L8	0.8	86.0	100	94	1600	-1.5
L9	0.9	100.0	100	90	900	-2.7

Table 1.2: Lottery Set 2

In one of the lottery sets, LS 1, the expected value is zero for all the lotteries in the set. The pair LS 2-3 can help categorize EUMs and LS 1 can test if they choose positive skewness over negative skewness since for each value of variance there are two lotteries in the set, one with positive skewness and another with negative skewness.

A design approach of choices between pair-wise gambles is good in understanding whether something is a significant factor in decision making. Many real-life situations are not the choices between a pair, rather a series of options varying such that there is a trade-off among the decision-making factors. In this sense, a lottery set has an advantage over pairwise choices to better depict a realistic situation.

A lottery set design also has an advantage over pairwise choices given to subjects by removing possibilities of different salience guiding choices between different pairs. For example, the choice between a pair which is close to each other in any lottery sets can be due to the salience of the amount to be won or amount to be lost while the choice between any pair far apart in any lottery set could be due to the probability of winning (losing). This design makes lotteries easier to compare among themselves.

There is evident salience in LS 2 and 3. In the first lottery (L1) in LS 2, the proportional cost (per unit probability of winning) is minimum. The case is similar to the last lottery (L9) in LS 3, in which the proportional cost of the last lottery is minimum. These two lotteries are the optimal choice for a non-risk-

Lottery Set 3	Probability of Winning	Cost	Prize	EV	Var	Skew
L1	0.1	20.0	100	90	900	2.7
L2	0.2	26.0	100	94	1600	1.5
L3	0.3	33.0	100	97	2100	0.9
L4	0.4	41.0	100	99	2400	0.4
L5	0.5	50.0	100	100	2500	0.0
L6	0.6	59.0	100	101	2400	-0.4
L7	0.7	67.0	100	103	2100	-0.9
L8	0.8	74.0	100	106	1600	-1.5
L9	0.9	80.0	100	110	900	-2.7

Table 1.3: Lottery Set 3

seeking (measured risk preference found in the experiment) expected utility maximizer.

The expected value (first moment) in LS 1 does not change, in LS 2 it decreases monotonically and in LS 3 it monotonically increases from top to bottom lottery. Variance is symmetric and decreases on either side away from the middle lottery. The skewness of the middle lottery is zero and is symmetric and increasing in magnitude as one moves away from the middle lottery on either side with top lotteries positively skewed and bottom lotteries negatively skewed. The variance and skewness of each lottery are the same across the three lottery sets.

In LS 2 and LS 3, optimal choice based on expected value and variance is in the opposite direction to skewness. The subjects who are predominantly driven by the probability of winning should not change their choice across the lottery sets LS 1 to 3. There is no lottery with the certainty of outcome in either of the lottery sets. This is to eliminate choices due to the "certainty effect" and avoid any abrupt change in the pattern of the moments.

The lottery set provides a series of probability of winning (losing) options, unlike many other studies where designs have limited values of probability of winning. This is to frame a gradual trade-off between cost and probability of winning for a fixed prize which captures many real-life situations. While there is a gradual trade-off between the expected value and probability of winning in LS 2 these are in the same direction in LS 3.

These features can help to gauge which are major risk dimensions of decision-making if subjects are driven by some behavioral approach. The fact that only two dimensions, cost, and the probability of winning, change gradually, as one moves down any lottery with the salience of L1 in LS 2 and L9 in LS 3, makes the task simple to comprehend. A presence of increasing or decreasing stochastic dominant lotteries and separately measuring risk aversion allows these subjects to be classified into broad types.

5 Experimental Design and Procedures

This is a within-subject design. As discussed above, the main task is framed as lotteries with a fixed prize where subjects have to choose one of the nine lotteries in each lottery set. The other two tasks are framed as a raffle where the choices made relate to the number of tickets (bid amount) they want to buy. Three sessions are conducted on consecutive days from 5 to 7 June 2018 with 24 students in each. All the subjects are undergraduate students. All the sessions lasted for around 75 minutes. The average earning is around 15.5 pounds. For further details refer to the instructions sheet in the Appendix section. The descriptive statistics of the payment subjects received can be found in the Appendix (Table 1.43). The experiment is implemented using the experimental software z-Tree (Fischbacher, 2007).

The experiment consists of six parts. In Part 1, subjects are provided with an explanation about the game of raffle by asking them six basic questions on calculating the probability of winning and payoff of the raffle upon winning and losing. The answers along with the explanations were provided after each set of three questions so that the underlying principles of the game were clear. In Part 2, a recap on the raffle game and its procedure was provided before we matched subjects in a fixed group of two for five rounds followed by a fixed group of three for five rounds. Subjects received the information on the outcome of each round. The purpose of this part is to give subjects experience of the game with a change in group size. This is to ensure that subjects have a good understanding of the game as the following part consists of a one-shot game. In Part 3, the subjects played the game of raffle with a change in group size. In the first two games, their group size doubled in the second period, while in the last two games their group size halved in the second period. The change in group size is made such that there is a minimum change in the number of new partners encountered. This part is designed is to understand how the subjects change their probability of winning and bid amount as their group size changes. In Part 4, subjects are matched with another subject and have to submit their response against the set of pre-populated opponents' bid amounts. These choices are used to categorize the subject's response curve. In Part 5, subjects have to choose a lottery from the set of lottery choices that have varied costs and the probability of winning ranging from 0.1 to 0.9. There are three sets of such lotteries. In Part 6, the subjects' risk aversion is measured.

The primary parts of the experiment (Part 3, 4 and 5) were organized as one-shot games. This preference for one-shot games over the repeated game is to decrease the impact of any learning as it is not clear what and how they will learn. It is unclear how the winning and losing will impact the decision-making approach subjects may have. It is suspected that subjects may approach the game differently when making decisions in repeated games.

One may question if the subjects understood the one-shot games. The explanatory instructions are given, but the constraint remained that examples could not be given in the instructions as this may have an anchoring effect. In the questionnaire at the end of the experiment, subjects were asked if the instructions were clear to them. The response in the survey suggests that the instructions for any part of the experiment were clear to most of the subjects. The analysis includes data only for the subjects who have stated that they understood that part of the experiment.

One general concern is whether the order of the parts of the experiment impacts the results and why the order is not randomized over three sessions. Even though the underlying contests game is the same, after Part 2 all games are one-shot and framed differently; hence, it is less likely that any significant learning would take place. Subjects may enhance their understanding of the contest game as they proceed in the session which means that it is better to put easier experiments first. The experiment is not concerned with comparing any treatments; rather, the focus remains on the proportion of EUM and TPW types in each part. The rationale of Parts 1 and 2 is largely to give subjects an understanding of the game. It is logical for Part 3 to follow Part 1 and 2. As Part 4 is on raffles and is more complicated in terms of instructions so it followed Part 3. Part 5 is on lotteries, so it followed all the parts which were based on raffles. Part 6 is to measure risk-aversion, so it is kept at last. In Part 2, the order of contests is not changed, having group size 2 with contests having group size 3. The reason is that only three sessions are run and no inferences are drawn from the parts which are designed for enhancing the understanding by giving subjects some experience of the game.

In Part 3, subjects are simply asked what they consider their target probability of winning to be. One may like to extend further and get incentivized elicitation of the sum of other subjects' effort and use both the inputs to check for the consistency of beliefs. However, using a modulus or square error to elicit opponents' effort will distort the incentives of the primary contest. The risk symmetric Nash equilibrium does not change if such an elicitation mechanism is applied but based on data from other experiments in the Tullock contest it is known that subjects deviate from standard theoretical predictions, in general, they are overbid. In this case, subjects know that they would possibly incur losses in predicting other subjects' efforts. So in response, they may change their actual bidding behavior. If they are loss averse, then they may further reduce their bids. If subjects are relative payoff maximizers then they may increase their bid even further so that the opponent incurs losses while predicting. Moreover, under behavioral factors (e.g., optimism and pessimism) at play, the consistency approach is not appropriate. Let's say the subject believes (in a two-person contest) that the opponent would put 50 and her actual bid amount is 50 and she puts in her probability of winning to be 70%. These choices can be explained by assuming that the subject is optimistic rather than being interpreted as inconsistent. The value of interest is 70%, not 50%. These are the reasons for simply asking subjects to input their estimated probability of winning assuming that is what they aimed for.

In Part 3, the assumption is that the joy-of-winning does not change as group size changes. This rules out a possible explanation of subjects increasing their bid amount as group size increases. The reason for not having a design for capturing the joy of winning was to keep the scope of the experiment within its set objectives. Nonetheless, subjects are asked in the questionnaire if they experience any joy in winning. The distribution is listed in the Appendix (Table 1.44). It is found that almost half of the subjects say that they do not have any joy in winning and the other half say they have somewhat. In Part 4, subjects are matched with another subject across raffles, so the joy of winning is the same across each raffle which should not change the shape of the response curve. In Part 5, subjects are playing against a computer and the interest is in how close the lottery choices are in the three different lottery sets. In LS 1 and 3, the EUM predictions for agents with some additive joy-of-winning are incorporated in the last lottery (L9).

It is useful to think about how the target probability of winning is different from the joy of winning and whether it can explain the behavior observed in different parts of the experiment. In the three main parts of the experiment, the inference is drawn based on their relative behavior in different raffles/lotteries in that part. It is reasonable to assume that the joy of winning does not change significantly for different raffles/lotteries in any part of the experiment which rules it out as a possible explanation for the difference in behavior. Described below is each part in more detail including the tables used. For further details please see the instructions sheet and z-tree screenshots.

Part 1 (Quizzes) Two quizzes with 3 questions each are framed in such a way that subjects understand the underlying game of raffle across the parts of the experiment and how to calculate the probability of winning, compute the payoffs upon winning and losing, and interchange notation of percentage and real number to express probability.

Part 2 (Experience) This part of the experiment aimed to give subjects some experience of the raffle game. In the first five rounds, subjects were matched in a fixed group of two players, and in the last five rounds, they were re-matched in a fixed group of three players. The subjects knew about the number of tickets they bought and the outcome at the end of each round.

Part 3 (Group Size Change) In this part of the experiment, four games of two periods each were played as shown in the table below. In the first two games, the group size was doubled in period 2 by amalgamating the two groups from period 1. In the last two games, the group size was decreased to half by splitting the groups formed in period 1. A separate screen was used to obtain the input for each game each period. In the first period of each game, subjects were told about what follows in period 2 and in the second period of the game subjects were told about what they choose in period 1. This is done to give them a perception of actual periods. The outcome of each game is presented only at the end of all the games in this part. This is done to avoid any impact of intermediate winning and losing during this part of the experiment. Subjects played Part 3 based on whatever understanding and learning they had by the end of Part 2. Table 1.4 below is used in the instructions sheet to describe this part of the experiment.

	Period 1					Period 2				
Game	No. of Participants	Choose No. Of Tickets You Want To Buy (0-100)	Your Tickets Total Cost	Prize	Probability of Winning Estimation	No. of Participants	Choose No. Of Tickets You Want To Buy (0-100)	Your Tickets Total Cost	Prize	Probability of Winning Estimation
G1	2	TI	TI	100	P1	4	T2	T2	100	P2
G2	3	T3	T3	100	P3	6	T4	T4	100	P4
G3	4	T5	T5	100	P5	2	T6	T6	100	P6
G4	6	T7	T7	100	P7	3	T8	T8	100	P8

Table 1.4: Design summary for Part 3

Part 4 (Response Curve) This part of the experiment aims to capture the response curve of the subjects. Subjects are presented with the pre-populated choice of the opponent in each of the six raffle games. Subjects are matched with another subject and all are given the same pre-populated choices to enter their choices against them. It is created in this way to give subjects a perception that they will be winning or losing against another subject rather than a computer. All the choices are entered on one screen. Table 1.5 below describes this part of the experiment.

Part 5 (Inverted Lotteries Sets) A brief description of the main features of this part is as follows. Three sets of lotteries are constructed each having the same prize value. Each set has nine lotteries to choose from with their probabilities ranging from 0.1 to 0.9. The variance and skewness are the same across the three lottery sets. The expected value is the same for all lotteries in LS 1. The expected

Raffle	Matched Participant's Fixed Tickets Choice	Your Tickets Choice (0-100)	Your Tickets Total Cost	Your Probability of Winning	Your Matched Participant's Probability of Winning	Prize
R1	10	T1	T1	T1/(T1 +10)	10/(T1 +10)	100
R2	20	T2	T2	T2/(T2 +20)	20/(T2 +20)	100
R3	40	T3	T3	T3/(T3 +40)	40/(T3 +40)	100
R4	60	T4	T4	T4/(T4 +60)	60/(T4 +60)	100
R5	80	T5	T5	T5/(T5 +80)	80/(T5 +80)	100
R6	100	T6	T6	T6/(T6 +100)	100/(T6 +100)	100

Table 1.5: Design summary for Part 4

value is highest for the first lottery (L1) in LS 2 and decreases towards the last lottery choice (L9). The expected value is highest for the last lottery (L9) in LS 3 which decreases towards the first lottery choice (L1). Table 1.6 describes this part of the experiment.

Lottery Table 1	Probability of Winning	Cost	Prize
L1	0.1	10.0	100
L2	0.2	20.0	100
L3	0.3	30.0	100
L4	0.4	40.0	100
L5	0.5	50.0	100
L6	0.6	60.0	100
L7	0.7	70.0	100
L8	0.8	80.0	100
L9	0.9	90.0	100

Lottery Table 2	Probability of Winning	Cost	Prize
L1	0.1	1.0	100
L2	0.2	14.0	100
L3	0.3	27.0	100
L4	0.4	39.0	100
L5	0.5	50.0	100
L6	0.6	61.0	100
L7	0.7	73.0	100
L8	0.8	86.0	100
L9	0.9	100.0	100

Lottery Table 3	Probability of Winning	Cost	Prize
L1	0.1	20.0	100
L2	0.2	26.0	100
L3	0.3	33.0	100
L4	0.4	41.0	100
L5	0.5	50.0	100
L6	0.6	59.0	100
L7	0.7	67.0	100
L8	0.8	74.0	100
L9	0.9	80.0	100

Table 1.6: Summary design for Part 5

Part 6 (Risk Preference) This part of the experiment aims to measure the risk aversion of the subjects using Holt and Laury (2002). Table 1.7 (Appendix) describes this part of the experiment.

6 Predictions

Following are the predictions for some parts of the experiment design. The order of the parts is changed compared to the one in the experiment to examine first the part which is central to our experiment.

Prediction 1 : In Part 5 (Inverted Lotteries Sets), if subjects are driven by EUM (smooth and continuous standard utility functions) and they are not risk-seeking then, irrespective of the risk preference, they will choose L1 in LS 2 and L9 in LS 3.

Prediction 2 : In Part 5 (Inverted Lotteries Sets), if subjects are driven by TPW then their choices will remain largely stable across all three lottery sets.

Prediction 3 : In Part 5 (Inverted Lotteries Sets), if subjects have a preference for positive skewness then they will choose lotteries in the upper half of the LS 1 and if they prefer negative skewness then they will choose in the lower half of the LS 1. This is because the expected value of all the lotteries in LS 1 is the same with variance decreasing as one moves away from the middle lottery. For any value of variance, there are two choices, one with positive skewness and the other with negative skewness.

Prediction 4 : In Part 4 (Response Curve), expected utility theory predicts that subjects' best response curve will be like the shape of a rightly skewed inverted parabola while TPW predicts that subjects' response will be in a straight line of the positive slope until they drop out. The below graph (Figure 1.8) shows the prediction of two competing theories for discrete values greater than equal to 10. The red curve is the response predicted by standard theory while other curves are based on subjects been driven by the TPW.

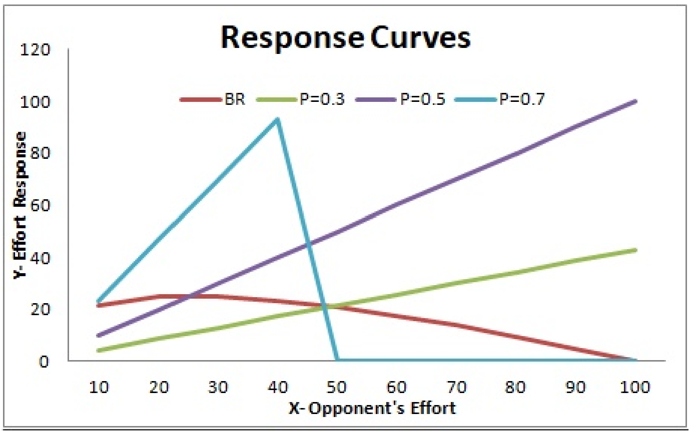

Figure 1.8: Best Response curve and TPW predictions

Prediction 5 : In Part 3 (Group Size Change), the expected utility theory predicts that subjects decrease their bid amount as the group size increases. Regarding TPW prediction, this depends on whether subjects increase or decrease their target probability of winning as the group size increases. TPW predicts an increase in bid amount if subjects do not decrease their minimum probability. The inference is drawn based on the direction of change rather than the point prediction.

7 Results

In this section, the main results of this experiment are briefly discussed. The results of each section will be covered in an order different from the experiment conducted; rather, the first parts are designed to make subjects understand followed by more degree of objectivity in other parts. First results are presented on how subjects performed in the Quizzes (Part 1) then the description of the behavior in Part 2 is designed to give experience to the subjects. Then the distribution of the risk-preference is measured in Part 6. Following this, choices made in Part 5 are analyzed which is central to this experiment. Subsequently, the qualitative behavior in Part 4 is studied. This is followed by an analysis of the impact of group size change on the bid amount and probability of winning of subjects in Part 3. As previously mentioned, all the results are based only on the choices of subjects who stated that they were clear about the instructions for that part of the experiment.

Part 1 (Quizzes) Quiz 1 and Quiz 2 each consist of 3 basic questions (see Instructions in Appendix) related to the underlying contests. Quiz 1 was followed by a detailed explanation of the answers before the start of Quiz 2 which has similar questions to those of Quiz 1. Table 1.9 shows the number of questions answered correctly. Out of 72, 62 subjects answered all the questions correctly in both the quizzes. In Quiz 1, 64 subjects answered all the questions correctly, which increased to 69 in Quiz 2. This suggests that almost all the subjects understood how to calculate the probability of winning and how to calculate payoff upon winning and losing.

Correct Answer1	Correct Answer2	Correct Answer3	Correct Answer4	Correct Answer5	Correct Answer6	Quiz1 All Correct	Quiz2 All Correct	All Correct
66	70	72	70	71	72	64	69	62

Table 1.9: Response summary for Quizzes

Part 2 (Experience) The average behavior of the subjects in the 10 rounds is given in Table 1.10 and the distribution of tickets (bid amount) is shown in Figure 1.11 (Appendix).

	Group Size 2: Raffle 1 Tickets	Group Size 2: Raffle 2 Tickets	Group Size 2: Raffle 3 Tickets	Group Size 2: Raffle 4 Tickets	Group Size 2: Raffle 5 Tickets	Group Size 3: Raffle 1 Tickets	Group Size 3: Raffle 2 Tickets	Group Size 3: Raffle 3 Tickets	Group Size 3: Raffle 4 Tickets	Group Size 3: Raffle 5 Tickets
Mean	33.1	34.0	35.1	37.2	33.4	31.7	32.7	30.4	32.8	32.9
Std. Dev	23.5	24.1	28.4	27.8	25.1	25.6	26.7	26.3	25.5	27.7
N	72	72	72	72	72	72	72	72	72	72
NE Prediction	25	25	25	25	25	22.2	22.2	22.2	22.2	22.2

Table 1.10: Summary of results in Part 2

Part 6 (Measuring Risk-Preference) Out of 72, 57 subjects were clear about the instructions for this part of the experiment and entered the choices which are valid[18]. The distribution of choices made is in Table 1.12. Very few subjects are found to be possibly risk-seeking (switching point ≤ 4).

Switching Point	4	5	6	7	8	9
Agents Count	5	9	15	16	11	1
CRRA Range	-0.15<r<0.15	0.15<r<0.41	0.41<r<0.68	0.68<r<0.97	0.97<r<1.37	1.37<r

Table 1.12: Risk distribution of subjects in Part 6

Part 5 (Inverted Lotteries Sets) In this part the choice behavior of decision-makers is examined and attempt to find if they are EUM or TPW. Further, it is examined if they prefer negative skewness over positive skewness. Out of 72, 56 subjects were clear about the instructions. Table 1.45 shows some statistics and distributions of the choices made in the three sets of lottery tables. Table 1.46 shows the choice distribution of the subjects in the three lottery sets.

As the lotteries in LS 2 and 3 follow second-order stochastic dominance and given that almost all subjects are either risk-averse or risk-neutral—as per expected utility theory predictions— subjects should choose L1 in LS 2 and L 9 in LS 3. Figure 1.13 shows the joint distribution of choices in LS 2 and LS 3.
Table 1.14 shows the classification of subjects into two main types (EUM & TPW). The variable Diff (LS3 - LS2) is the difference between the choice made in lottery set 3 and 2. If subjects are EUM, then the predicted difference in choices should be 8 (as subjects are not risk-seeking) while if their behavior is driven by TPW then the difference should be zero. The data shows that only 5% of subjects have made a choice such that $LS3 < LS2$ which strengthens the belief that subjects are not making the choices randomly. The direction of the stochastic dominant lottery appears to impact the choices of the subjects. From the frequency table of the difference in choices between LS 2 and 3, one can categorize the behavior as

[18] The choices are considered to be valid if the subject has switched only once with the order of switch from Option A to Option B and last choice as Option B.

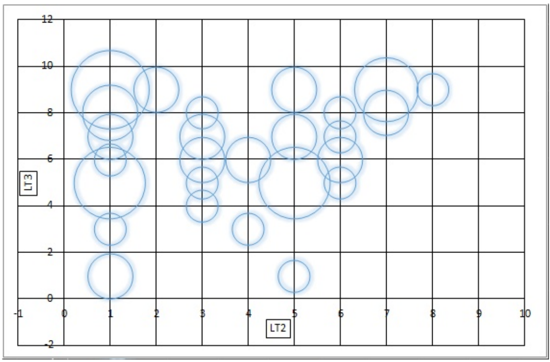

Figure 1.13: Joint distribution of choices in LS2 and LS3

Diff (LS3-LS2)	Frequency	%	Type Classification
-4	1	2%	
-3	0	0%	LS3<LS2
-2	0	0%	
-1	2	4%	
0	11	20%	
1	5	9%	TPW
2	11	20%	
3	2	4%	
4	9	16%	Others
5	2	4%	
6	2	4%	
7	5	9%	EU
8	6	11%	

Table 1.14: Classification of Types

follows: subjects with a difference of 0 to 2 are categorized as driven by the target probability of winning, while subjects with a difference of 6 to 8 are categorized as expected utility maximizers. The subjects with a difference of 3 to 5 are categorized as others. The proportion of the population is estimated in each category using maximum likelihood estimation and approximating it to normal distribution. Table 1.15 shows the estimated mean values of the proportion along with the confidence interval for each category.

Result 1 In Part 5 (Inverted Lotteries Sets), the proportion of subjects driven by expected utility maximization are approximately 23%. The criterion used for EUM classification is: any choice in LS 1 and difference in lottery choices between LS 2 and 3 is ≥ 6. The predicted difference is 8 as these lottery sets have dominant lotteries on opposite ends.

	n	$\hat{p}$	std error	confidence interval (95%) +/-
EU	13	0.23	0.06	0.11
TPW	27	0.48	0.07	0.13
Others	16	0.29	0.06	0.12

Table 1.15: Proportion estimation of each type in Part 5.

Result 2 In Part 5 (Inverted Lotteries Sets), the criterion for classifying an agent as TPW is the difference between the choices in LS 2 and 3 is less than equal to 2 (irrespective of choice in LS 1). This criterion takes TPW counts to 27 which is 48%.

Robustness Check

A robustness check is done using how many agents have LS 1 choices within the choices they made in LS 2 and 3, this criterion makes TPW agents count to 25 which is 45%. It is found that due to the choices of 2 subjects in LS 1 they are categorized as TPW based on the second criterion but not based on the first criterion.[19]

Another robustness check controls for possible status quo bias. Our definition of status quo bias is that agents make the same choices across LS 1 to 3 that is either all L4 or all L5 or all L6[20]. It reduces the estimate to 36%.

A further robustness check is to see if the decision rule holds for the subjects classified as TPW. What can falsify it? If subjects classified as TPW strongly respond to the cost difference between LS 2 and 3 at either end. Below is the graph (Figure 1.16) drawn for the smaller to middle probabilities TPWs and for middle to higher[21] probabilities TPWs. The difference is examined if it is correlated with the lottery number in LS 2. For smaller to middle probabilities lotteries, the graph is almost flat. For middle to higher probabilities lotteries, it seems that the difference increases as the probability increases. But one should notice the salience effect. Out of 7 L7 choices made in LS 2, the corresponding choices in LS 3 are L9 for 6 cases and L8 for 1 case. This shows that agents jump

[19]Note, pairwise comparison between two sets for consistency of type by categorizing TPW based on any two lottery sets and comparing it with the third lottery set is not appropriate as the first lottery set does not have any second-order stochastic dominant lottery.

[20]Note, any other lottery has different costs across the three lottery sets. For details see status quo bias under section Alternative Explanations

[21]Note, omitted are L8 and 9 in LS 2 because the difference between LS 3 and 2 cannot reach 2. If those are included then the regression line will be forced to be flatter.

to choice L9 in LS 3 due to salience which causes the positive slope but the R square explained is low.

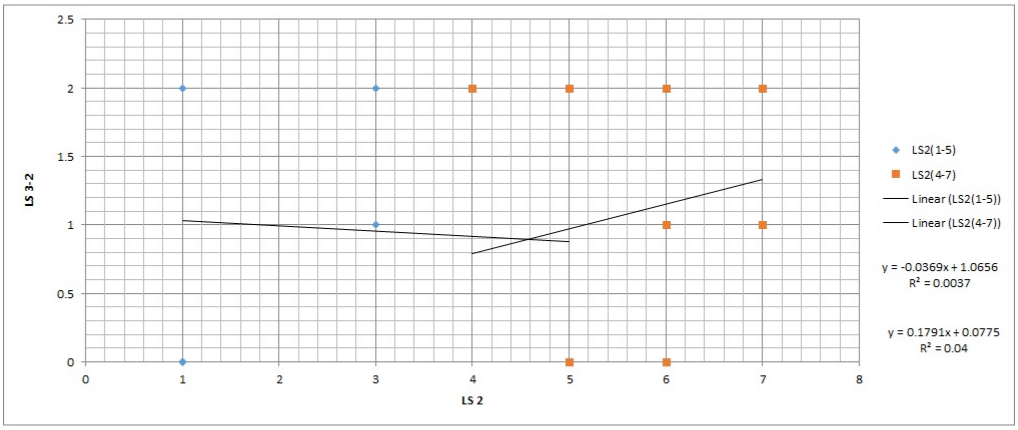

Table 1.16: Decision Rule Robustness

Result 3 In Part 5 (Inverted Lotteries Sets), the design of LS 1 helps to answer whether more subjects prefer positive skewness over negative skewness. Note, the measured values of risk aversion in Part 6 shows that almost all of the subjects are risk-averse. For subjects who are not risk-seeking, the CRRA utility is almost unchanged over the lotteries L 1-9 in LS 1 as shown in Table 1.19 (Appendix). From Table 1.20 the ratio of the population preferring negative skewness to positive skewness for each type can be calculated. The ratio (=1.5) is least for the EUM types and highest (=3.0) for TPW types.

Figure 1.21 shows the histogram of the choices in LS 1. It validates the assertion that subjects preferred positive skewness over negative skewness when the expected value and variance are the same. Note, it cannot be inferred that EUM subjects prefer positive or negative skewness per se. This is because the middle lotteries have relatively high variance which could be the reason why these subjects choose skewed lotteries. EUM types have the least proportion of preference for zero skewness. This serves as another robustness check that our classification of types is not arbitrary rather is directionally consistent with the theoretical predictions that the risk-averse subjects of EUM types should prefer positive skewness and largely prefer positive over negative. It still leaves the puzzle of why any EUM type prefers negative skewness at all, as it does not find its explanation in the theory. It could be that these subjects mostly have a utility function (for example, crra) such that there is no significant difference in utilities between positive and negative skewness options for a given variance in LS 1.
In Part 5, there is no certainty lottery option (probability of winning equals

Skew	EUM	TPW	Others	Total
+ve	31%	15%	19%	20%
0	23%	37%	44%	36%
-ve	46%	48%	38%	45%

Table 1.20: Distribution of preference for skewness in Lottery Set 1

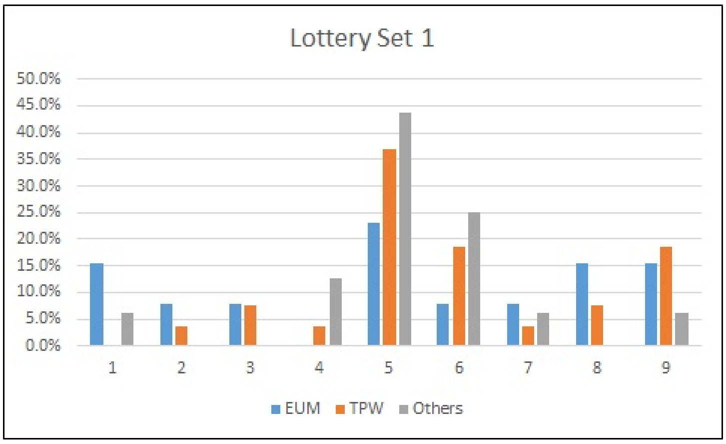

Figure 1.21: Histogram showing the preference for skewness in Part 5

0 or 1) in any lottery sets. This is done to avoid the first option in LS 2 and the last option in LS 3 with an abrupt change in distribution pattern in that lottery set. One drawback of an absence of certainty option in a lottery set is that subjects can choose lottery 1 in LS 2 and LS 3 because these are the least cost option preferred by subjects who do not want to play this game. The data indicate that there are no observations with all choices as L1 across lottery sets LS1-3.

Part 4 (Response Curve) The purpose of this part of the experiment is to understand the response curve of the subjects. Out of the total 72 subjects, 53 stated that they have clarity on the instructions for this part of the experiment. The results are shown in Table 1.22. The classification criterion used is as follows:

EU : If the subject first increases then decreases the bid amount, it is classified as an EU type. The qualitative shape of the response curve is the only criterion used for classification.

TPW : If the subject increases the bid amount (unless drops out) as the prepopulated bid amount of the opponent increases then she is classified as TPW type.

Others : If the subjects are difficult to classify into either of the two above types then they are grouped under the type Others.

	n	$\hat{p}$	std error	confidence interval (95%) +/-
EU	8	0.15	0.05	0.10
TPW	12	0.23	0.06	0.11
Others	33	0.62	0.07	0.13

Table 1.22: Proportion estimation of each type in Part 4.

Result 4 In experiment Part 4, the proportion of subjects driven by the target probability of winning (TPW) is approximately 23%, while the subjects driven by expected utility (EU) represent 15%.

The above qualitative classification (based on the manual observation) considers only responses that can be classified into one of the categories. The minimum probability can be estimated for the cases classified as TPW. The data for this part of the experiment is included in the Appendix (Table 1.47) for self-verification.

Part 3 (Group Size Change) Out of the total of 72 subjects, 63 stated that they have clarity on the instructions for this part of the experiment. Figure 2.24 (Appendix) illustrates the distribution of the difference in subjects' bid amount as the group size changes in the four games. The difference is calculated as the bid amount high group size minus low group size irrespective of the initial group size. The interest is in the direction of change in the bid amount (increases or decreases) in the four games rather than the point prediction. This is because the expected utility theory predicts a decrease in bid amount as group size increases and the target probability of winning conjecture predicts an increase in bid amount if subjects do not decrease their minimum probability.

Based on the direction of change in the four games, subjects are categorized as consistent if their direction of change was the same for at least three out of four games. Table 1.25 shows the number of subjects who are consistent in either direction, including no change, along with their measured risk preference. The number of subjects found consistent in the direction of change is the same for the increase and decrease, and their mean value of risk preference is similar. Out of the total of 63 subjects who have clarity on the instructions, 49 subjects are consistent. Note, that the probability of a behavior being classified as consistent when it is random is $(\frac{1}{3} \cdot \frac{1}{3} \cdot \frac{1}{3} =)\frac{1}{27}$ which is low.

	Consistent No Change	Consistent Decrease	Consistent Increase	Inconsistent
Agent Count	19	15	15	14
Mean Risk	6.6	6.4	6.7	6.1
Std. Dev.	1.4	1.2	1.2	1.2

Table 1.25: Number of subjects and risk for each consistency type.

Result 5 In Part 3, approximately 25% of subjects increase their bid amount in at least three of the four games as their group size decreases. Similarly, approximately 25% of subjects decrease their bid amount in at least three of the four games as their group size increases.

Result 6 In Part 3, 48 subjects are consistent in terms of their directional change (including no change). In Table 1.25 38 subjects are consistently decreasing their probability of winning (based on their judgment) upon an increase in the number of subjects in the game. In Table 1.27 14 subjects who decrease their bid amount and probability of winning upon the increase in the number of subjects in the game cannot be rejected as EUM types. 23 subjects either increase bid amount or probability of winning or both and cannot be rejected as TPW types.

Prob. change is consistent (no change)	Prob. change is consistent (decrease)	Prob. change is consistent (increase)	Prob. change is consistent
5	38	5	48

Table 1.27: Consistent change in probability of winning

	Prob. change is consistent (no change)	Prob. change is consistent (decrease)	Prob. change is consistent (increase)	Prob. change is consistent
Bid change is consistent (no change)	5	11	0	16
Bid change is consistent (decrease)	0	14	0	14
Bid change is consistent (increase)	0	7	5	12
Bid change is consistent	5	32	5	42

Table 1.28: Joint distribution of consistent change in probability of winning and bid amount

8 Part 5 Results - Alternative Explanation

Risk Aversion

There are many subjects classified as TPW choosing middle lotteries that have the least skewness, maximum variance and median expected values, which suggests that these subjects are not driven by any expected utility maximization but are targeting the probability of winning. Similar results are found in Edwards (1953, 1954) and in Tversky (1969) where it is presumed that subjects choose middle lotteries considering them as “fair bets”. The other subjects classified as TPW which have opted for choices corresponding to lower probabilities of winning can be rationalized as EUT only if they are risk-seeking. But, the measured risk aversion in Part 6 has a scale of monetary distribution higher than these individual lotteries and almost all of the subjects are found to be risk-averse. This implies any explanation assuming subjects have convex utility functions at these lower monetary distributions is inconsistent. The TPWs do not opt for the maximum probability of winning across lottery sets either, which could indicate that these subjects just want to win the game. It is not clear how and why they are targeting such a probability of winning. The subjects who are classified as intermediate (neither EUT nor TPW) are possibly the ones who value both expected utility and probability of winning (within this setup) as argued by Roy (1952).

Cumulative Prospect Theory

The design of lotteries in LS 2 and 3 being second-order stochastic dominant, TPW subjects are ruled out from being expected utility maximizers. One of the widely used descriptive models of risky choice is prospect theory. While the reference point of the individual in these models can be anything, the generally considered reference point is the subject’s endowment. The expected payoff is the subjective value of the two possible outcomes combined with their weighted probabilities. The probability weights will remain the same for any lottery across the lottery sets. If it can be shown that the stochastic order of the lotteries within each lottery set has some order for widely accepted parameters then it can be ruled out that the behavior can be explained using cumulative prospect theory. The functional forms used for the value function (v) and probability weighting functions (w+ and w-) are as proposed by Tversky and Kahneman (1992). Based on these value functions and standard parametric values the calculated expected value for the three lottery sets is as shown in Table 1.29-1.31. The expected value monotonically decreases before increasing. Thus, for a wide range of parametric values, the highest should be either the first lottery or the last lottery. Therefore, it seems that TPW cannot be explained using cumulative prospect theory, which concurs with the findings of Wu and Gonzalez (1996). Both the models are examined for the reference point as either 100 and 150.

alpha+	alpha-	l	gamma+	gamma-	x(+)^alpha+	x(-)^alpha-	w(p)	w(1-p)	Ev(x)
0.88	0.88	2.25	0.61	0.69	52	-8	0.19	0.77	-3.5
0.88	0.88	2.25	0.61	0.69	47	-14	0.26	0.67	-8.7
0.88	0.88	2.25	0.61	0.69	42	-20	0.32	0.59	-13.0
0.88	0.88	2.25	0.61	0.69	37	-26	0.37	0.52	-16.4
0.88	0.88	2.25	0.61	0.69	31	-31	0.42	0.45	-18.8
0.88	0.88	2.25	0.61	0.69	26	-37	0.47	0.39	-20.2
0.88	0.88	2.25	0.61	0.69	20	-42	0.53	0.33	-20.3
0.88	0.88	2.25	0.61	0.69	14	-47	0.61	0.26	-18.9
0.88	0.88	2.25	0.61	0.69	8	-52	0.71	0.17	-14.7

Table 1.29: Expected value (based on PT) of Lottery Set 1

alpha+	alpha-	l	gamma+	gamma-	x(+)^alpha+	x(-)^alpha-	w(p)	w(1-p)	Ev(x)
0.88	0.88	2.25	0.61	0.69	57	-1	0.19	0.77	8.9
0.88	0.88	2.25	0.61	0.69	50	-10	0.26	0.67	-2.2
0.88	0.88	2.25	0.61	0.69	44	-18	0.32	0.59	-10.2
0.88	0.88	2.25	0.61	0.69	37	-25	0.37	0.52	-15.5
0.88	0.88	2.25	0.61	0.69	31	-31	0.42	0.45	-18.8
0.88	0.88	2.25	0.61	0.69	25	-37	0.47	0.39	-20.9
0.88	0.88	2.25	0.61	0.69	18	-44	0.53	0.33	-22.4
0.88	0.88	2.25	0.61	0.69	10	-50	0.61	0.26	-22.9
0.88	0.88	2.25	0.61	0.69	0	-58	0.71	0.17	-22.0

Table 1.30: Expected value (based on PT) of Lottery Set 2

Discontinuous Value Function

Diecidue and Van (2008), based on experimental evidence in other papers (including Payne, 2005), theorize aspiration levels as a relevant aspect of decision making in value allocation tasks. They develop a model that includes the overall probabilities of success and failure relative to the aspiration level into an expected utility representation. This turns out to be equivalent to the expected utility with a discontinuous utility function. The discontinuous value function around the aspiration level as a reference point exhibits the extreme form of loss aversion. For two possible outcome prospects that involve the aspiration level, the model shows that subjects are always risk-averse from above and risk-seeking

alpha+	alpha-	l	gamma+	gamma-	x(+)^alpha+	x(-)^alpha-	w(p)	w(1-p)	Ev(x)
0.88	0.88	2.25	0.61	0.69	47	-14	0.19	0.77	-15.5
0.88	0.88	2.25	0.61	0.69	44	-18	0.26	0.67	-15.0
0.88	0.88	2.25	0.61	0.69	40	-22	0.32	0.59	-15.8
0.88	0.88	2.25	0.61	0.69	36	-26	0.37	0.52	-17.2
0.88	0.88	2.25	0.61	0.69	31	-31	0.42	0.45	-18.8
0.88	0.88	2.25	0.61	0.69	26	-36	0.47	0.39	-19.4
0.88	0.88	2.25	0.61	0.69	22	-40	0.53	0.33	-18.2
0.88	0.88	2.25	0.61	0.69	18	-44	0.61	0.26	-14.8
0.88	0.88	2.25	0.61	0.69	14	-47	0.71	0.17	-8.2

Table 1.31: Expected value (based on PT) of Lottery Set 3

from below. The functional form of the model is given as:

$$V(x) = \sum_{j=1}^{n} p_j u(x_j) + \mu P(x+) - \lambda P(x-)$$

where
n is the number of prospects which in our case is 2 for every lottery (L)
p_j is the probability of prospect j,
$u(x_j)$ is the utility of prospect x_j,
$P(x+)$ is the overall probability of success,
$P(x-)$ is the overall probability of failure,
$\mu, \lambda \in \mathbb{R}^+$
and aspiration level is taken as zero (there is no endowment in the value allocation task)

The above functional form for our set-up of two possible outcomes with endowment as aspiration level

$$V(x) = pv(x+) + (1-p)v(x-) + \mu P(x+) - \lambda P(x-)$$

where
$v(x+) = x+^{0.88}$,
$v(x-) = x-^{0.88}$,
and other notations are as defined as above

Can it explain the TPW behavior? Irrespective of the parameters of the overall gain and overall loss probabilities (the last two parts of the equation above), it can be said that as one move from top to bottom lotteries (in all three lottery sets) the net value from this part of the functional form increases monotonically.

Based on the first two components of the value function and parametric values used above it can be seen (as shown in Table 1.32-1.34) that the expected value almost monotonically increases in LS 1 and 3 and monotonically decreases in LS 2. When the values from all four parts of the value function will be combined, it will give the last lottery (and not middle lotteries) in LS 1 and 3 as the preferred choice for a range of parametric values which is not supported by the experimental data.

Lottery Set 1	p	Cost	Prize	EV	Var	Skew	alpha+	alpha-	v(x+)=x(+)^ alpha+	v(x-)=x(-)^ alpha-	P(x+)	P(x-)	V(x)
L1	0.1	10.0	100	100	900	2.7	0.88	0.88	52	-8	0.10	0.90	-1.6
L2	0.2	20.0	100	100	1600	1.5	0.88	0.88	47	-14	0.20	0.80	-1.7
L3	0.3	30.0	100	100	2100	0.9	0.88	0.88	42	-20	0.30	0.70	-1.3
L4	0.4	40.0	100	100	2400	0.4	0.88	0.88	37	-26	0.40	0.60	-0.7
L5	0.5	50.0	100	100	2500	0.0	0.88	0.88	31	-31	0.50	0.50	0.0
L6	0.6	60.0	100	100	2400	-0.4	0.88	0.88	26	-37	0.60	0.40	0.7
L7	0.7	70.0	100	100	2100	-0.9	0.88	0.88	20	-42	0.70	0.30	1.3
L8	0.8	80.0	100	100	1600	-1.5	0.88	0.88	14	-47	0.80	0.20	1.7
L9	0.9	90.0	100	100	900	-2.7	0.88	0.88	8	-52	0.90	0.10	1.6

Table 1.32: Expected value (based on Diecidue and Van (2008)) of Lottery Set 1

Lottery Set 2	p	Cost	Prize	EV	Var	Skew	alpha+	alpha-	v(x+)=x(+)^ alpha+	v(x-)=x(-)^ alpha-	P(x+)	P(x-)	V(x)
L1	0.1	1.0	100	109	900	2.7	0.88	0.88	57	-1	0.10	0.90	4.8
L2	0.2	14.0	100	106	1600	1.5	0.88	0.88	50	-10	0.20	0.80	1.9
L3	0.3	27.0	100	103	2100	0.9	0.88	0.88	44	-18	0.30	0.70	0.4
L4	0.4	39.0	100	101	2400	0.4	0.88	0.88	37	-25	0.40	0.60	-0.2
L5	0.5	50.0	100	100	2500	0.0	0.88	0.88	31	-31	0.50	0.50	0.0
L6	0.6	61.0	100	99	2400	-0.4	0.88	0.88	25	-37	0.60	0.40	0.2
L7	0.7	73.0	100	97	2100	-0.9	0.88	0.88	18	-44	0.70	0.30	-0.4
L8	0.8	86.0	100	94	1600	-1.5	0.88	0.88	10	-50	0.80	0.20	-1.9
L9	0.9	100.0	100	90	900	-2.7	0.88	0.88	0	-58	0.90	0.10	-5.8

Table 1.33: Expected value (based on Diecidue and Van (2008)) of Lottery Set 2

Lottery Set 3	p	Cost	Prize	EV	Var	Skew	alpha+	alpha-	v(x+)=x(+)^ alpha+	v(x-)=x(-)^ alpha-	P(x+)	P(x-)	V(x)
L1	0.1	20.0	100	90	900	2.7	0.88	0.88	47	-14	0.10	0.90	-7.8
L2	0.2	26.0	100	94	1600	1.5	0.88	0.88	44	-18	0.20	0.80	-5.2
L3	0.3	33.0	100	97	2100	0.9	0.88	0.88	40	-22	0.30	0.70	-3.0
L4	0.4	41.0	100	99	2400	0.4	0.88	0.88	36	-26	0.40	0.60	-1.3
L5	0.5	50.0	100	100	2500	0.0	0.88	0.88	31	-31	0.50	0.50	0.0
L6	0.6	59.0	100	101	2400	-0.4	0.88	0.88	26	-36	0.60	0.40	1.3
L7	0.7	67.0	100	103	2100	-0.9	0.88	0.88	22	-40	0.70	0.30	3.0
L8	0.8	74.0	100	106	1600	-1.5	0.88	0.88	18	-44	0.80	0.20	5.2
L9	0.9	80.0	100	110	900	-2.7	0.88	0.88	14	-47	0.90	0.10	7.8

Table 1.34: Expected value (based on Diecidue and Van (2008)) of Lottery Set 3

Non-Standard Weighting Functions

Can non-standard weighting functions explain this experimental data. To answer this take three weighting functions—one which has abrupt jump ($w(p) = 0$ for $p <= p'$ & $w(p) = 1$ for $p > p'$), another which has concave smooth jump ($w(p) = 0$ for $p <= p'$ & $w(p) = p^{0.5}$ for $p > p'$) and another which has convex smooth jump ($w(p) = 0$ for $p <= p'$ & $w(p) = p^2$ for $p > p'$). The concave and convex functions are chosen to be able to judge a combined weighting function for any arbitrary switching point to give a general weighting function. A general weighting function is convex for a range of small probabilities and concave above that. This is done for three values of loss aversion parameter (l=1, 1.75 and 2.25) and a set of jump probabilities (p'={0.1, 0.2, 0.3, 0.4, 0.5, 0.6}). The predictions of the EUM and CPT models are calculated with these weighting functions.

The prediction for the EUM model is calculated with the subjective perception for winning defined as per the weighting function and the remaining probability for losing. This indicates that the abrupt and concave weighting function gives a prediction that is the same as TPW, while convex weighting predicts the first or the last lottery as the highest value. Note, in general, weighting functions are found to be concave for small probabilities and convex for large probabilities. Also, what drives the prediction in the abrupt model is the increasing cost as all probabilities below the jump point are perceived to be zero. Similarly, a CPT model with an abrupt jump and reference point as zero (or below) also gives the same prediction as that of TPW.

A CPT model with the above weighting functions and endowment (=100) as the reference point predicts behavior similar to TPW around lotteries L6-9 regardless of p at which jump is taken as shown in Table 1.35. This is a limited range and as one can see the middle lottery (L5) which has the highest proportion in experimental data is not predicted. This feature seems to be robust for a range of parameters as what is driving this result is the fact that for $p < p'$ only negative values will be reflected in the expected value of a value function.

Weighting Function Type														
	Abrupt Jump				Smooth Concave Jump						Smooth Convex Jump			
p<=p' then w(p)= 0, otherwise w(p)=1					p<=p' then w(p)= 0, otherwise w(p)=p^(0.5)					p<=p' then w(p)= 0, otherwise w(p)=p^(2)				
Eg: p<=0.1 then w(p)= 0, otherwise w(p)=1					Eg: p<=0.1 then w(p)= 0, otherwise w(p)=p^(0.5)					Eg: p<=0.1 then w(p)= 0, otherwise w(p)=p^(2)				
Prediction														
p'						p'					p'			
0.1		TPW	L2			0.1		EUM			0.1		TPW	L8,9
0.2		TPW	L8; l=2.25			0.2		TPW	L8		0.2		TPW	L8,9
		EUM	l=1.75											
0.3		TPW	L7			0.3		TPW	L7		0.3		TPW	L7
0.4		TPW	L6			0.4		TPW	L6		0.4		TPW	L6,7
0.5		TPW	L6			0.5		TPW	L6		0.5		TPW	L6,7
0.6		TPW	L7			0.6		TPW	L7		0.6		TPW	L7

Table 1.35: Jump Weighting Function

Priority Heuristics

Brandstatter, Gigerenzer and Hertwig (2006) generalize the framework of fast and frugal heuristics as the priority heuristic can explain many experimental pieces of evidence that are different from expected utility maximization. It does so in gambling environments that were designed to demonstrate the empirical validity of theories of risky choice that assume both weighting and summing. It is a simple heuristic that forgoes summing and therefore does not make trade-offs. It proposes the priority rule of reasons in the order of minimum gain, probability of minimum gain, maximum gain and probability of maximum gain. Although it is clearly stated that the priority heuristics does not apply in cases where one of the gambles dominates the other, in general, it predicts the top lottery to be chosen as both the minimum amount and the probability of minimum amount are higher than the immediate lower lottery.

Status Quo Bias

The simplicity of this design is that only one dimension (cost) changes across the sets which makes a comparison of the lottery within the set and across the sets easy. Still, the status quo bias due to decision avoidance (Dean, 2008) can be conjectured as a possible reason for subjects classified as TPW who chose the same lottery across lottery sets. Except for middle lottery L5, all lotteries across the lottery sets are different. One can consider L4 and L6 to be close enough across the lottery sets. Considering these three lotteries to be the same across the three lottery sets, there is a total of 7 subjects who chose these lotteries. These subjects could also be considered as targeting cost or making choices considering these lotteries as 'fair' (Tversky, 1969). If all these subjects are considered not to be TPW, then it reduces the estimate to 36%.

Security-Potential/Aspiration Theory

SP/A dual criterion theory that combines a decumulative weighting process (the security potential part of SP/A) with a process that maximizes the probability of achieving an aspiration level describes both preferences and reasoning patterns across a wide variety of behavioral phenomena. This model captures the idea of the probability of attaining a certain aspiration level as one of the dual criteria used for decision-making. It can be thought that subjects aspire to win (receive the outcome higher than endowment) in the two possible outcome games rather than aspiring to any specific value. Unlike this model, TPW subjects are cost-sensitive. This can be confirmed from the choices that the TPW subjects make in LS 3 where the lowest lottery (L9) has maximum expected utility and highest probability of winning but all these subjects do not make it as their choice possibly because its cost is highest in that set.

Spiteful Behavior

Herrmann and Orzen (2008) investigate the importance of spiteful rivalry in Tullock contests. In the Fehr-Schmidt model, spiteful agents dislike disadvantageous inequality but enjoy advantageous inequality. They find subjects overinvest to some extent even in decision tasks when there are no other players and social preferences can play no role. This is similar to the results in the main design of this experiment. In another task, the best response function for each player is elicited in a one-shot setting. The difference in response curves — increasing vs hump-shaped — is attributed to spite and excessive rivalry between players. In this experiment, both the results, that is, decision task in main design with probabilities and response curves (more like a decision task) are explained by the same underlying behavior types. The increasing response curve is classified as TPW and the humped-shaped response curve as EUMs. This makes the inference of behavior types as TPW and EUMs more robust.

9 Discussion

The support for TPW is found with a clearer main task that can separate EUMs from TPWs and some important alternative explanations for the choices made. The risk preference measured helps to rule out risk-based residual explanations for such behavior. Similarly, these tasks help to rule out other possible explanations in the literature like joy-of-winning, CPT, discontinuous value function, status quo bias, SP/A, priority heuristics as discussed in Section 1.8. Non-standard weighting functions are simulated. While these weighting functions are conceptually different than TPW these do support the possibility of such choices being optimized behavior. There is also supportive evidence for these behavioral types in contests tasks tested.

This chapter contributes to decision-making literature in risky choices including areas in lotteries, lottery-like financial decision making and winner-take-all competitions. Some more specific applied areas for illustration purposes are as follows. It can contribute to the literature on pricing by measuring the trade-offs between risk dimensions, for example, a salesperson deciding on how much minimum secret discount to offer a customer to make a B2B sales in a limited information environment. Similarly, it can contribute to the literature on salary negotiation in a market with structural differences like perceived taste-based and statistical discrimination.

Further to above, we would suggest that this decision-making approach holds wherever there is a possibility where subjects can trade-off the chance of winning with the cost and the two possible outcomes are winning and losing. Subjects would follow this decision-making irrespective of whether it increases or decreases the expected payoff. This can be seen in Part 5 (LS 3) where lower lotteries have a higher probability of winning as well as a higher expected value, these subjects do not choose the last lottery. This shows that their behavior is primarily driven by two of the basic dimensions of the game which are a probability of winning and cost, with priority given to the probability of winning up to a target and then to the cost. This is in line with the results in Slovic and Lichtenstein (1968) but is different from the priority heuristic in Brandstatter, Gigerenzer and Hertwig (2006). In this experimental design, the trade-offs are with cost. Lottery buying in a syndicate is an example of a trade-off with the size of the prize. Similarly, trade-offs with other risk dimensions can be studied with different designs.

A one-shot game provides a starting point to investigate the underlying decision-making approach; however, there are a number of ways in which further research could address the limitations of the present research. The parts of this experiment could be extended further as a repeated game with and without intermediate feedback to examine any difference in behavior. Further studies are required to understand the general decision-making process of these subjects who are being classified as TPW type which can answer how and why these subjects make such decisions of the target probability of winning and the theoretical equilibrium predictions are in the presence of these types.

To robustly corroborate the results one can design an experiment with a series of lotteries which are transformations of LS 1-3 for a fixed common value prize and endowment. If subjects make choices in 20 such lotteries (LS 1-3), this can allow for more robust statistical tests. Additionally, a graphical alternative of the above design, which can help understand how subjects choose TPW, could be achieved by giving subjects various cost vs probability of winning ($p=f(c)$) graphs for a fixed common value prize and endowment. The pattern of their choices across various such graphs can reveal if they have a kink or can offer insights into how they value a probability of winning and cost.

Another design that uses equivalent designs of LS 1-3 with cost and prize replaced by values of two possible outcomes can be used to test the generality of the result by changing the context. Such a design can have different results due to a change in frame. The frame of two possible positive outcomes (without any endowment) is in the gain domain while the present framing is in the mixed domain if subjects have endowment as a reference point.

To further test the robustness the sequence of lotteries can be randomized in every lottery set (in Part 5) such that no lottery is at the same row across the lottery sets. This can filter out the possibility that subjects merely choose a row of a position on the computer screen. Nevertheless, this might make comparing lotteries difficult/costly for subjects.

For empirical validation, one can collect applications for the position of assistant professors in top universities and one stratum lower-ranking universities. These applications are generally costless other than the manual effort of applying. The distribution of applications from all strata of universities can be examined to see if students generally fail to even apply to relatively higher-ranking universities where they believe that they will not get through. Similarly, applications for any other competitive positions where application cost is low can be examined.

Much remains unknown about TPW behavioral types. Venkatraman, Payne and Huettel (2014) and Zeisberger (2016) have labeled it as a heuristic. We propose to repeat the experiments (those of Venkatraman et al. (2014) and our main design) by giving subjects a calculator in one treatment and with additional information on statistical moments in another treatment. If the proportion of these types do not fall considerably then one needs to run a series of designs to further investigate how these subjects approach such decisions. Based on the present results it is not clear whether this decision-making approach is being used by the subjects (who are classified as TPW) as a heuristic (see, for example, Tversky and Kahneman, 1973; Tversky and Kahneman, 1974) or more of these subjects choosing higher probabilities is a reflection of behavioral tendencies which in real-life might give some evolutionary (survival) advantage. The non-standard jump weighting functions predictions are similar to TPW, showing that the decision-making approach can also be viewed as optimization. In this experimental design, incentive-based joy-of-winning is not captured. One can do this and correlate it with the TPW types. It can give insight into the question if both types might have a similar evolutionary origin.

In the next chapter, we show that the decision rule has utility representation and how agents may learn in a severely limited information environment of repeated contests when driven by TPW. The reinforcement learning model predictions track the experimental data available from other studies reasonably well. This strengthens support for TPW.

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10 Appendix

10.1 News and Social Media Posts

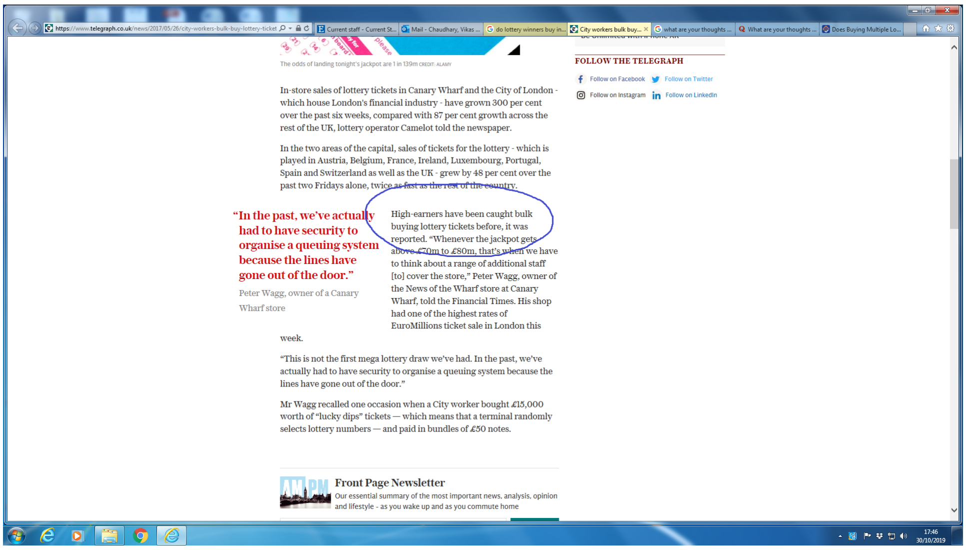


Figure 1.36: Individuals buying in bulk.

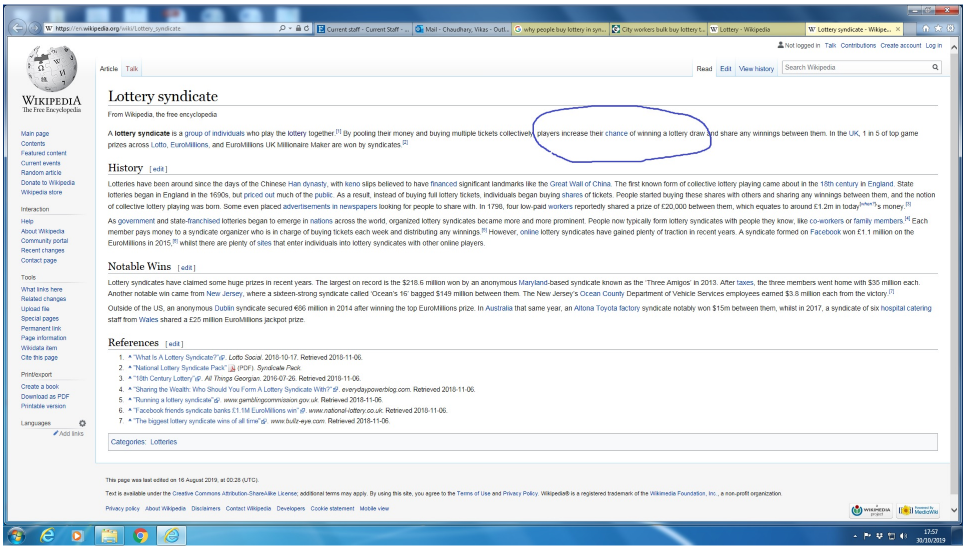


Figure 1.37: Individuals buying in syndicate.

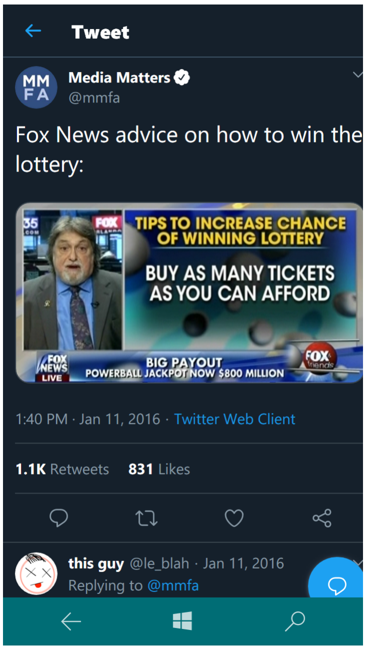


Figure 1.38: Media promoting bulk buying.

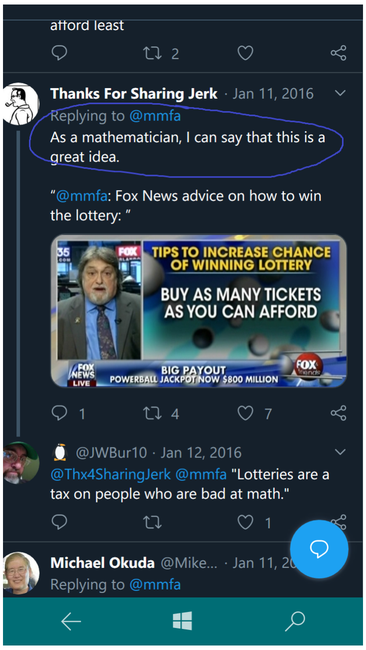


Figure 1.39: Individual response to media promoting bulk buying 1.

Figure 1.40: Individual response to media promoting bulk buying 2.

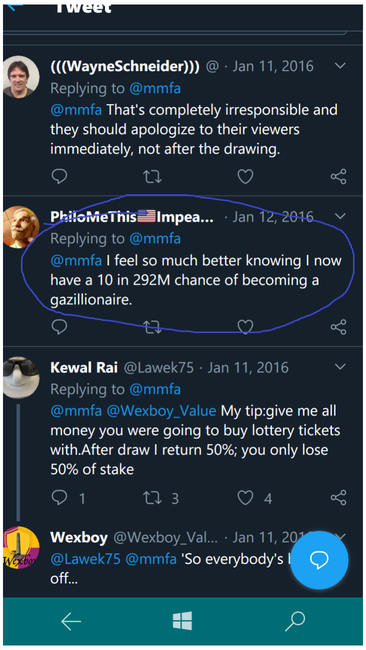


Figure 1.41: Individual response to media promoting bulk buying 3.

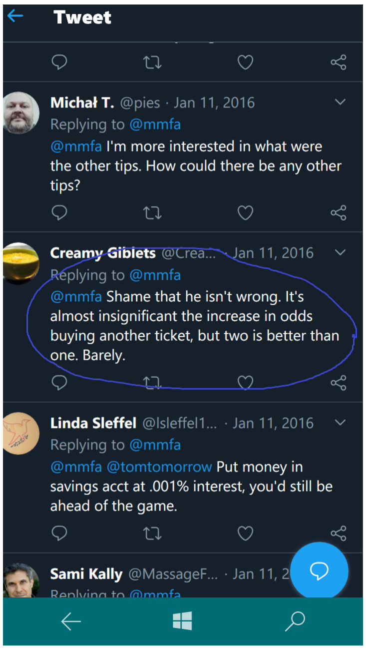


Figure 1.42: Individual response to media promoting bulk buying 4.

10.2 Further Charts and Data

Decision	Option A				Option B			
	Pr A1	A1	Pr A2	A2	Pr B1	B1	Pr B2	B2
D1	0.1	100	0.9	80	0.1	193	0.9	5
D2	0.2	100	0.8	80	0.2	193	0.8	5
D3	0.3	100	0.7	80	0.3	193	0.7	5
D4	0.4	100	0.6	80	0.4	193	0.6	5
D5	0.5	100	0.5	80	0.5	193	0.5	5
D6	0.6	100	0.4	80	0.6	193	0.4	5
D7	0.7	100	0.3	80	0.7	193	0.3	5
D8	0.8	100	0.2	80	0.8	193	0.2	5
D9	0.9	100	0.1	80	0.9	193	0.1	5
D10	1	100	0	80	1	193	0	5

Table 1.7: Summary design for Part 6

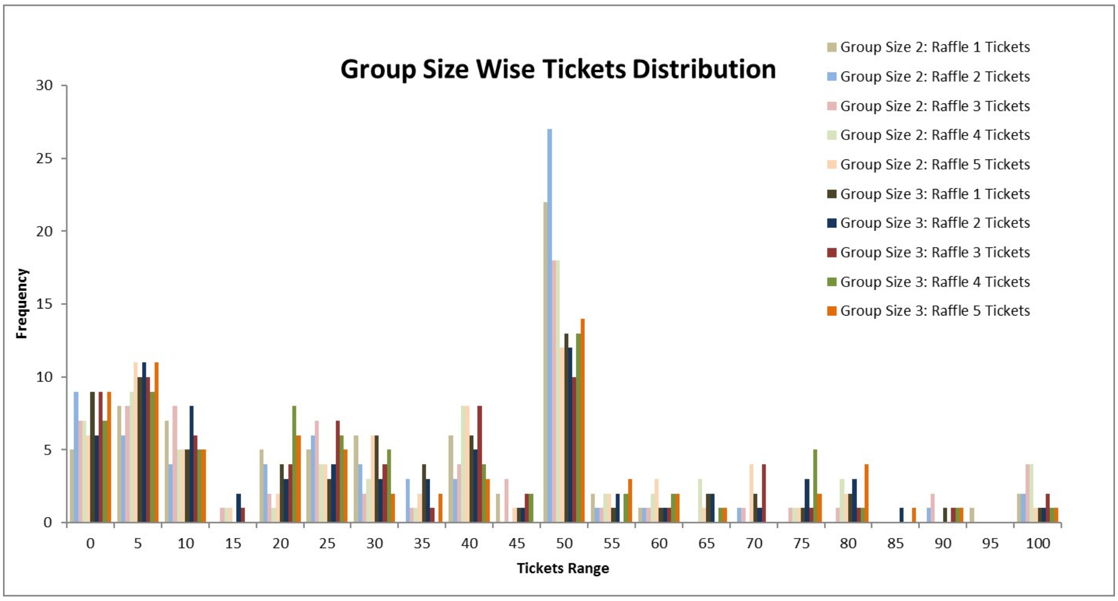


Figure 1.11: Tickets distribution in Part 2

Lottery Set 1										
	Cost	10.0	20.0	30.0	40.0	50.0	60.0	70.0	80.0	90.0
r	p	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
-1		5450.0	5800.0	6050.0	6200.0	6250.0	6200.0	6050.0	5800.0	5450.0
-0.9		3570.8	3767.7	3910.8	3999.3	4032.4	4009.0	3927.9	3787.7	3586.3
-0.8		2348.9	2458.3	2539.2	2590.7	2611.9	2601.7	2558.7	2481.1	2366.6
-0.7		1551.7	1611.6	1656.6	1686.1	1699.3	1695.3	1672.9	1630.7	1566.7
-0.6		1029.8	1061.9	1086.4	1103.0	1110.9	1109.7	1098.4	1076.0	1040.9
-0.5		686.9	703.6	716.6	725.6	730.2	730.1	724.6	713.0	694.3
-0.4		460.7	469.1	475.7	480.4	482.9	483.1	480.6	474.9	465.3
-0.3		310.9	314.8	318.0	320.3	321.6	321.8	320.7	318.1	313.5
-0.2		211.2	212.9	214.2	215.2	215.8	216.0	215.6	214.5	212.5
-0.1		144.7	145.2	145.6	145.9	146.1	146.2	146.1	145.8	145.2
0		100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
0.1		69.9	69.7	69.5	69.4	69.3	69.2	69.3	69.4	69.6
0.2		49.5	49.2	49.0	48.8	48.7	48.6	48.7	48.8	49.1
0.3		35.6	35.4	35.2	35.0	34.9	34.8	34.8	34.9	35.2
0.4		26.2	26.0	25.8	25.7	25.6	25.5	25.5	25.6	25.8
0.5		19.8	19.7	19.5	19.4	19.3	19.3	19.2	19.3	19.5
0.6		15.6	15.5	15.4	15.3	15.3	15.2	15.2	15.2	15.4
0.7		13.2	13.1	13.0	12.9	12.9	12.8	12.8	12.9	13.0
0.8		12.5	12.4	12.4	12.3	12.3	12.2	12.2	12.2	12.3
0.9		15.8	15.8	15.7	15.7	15.6	15.6	15.6	15.6	15.7
0.95		25.1	25.1	25.1	25.0	25.0	25.0	25.0	25.0	25.0

Table 1.19: CRRA utility values with different risk preference for each lottery in Lottery Set 1

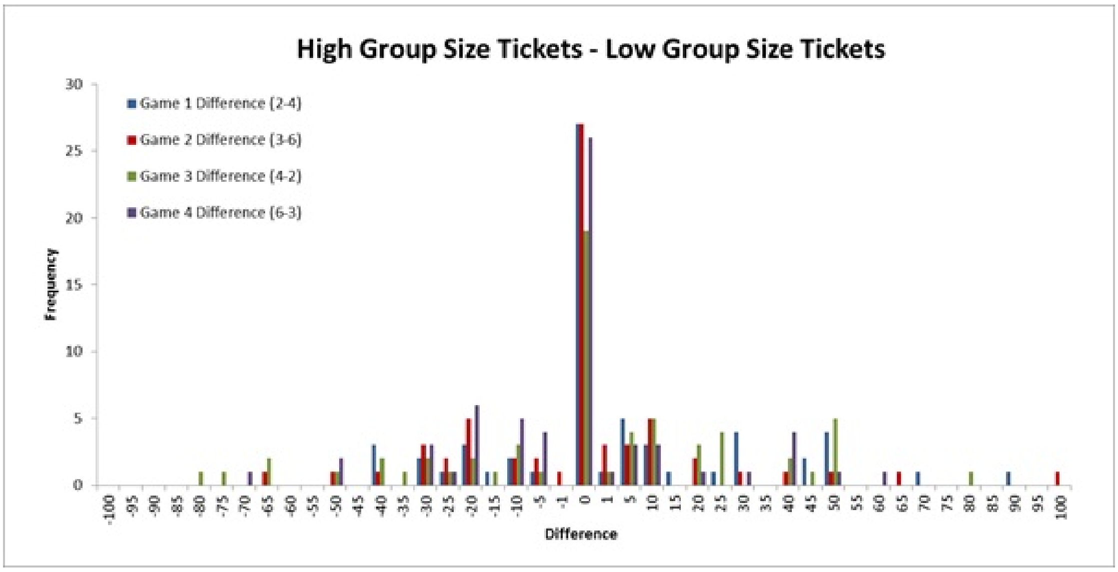


Figure 1.24: Distribution of difference in bid amount with change in group size.

Mean	15.7
Median	15.5
Mode	15.0
Standard Deviation	1.8
Kurtosis	0.0
Skewness	-0.1
Minimum	10.5
Maximum	19.5
Count	72

Table 1.43: Descriptive statistics of the payment subjects received.

Winning Utility	Agent Count
not at all	35
somewhat	30
very much	5
absolutely: winning at any cost	2

Table 1.44: Distribution of winning utility of subjects.

	LS1	LS2	LS3	Diff (LS3-LS2)
Mean	5.5	3.6	6.6	3.0
Standard Deviation	2.1	2.5	2.2	3.0
Confidence Level(95.0%)	0.6	0.7	0.6	0.8
N	56	56	56	56

Table 1.45: Summary statistics of choices in three lottery sets in Part 5

Lottery	LS1	LS2	LS3
1	3	20	3
2	2	2	0
3	3	7	2
4	3	3	1
5	20	10	12
6	10	5	7
7	3	6	7
8	4	1	7
9	8	2	17

Table 1.46: Choice distribution of three lottery sets in Part 5

10.3 Risk Aversion for Part 5, 4 and 3

We further state and test predictions if the difference between TPW and EUM can be explained by the difference in measured risk preferences of these subjects as stated below.

Prediction 6 : In Part 5 (Inverted Lotteries Sets), if TPW is a conceptually different way of decision making then the measured risk aversion of the subjects should not be able to explain the difference in their classification as EUM and TPW.

Prediction 7 : In Part 4 (Response Curve), if TPW is a conceptually different way of decision making then the measured risk aversion of the subjects should not be able to explain the difference in their classification as EUM and TPW.

Prediction 8 : In Part 3 (Group Size Change), if TPW is a conceptually different way of decision making then the measured risk aversion of the subjects should not be able to explain the difference in their classification as EUM and TPW.

Result for Prediction 6 In Part 5 (Inverted Lotteries Sets), the risk preference for each type is shown in Table 1.17. It appears that for the type TPW (0,2) the mean value of risk preference is lower than the type EU (6,8). Wilcoxon Rank-Sum test is not able to reject that both the samples are taken from the same distribution. The calculation for the test is shown in Table 1.18

Diff (LS3 - LS2)	[-4,-1]	[0,2]	[3,5]	[6,8]
Agent Count	3	27	13	13
Mean Risk	6.0	6.1	6.8	6.5
Std Dev.	1.0	1.2	1.4	1.5

Table 1.17: Mean risk of each type in Part 5

Type	Ties Adjusted Rank Sum	Count	2-Tailed Critical Values
EU	295	13	
TPW	525	27	
Output from R			
Wilcoxon rank sum test with continuity correction			
data: eu and tpw			
W = 204, p-value = 0.4076			
alternative hypothesis: true location shift is not equal to 0			

Table 1.18: Wilcox Risk Difference between EU and TPW Part 5

Result for Prediction 7 In experiment Part 4 the measured risk aversion can't explain the difference in choices made by the types of subjects. Table 1.23 shows the mean risk for each category and the result of the significance test of difference in the mean risk for each category.

	EU	TPW	Others
Agent Count	8	12	33
Mean Risk	6.3	6.3	6.4
Std Dev	0.9	1.4	1.1

Table 1.23: Mean risk for each type in Part 4

Result for Prediction 8 In Part 3, the measured risk aversion can't explain the difference in choices made by the types of subjects. In the below table we see the mean risk for each category. Wilcoxon Rank-Sum test (Table 1.26) can't reject that both the samples are taken from the same distribution.

Type	Count	Ties Adjusted Rank Sum	2-Tailed Critical Values
Decrease	15	218	184, 281
Increase	15	247	

Table 1.26: Wilcox risk difference between increase and decrease consistency type Part 3

Session	Subject	Part4 Clarit	Part6 Clarit	Valid order	risk factor{R }	adjusted {R}	Raffle 1 (10)	Raffle 2 (20)	Raffle 3 (40)	Raffle 4 (60)	Raffle 5 (80)	Raffle 6 (100)	EU	TPW	Decreasing	Flat	Other	Max Cost Part 4	Min Cost Part 4	Cost Variation Part 4
1	1	1	1	0	6	6.36	90	80	60	40	20	0			1			90	0	90
1	2	1	1	1	6	6	30	30	25	20	20	15			1			30	15	15
1	3	1	1	1	5	5	11	21	41	1	1	1		1				41	1	40
1	6	1	1	1	8	8	50	50	0	0	0	0					1	50	0	50
1	7	1	1	1	6	6	20	40	75	70	20	10	1					75	10	65
1	8	1	1	1	7	7	10	20	40	60	80	100		1				100	10	90
1	10	1	1	1	7	7	0	0	0	0	0	0				1		0	0	0
1	11	1	1	1	5	5	20	40	40	0	0	0					1	40	0	40
1	12	1	1	1	6	6	40	35	55	40	15	20	1					55	15	40
1	16	1	1	1	5	5	20	40	50	0	0	0		1				50	0	50
1	17	1	1	1	4	4	90	80	60	40	20	100			1			100	20	80
1	18	1	1	1	7	7	100	80	60	40	20	10			1			100	10	90
1	19	1	1	0	5	6.36	5	5	5	7	7	0				1		7	0	7
1	20	1	1	0	5	6.36	30	40	50	30	35	10	1					50	10	40
1	21	1	1	1	6	6	25	50	50	75	80	100		1				100	25	75
1	22	1	1	1	7	7	50	60	60	50	30	20			1			60	20	40
1	23	1	1	1	7	7	50	50	50	50	50	50				1		50	50	0
1	24	1	1	1	6	6	100	80	60	40	20	10			1			100	10	90
2	1	1	1	1	8	8	40	60	90	0	0	0		1				90	0	90
2	2	1	1	1	7	7	50	50	10	10	10	10					1	50	10	40
2	3	1	1	1	8	8	25	25	25	25	25	50				1		50	25	25
2	4	1	1	1	7	7	20	20	20	15	5	5			1			20	5	15
2	5	1	1	1	5	5	20	40	50	10	10	10	1					50	10	40
2	6	1	1	1	8	8	10	5	5	5	5	5				1		10	5	5
2	7	1	1	1	8	8	45	50	45	0	0	0				1		50	0	50
2	8	1	1	1	7	7	50	50	60	40	50	50				1		60	40	20
2	10	1	1	1	7	7	20	30	50	60	90	100		1				100	20	80
2	11	1	1	1	6	6	1	1	1	1	1	1				1		1	1	0
2	13	1	1	1	6	6	50	50	0	0	0	0				1		50	0	50
2	14	1	1	1	6	6	25	25	25	25	25	25				1		25	25	0
2	18	1	1	1	6	6	40	40	40	0	0	0				1		40	0	40
2	19	1	1	1	7	7	10	10	10	10	10	10				1		10	10	0
2	21	1	1	1	4	4	0	0	0	0	0	0				1		0	0	0
2	22	1	1	0	6	6.36	30	35	35	35	20	20	1					35	20	15
2	24	1	1	0	6	6.36	80	70	55	40	15	10			1			80	10	70
3	1	1	1	1	4	4	50	50	50	50	50	50				1		50	50	0
3	2	1	1	1	4	4	10	20	40	0	0	0		1				40	0	40
3	3	1	1	1	7	7	30	35	40	20	10	1	1					40	1	39
3	4	1	1	1	5	5	80	60	40	40	20	20			1			80	20	60
3	5	1	0	1	9	6.36	40	30	20	10	5	0			1			40	0	40
3	6	1	1	1	5	5	10	50	50	0	0	0		1				50	0	50
3	8	1	1	1	8	8	40	50	60	65	65	65					1	65	40	25
3	9	1	1	1	7	7	25	25	50	0	0	0		1				50	0	50
3	11	1	1	1	8	8	10	20	40	60	80	100		1				100	10	90
3	13	1	1	1	7	7	50	50	50	50	50	50				1		50	50	0
3	15	1	1	1	8	8	10	20	40	25	50	50		1				50	10	40
3	16	1	1	1	6	6	20	30	50	50	60	70		1				70	20	50
3	19	1	1	1	6	6	50	50	40	30	20	10			1			50	10	40
3	20	1	1	1	7	7	20	22	23	0	0	0				1		23	0	23
3	21	1	1	1	6	6	15	30	60	20	10	0	1					60	0	60
3	22	1	1	1	8	8	25	30	50	50	25	25	1					50	25	25
3	23	1	1	1	5	5	65	40	50	35	15	0			1			65	0	65
3	24	1	1	1	6	6	10	20	40	10	20	40					1	40	10	30
													8	12	12	16	5			

Table 1.47: Data from Part 4.

Session	Subject	Part5 Clarity	Risk Preference	Lottery Table 1	Lottery Table 2	Lottery Table 3	Min Cost Part 3	Max Cost Part 3	Min Cost Part 4	Max Cost Part 4	Target Cost	EU	TPW	Other
1	1	0	6	5	6	7	15	70	0	90	0	0	1	0
1	2	1	6	8	7	8	10	30	15	30	0	0	1	0
1	3	1	5	5	1	8	3	3	1	41	0	1	0	0
1	4	1	6	6	3	7	0	50	0	40	0	1	0	0
1	5	1	5	5	5	5	1	50	10	100	0	0	1	0
1	6	1	8	5	5	5	0	50	0	50	0	0	1	0
1	7	1	6	6	6	7	5	100	10	75	0	0	1	0
1	8	1	7	4	6	5	0	70	10	100	0	0	1	0
1	9	1	4	6	6	6	51	80	20	80	0	0	1	0
1	10	1	7	1	1	2	0	0	0	0	1	0	0	0
1	11	1	5	1	1	2	1	1	0	40	1	0	0	0
1	12	1	6	5	5	5	20	70	15	55	0	0	1	0
1	13	0	5	8	8	9	50	85	50	90	0	0	1	0
1	14	1	7	5	5	5	40	40	10	100	0	0	1	0
1	15	1	7	9	3	8	0	25	0	0	0	1	0	0
1	16	1	5	3	3	5	0	50	0	50	0	0	1	0
1	17	1	4	5	7	9	20	85	20	100	0	0	0	1
1	18	1	7	2	1	3	0	100	10	100	0	0	1	0
1	19	1	5	9	9	9	4	15	0	7	0	0	1	0
1	20	1	5	3	3	4	28	56	10	50	0	0	1	0
1	21	1	6	9	9	9	50	75	25	100	0	0	1	0
1	22	1	7	5	5	7	20	70	20	60	0	0	1	0
1	23	1	7	4	4	6	30	50	50	50	1	0	0	0
1	24	1	6	9	7	9	20	100	10	100	0	0	1	0
2	1	1	8	8	1	8	0	90	0	90	0	1	0	0
2	2	1	7	2	2	9	10	10	10	50	0	1	0	0
2	3	1	8	1	1	5	5	40	25	50	0	0	0	1
2	4	1	7	5	3	6	2	30	5	20	0	0	0	1
2	5	1	5	5	1	6	10	50	10	50	0	0	0	1
2	6	1	8	1	1	9	5	5	5	10	0	1	0	0
2	7	1	8	5	1	5	5	45	0	50	0	0	0	1
2	8	1	7	5	5	5	50	50	40	60	1	0	0	0
2	9	1	7	5	7	8	0	100	0	90	0	0	0	1
2	10	1	7	1	1	9	1	1	20	100	0	1	0	0
2	11	0	6	1	1	1	1	1	1	1	1	0	0	0
2	12	1	8	5	4	6	10	50	5	50	0	0	1	0
2	13	1	6	7	1	7	0	0	0	50	0	1	0	0
2	14	1	6	1	2	1	10	20	25	25	1	0	0	0
2	15	0	5	7	7	9	17	51	1	51	0	0	1	0
2	16	0	6	5	5	5	50	50	50	50	1	0	0	0
2	17	1	8	6	1	8	0	33	1	60	0	1	0	0
2	18	1	6	4	3	6	0	40	0	40	0	0	0	1
2	19	1	7	9	1	1	0	75	10	10	0	0	0	1
2	20	1	7	4	1	1	0	100	0	40	0	0	0	1
2	21	1	4	9	1	9	0	0	0	0	0	1	0	0
2	22	1	6	7	6	6	10	65	20	35	0	0	1	0
2	23	0	6	6	4	8	1	75	50	50	0	0	0	1
2	24	1	6	7	4	3	20	85	10	80	0	0	0	1
3	1	1	4	5	5	5	25	100	50	50	0	0	1	0
3	2	1	4	5	1	9	0	95	0	40	0	1	0	0
3	3	1	7	9	2	9	1	25	1	40	0	1	0	0
3	4	1	5	6	5	1	0	100	20	80	0	0	0	1
3	5	0	9	5	5	5	0	20	0	40	0	0	1	0
3	6	1	5	5	3	7	30	50	0	50	0	1	0	0
3	7	0	10	7	4	7	20	45	15	45	0	0	0	1
3	8	1	8	9	8	9	65	65	40	65	0	0	1	0
3	9	1	7	5	1	5	0	0	0	50	0	0	0	1
3	10	0	6	2	1	9	0	30	0	40	0	1	0	0
3	11	1	8	5	1	9	0	0	10	100	0	1	0	0
3	12	0	6	6	6	6	50	60	50	50	1	0	0	0
3	13	1	7	5	4	6	20	33	50	50	0	0	1	0
3	14	1	10	5	1	5	50	100	50	50	0	0	0	1
3	15	1	8	5	1	5	50	50	10	50	0	0	0	1
3	16	1	6	6	6	8	10	50	20	70	0	0	1	0
3	17	1	5	8	1	9	5	5	1	50	0	1	0	0
3	18	1	9	1	1	2	5	5	5	5	1	0	0	0
3	19	1	6	6	5	9	10	40	10	50	0	0	0	1
3	20	1	7	3	1	7	22	23	0	23	0	1	0	0
3	21	1	6	8	7	9	0	10	0	60	0	0	1	0
3	22	1	8	6	5	7	25	50	25	50	0	0	1	0
3	23	1	5	6	7	9	10	10	0	65	0	0	0	1
3	24	1	6	6	5	9	5	50	10	40	0	0	0	1

Table 1.48: Data from Part 5.

10.4 Instructions Set

General Instructions for the Experiment

Welcome to the experiment. This is an experiment related to decision-making. Over approximately next 75 minutes, you will be asked to participate in several tasks. For simply showing up to this experiment you have already received £3. You can earn considerably more. During the experiment, you may earn ECU (Experimental Currency Unit). The total amount of ECU that you will have earned during the experiment will be converted into £ at the end of the experiment; 50 ECU = £1. You will receive these earnings in cash, in £, and in private at the end of the experiment. Please stay seated until we ask you to leave.

There are six independent parts of this experiment followed by a questionnaire. The details will be provided in the instructions for each part. Any examples in the instructions are merely for illustration purposes; you should not interpret them as the advice of any kind.

Please read the instructions carefully. If you have any questions, please raise your hand. One of the experimenters will come to you and answer your questions. From now on communication with other participants is **not** allowed. Do not use your mobile phones during the experiment.

Remember, on the computer screen once **Submit** button is clicked you **can't go back** and change your choices.

Instructions for Part 1:

This part of the instructions explains the raffle task followed by two quizzes. Each quiz has three questions to be answered. All questions are multiple-choice questions and there is one correct answer. If you choose a correct answer then you will score 100 ECU for that question, an incorrect answer will score zero. Your score from one of the six questions will be **chosen randomly** for the actual payment.

There is a raffle where a **prize worth 100 ECU** can be won. Your probability of winning is the number of raffle tickets you buy divided by the number of raffle tickets sold in total. For instance, if you buy X raffle tickets and the other participants Y, your chance of winning is X / (X+Y). **Each raffle ticket costs 1 ECU**

If you **win**, your income from the raffle will be:
Income = 100 (Endowment) - No. of tickets you bought (0-100) + 100 (Prize Value)

If you **lose**, your income from the raffle will be:
Income = 100 (Endowment) - No. of tickets you bought (0-100)

On the computer screen, Quiz 1 will be followed by its answers and explanations after you have clicked **Submit** button. Similarly, Quiz 2 will be followed by its answers and explanations.

QUIZ 1

Q1. Assume that you bought 10 tickets in a raffle and **all other** participants in the raffle bought 90. What is your chance of winning the raffle?

(a) 10 / 90
(b) 10 / 100
(c) 10 / 80
(d) 80 / 90

Q2. Assume that from an **endowment of 100 ECU** you bought 40 raffle tickets. What is your income if you win? (Hint: If you win, Income = Endowment - Ticket Cost + Prize Value)

(a) 80
(b) 180
(c) 160
(d) 40

Q3. Assume your probability of winning in a raffle is 0.8. What is your chance of winning expressed in percentage?

(a) 40%
(b) 80%
(c) 60%
(d) 100%

Please **WRITE DOWN** your answers in this instructions sheet **BEFORE** clicking the **Submit** button on your computer screen.

QUIZ 2

Q4. Assume that in a raffle you bought 60 tickets and all **other** participants bought 140. What is your chance of winning the raffle?

(a) 60 / 160
(b) 160 / 200
(c) 60 / 200
(d) 160 / 300

Q5. Assume that from an **endowment of 100 ECU** you bought 40 raffle tickets. What is your income if you lose? (Hint: If you lose, Income = Endowment - Your Ticket Cost)

(a) 60
(b) 140
(c) 30
(d) 170

Q6. Assume your probability of winning in a raffle is 0.3. What is your chance of winning expressed in percentage?

(a) 40%
(b) 60%
(c) 80%
(d) 30%

Please **WRITE DOWN** your answers in this instructions sheet **BEFORE** clicking the **Submit** button on your computer screen.

Instructions for Part 2:

In this part of the experiment, you will play **10 rounds** of the **raffle** described in the quizzes earlier and explained again in the paragraphs below. In the first five rounds, you will be in a **group of size 2** and in the last five rounds **group size will be 3**. Groups will be formed randomly at the beginning of each group size. You will stay in the **same group** for all five rounds of each group size.

In each round, you have an **endowment of 100 ECU** and you can buy between 0 to 100 tickets. Similarly, other members of your group will also choose to buy between 0 to 100 tickets. You will not know how much the other participants choose. The **winning prize is 100 ECU** and the **cost of each ticket is 1 ECU.**

Your probability of winning is the number of tickets you buy divided by the total number of the tickets bought in your group (including you). One of the participants from your group will be chosen randomly as a winner. Your income in ECU in any round will be as follows:

If you **win**, your income will be:
Income = 100 (Endowment) - No. of tickets you bought (0-100) + 100 (Prize Value)

If you **lose**, your income will be:
Income = 100 (Endowment) - No. of tickets you bought (0-100)

Out of the 10 rounds, your income from one of the rounds will be **chosen randomly** as your actual payment from this part of the experiment.

Instructions for Part 3:

In this part of the experiment, you will be grouped with other participants. You will play 4 games. Each game has **2 raffles**, one in Period 1 followed by another in Period 2.

In Game 1, in Period 1 you will be grouped in a group of size 2 and in Period 2 two additional participants will join your group and your group size will increase to 4, as shown in Table 1 below.

In Game 2, in Period 1 you will be grouped in a group of size 3 and in Period 2 three additional participants will join your group and your group size will increase to 6, as shown in Table 1 below.

In Game 3, in Period 1 you will be grouped in a group of size 4 and in Period 2 two group members will leave your group and your group size will decrease to 2, as shown in Table 1 below.

In Game 4, in Period 1 you will be grouped in a group of size 6 and in Period 2 three group members will leave your group and your group size will decrease to 3, as shown in Table 1 below.

In **each game**, at the start of **each period**, you will get an **endowment of 100 ECU** and you have to decide how much of this endowment will you like to use to purchase tickets. **Each ticket costs 1 ECU**. You can buy from 0 to 100 raffle tickets. In each game, each period the **prize value is 100 ECU**.

You will not know how many tickets the other group members have bought. You will know the outcomes of all the raffles ONLY at the end of Period 2 of Game 4. Note that exactly one of the participants will win the prize in every group, for each period and in every game.

Additionally, you have to estimate your 'probability of winning' (P1-P8) given the number of tickets you have purchased in each game in each period. Your estimation of the 'probability of winning' will not be used in computing your income.

Table 1

	Period 1					Period 2				
Game	No. of Participants	Choose No. Of Tickets You Want To Buy (0-100)	Your Tickets Total Cost	Prize	Probability of Winning Estimation	No. of Participants	Choose No. Of Tickets You Want To Buy (0-100)	Your Tickets Total Cost	Prize	Probability of Winning Estimation
G1	2	TI	TI	100	P1	4	T2	T2	100	P2
G2	3	T3	T3	100	P3	6	T4	T4	100	P4
G3	4	T5	T5	100	P5	2	T6	T6	100	P6
G4	6	T7	T7	100	P7	3	T8	T8	100	P8

Your income (in ECU) in each raffle will be calculated as follows:

If you **win**, your income will be:
Income = 100 (Endowment) - No. of tickets you bought (0-100) + 100 (Prize Value)

If you **lose**, your income will be:
Income = 100 (Endowment) - No. of tickets you bought (0-100)

Out of the total 8 raffles you played, your income from one of the raffles will be **chosen randomly** as your actual payment for this part of the experiment.

Instructions for Part 4:

This part of the experiment consists of 6 raffles (R1-R6). You will be matched with another participant. For each raffle, you are **endowed with 100 ECU**. The endowment can be used to purchase raffle tickets. You can buy between 0 to 100 tickets. **Each raffle ticket costs 1 ECU.** The **prize value** of each raffle **is 100 ECU**.

Both you and your matched participant are provided with Table 2. In Table 2, column 2 ("Matched Participant's Fixed Tickets Choice") has fixed ticket choices for each raffle R1-R6. Against these fixed ticket choices, you have to enter a number of tickets you want to buy for each raffle R1-R6. You will enter your choices of a number of tickets in column 3 of your Table 2. Similarly, your matched participant will enter her choices of a number of tickets in column 3 of her Table 2. Note, you can't make any choices in your matched participants Table 2 and she can't make any choices in your Table 2.

The fixed tickets choices in your Table 2 will be considered as your matched participant's ticket choices in your table. Similarly, the fixed tickets choices in your matched participant's Table 2 will be considered as your tickets choices in her table. The fixed tickets choices can't be changed.

Either your Table 2 or your matched participants Table 2 will be selected for the actual payment calculation. The unselected Table 2 will be discarded. You and your matched participant have an equal chance of getting your Table 2 selected.

Once either yours or your matched participant's Table 2 is selected, one of the raffles (R1-R6) will be selected from this table for yours and your matched participant's actual payment calculation. All six raffles are equally likely to be chosen.

If your Table 2 is selected, your probability of winning the raffle will be as given in column 5 of your Table 2 and your matched participant's probability of winning the raffle will be as given in column 6 of your Table 2.

If your matched participant's Table 2 is selected, her probability of winning the raffle will be as given in column 5 of her Table 2 and your probability of winning the raffle will be as given in column 6 of her Table 2.

Table 2

Raffle	Matched Participant's Fixed Tickets Choice	Your Tickets Choice (0-100)	Your Tickets Total Cost	Your Probability of Winning	Your Matched Participant's Probability of Winning	Prize
R1	10	T1	T1	T1/(T1 +10)	10/(T1 +10)	100
R2	20	T2	T2	T2/(T2 +20)	20/(T2 +20)	100
R3	40	T3	T3	T3/(T3 +40)	40/(T3 +40)	100
R4	60	T4	T4	T4/(T4 +60)	60/(T4 +60)	100
R5	80	T5	T5	T5/(T5 +80)	80/(T5 +80)	100
R6	100	T6	T6	T6/(T6 +100)	100/(T6 +100)	100

Your actual payment (in ECU) is given as follows:

If your Table 2 is selected and a raffle from R1-R6 is selected:

If you **win**, your actual payment will be:
100 (Endowment) - Your Ticket Choice for the **selected** raffle + 100 (Prize Value)

If you **lose**, your actual payment will be:
100 (Endowment) - Your Ticket Choice for the **selected** raffle

If your matched participant's Table 2 is selected and a raffle from R1-R6 is selected:

If you **win**, your actual payment will be:
100 (Endowment) - Fixed Ticket Choice for the **selected** raffle + 100 (Prize Value)

If you **lose**, your actual payment will be:
100 (Endowment) - Fixed Ticket Choice for the **selected** raffle

Instructions for Part 5:

In this part of the experiment, you are **not** grouped with other participants. You must choose one of the lotteries (L1-L9) from each Lottery Table 1, Lottery Table 2, and Lottery Table 3. For each Lottery Table, you are **endowed with 100 ECU**. The endowment can be used to purchase any **one** of the lotteries in that Lottery Table.

For each of the lotteries in all the Lottery Tables, its **probability of winning, cost and prize value** of the lottery is mentioned in the table. Unlike in the earlier parts of the experiment, in this part, the probability of winning is fixed for each lottery. **Note:** Only the values in the 'Cost' column are different in each Lottery Table.

Once you have made your choices, any **one** of the three Lottery Tables will be **selected randomly**. All Lottery Tables are equally likely to be chosen. After the Lottery Table is selected, the lottery you have chosen in that Lottery Table will be considered for the actual payment calculation.

Lottery Table 1	Probability of Winning	Cost	Prize
L1	0.1	10.0	100
L2	0.2	20.0	100
L3	0.3	30.0	100
L4	0.4	40.0	100
L5	0.5	50.0	100
L6	0.6	60.0	100
L7	0.7	70.0	100
L8	0.8	80.0	100
L9	0.9	90.0	100

Lottery Table 2	Probability of Winning	Cost	Prize
L1	0.1	1.0	100
L2	0.2	14.0	100
L3	0.3	27.0	100
L4	0.4	39.0	100
L5	0.5	50.0	100
L6	0.6	61.0	100
L7	0.7	73.0	100
L8	0.8	86.0	100
L9	0.9	100.0	100

Lottery Table 3	Probability of Winning	Cost	Prize
L1	0.1	20.0	100
L2	0.2	26.0	100
L3	0.3	33.0	100
L4	0.4	41.0	100
L5	0.5	50.0	100
L6	0.6	59.0	100
L7	0.7	67.0	100
L8	0.8	74.0	100
L9	0.9	80.0	100

Your actual payment (in ECU) will be as follows:

If you **win**, your actual payment will be:
100 (Endowment) - Cost of your **chosen** lottery in the **selected** Table + 100 (Prize Value)

If you **lose**, your actual payment will be:
100 (Endowment) - Cost of your **chosen** lottery in the **selected** Table

Instructions for Part 6:

In this part of the experiment, you are **not** grouped. You have to make 10 choices. Each decision is a paired choice between "Option A" and "Option B". For each decision row (D1-D10), you will have to choose between Option A and Option B. You may choose A for some decision rows and B for other rows and you may change your decisions and make them in any order.

Now, please look at decision D1 at the top in the below table. Option A has two possible outcomes A1 and A2. A1 pays 100 ECU with a probability of 0.1 and A2 pays 80 ECU with the remaining probability of 0.9. Similarly, Option B has two possible outcomes B1 and B2. B1 pays 193 ECU with a probability of 0.1 and B2 pays 5 ECU with the remaining probability of 0.9.

The other decisions are similar, except that **as you move down the table, the chances of the higher paying outcome for each option increases.** In fact, for decision D10 in the bottom row, each option pays the highest payoff for sure, so your choice here is between 100 or 193 ECU.

To determine your income, one of the decisions (D1-D10) will be selected randomly. All decisions have an equal chance of being selected for your actual payment calculation.

Decision	Option A				Option B			
	Pr A1	A1	Pr A2	A2	Pr B1	B1	Pr B2	B2
D1	0.1	100	0.9	80	0.1	193	0.9	5
D2	0.2	100	0.8	80	0.2	193	0.8	5
D3	0.3	100	0.7	80	0.3	193	0.7	5
D4	0.4	100	0.6	80	0.4	193	0.6	5
D5	0.5	100	0.5	80	0.5	193	0.5	5
D6	0.6	100	0.4	80	0.6	193	0.4	5
D7	0.7	100	0.3	80	0.7	193	0.3	5
D8	0.8	100	0.2	80	0.8	193	0.2	5
D9	0.9	100	0.1	80	0.9	193	0.1	5
D10	1	100	0	80	1	193	0	5

Your income (in ECU) will be as follows:

If you have chosen **A,** your income will be either 100 or 80 based on the probabilities stated in the table.

If you have chosen **B,** your income will be either 193 or 5 based on the probabilities stated in the table.

Questionnaire:

Please answer the following questions. These answers will be anonymous and there are no right and wrong answers. The more exhaustive you will be in answering these questions, the more you will be helping the research study. Please write clearly!

1. Your Age? _____

2. Your Gender? *Tick*
   1) Female, **2)** Male, **3)** Not Listed, **4)** Prefer Not to Answer

3. Your Nationality?___________________

4. Your subject of study?(Eg: Economics)_______________________

5. Your level of study? *Tick **one** below*
   1) Undergraduate Year 1, **2)** Year 2, **3)** Year 3, **4)** Year 4, **5)** Masters, **6)** PhD

6. Which Parts of the experiment have clear instructions? *Tick **any** below*
   1) Part 1, **2)** Part 2, **3)** Part 3, **4)** Part 4, **5)** Part 5, **6)** Part 6

7. Were quizzes helpful in making you understand the game of raffle? *Tick **one***
   1) not at all, **2)** somewhat, **3)** very much, **4)** absolutely

8. In which Parts you felt confident of the approach you took in making choices? *Tick **any** below*
   1) Part 1, **2)** Part 2, **3)** Part 3, **4)** Part 4, **5)** Part 5, **6)** Part 6

9. Were results in one part of the experiment impacted your decisions in the following parts? *Tick **one** below*
   1) Yes, **2)** No
   *If yes, how exactly:*_____________________________

10. Did you have some basic understanding of probability prior to this experiment? *Tick **one** below*
    1) Yes, **2)** No

11. Are you comfortable with numeric calculations? *Tick **one** below*
    1) not at all, **2)** somewhat, **3)** very much, **4)** absolutely: it makes me feel better.

12. Have you played any raffle/lottery games earlier? *Tick **any** below*

1) Yes in real life, **2)** Yes in Another experiment, **3)** Not at all.

13. In the games where you were in a group, did your choice-making take into consideration what choices other group members may be making? *Tick **one***

1) Not at all, **2)** Somewhat, **3)** Fully Considered

14. In general, which of the following factors did you considered to make your choices? *Tick **any** below*

1) Income/Actual Payment, **2)** Cost, **3)** Probability of Winning

15. Do you like winning even if you end up making losses in total? *Tick **one** below*

1) not at all, **2)** somewhat, **3)** very much, **4)** absolutely*:* winning at any cost

16. How you approached the game of raffle/lottery? On what basis were you making your choices/decisions? ____

17. Was there a common strategy you took to make decisions in every part of the experiment?____

18. How winning or losing in any raffle/lottery impacted your choices in the following raffle/lottery?____

19. Any thoughts, comments or suggestions on improvements in the experiment?

____

Thank you very much for your participation! Please do not share anything about this experiment with anyone for next two months. There are other sessions to be run and it will contaminate the research study.

10.5 z-Tree Screenshots

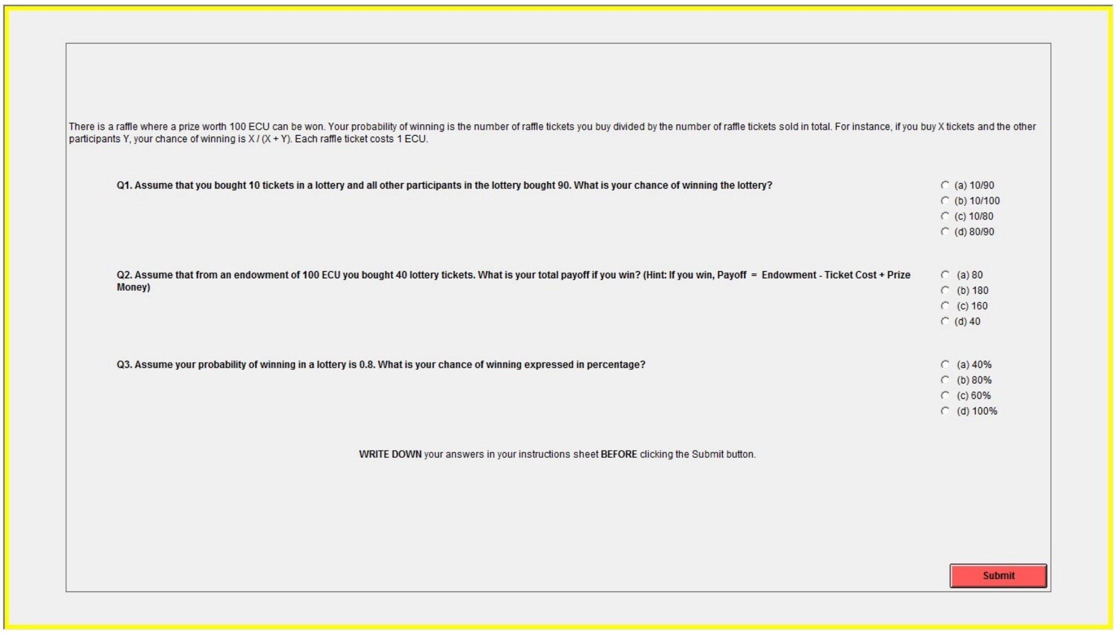
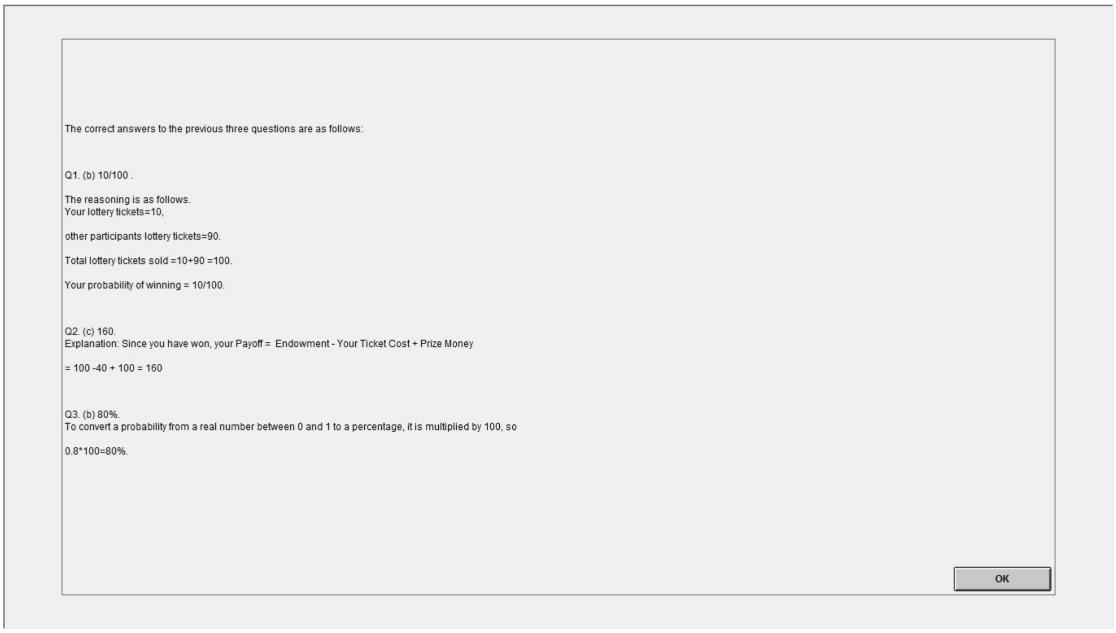


Figure 1.49: z-tree screenshot of Part 1 (Quizzes) - questions

Figure 1.50: z-tree screenshot of Part 1 (Quizzes) - solutions



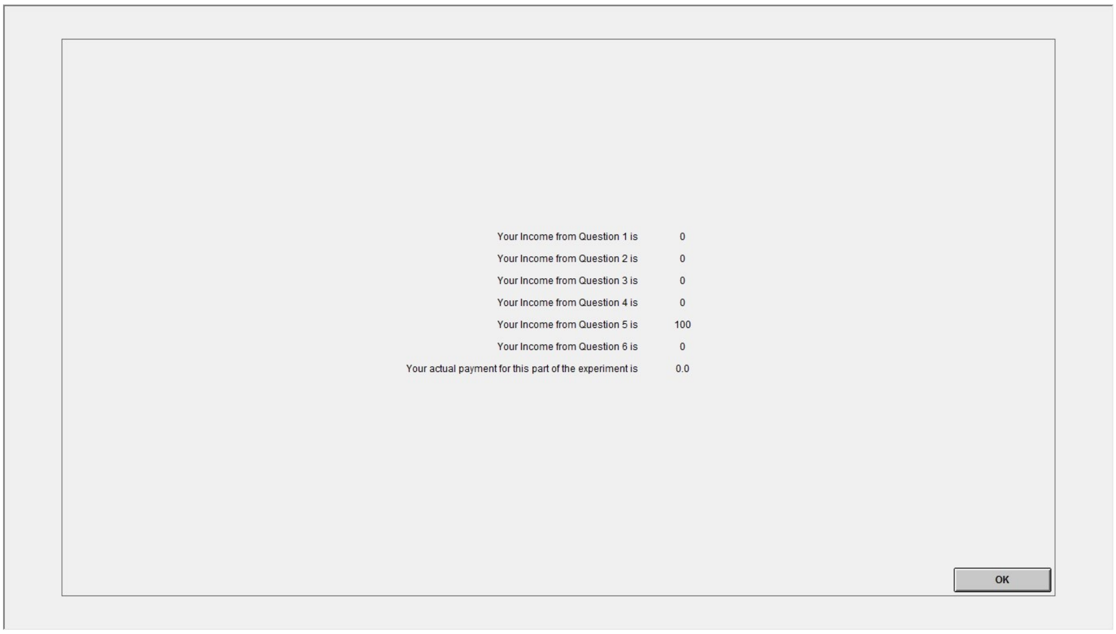


Figure 1.51: z-tree screenshot of Part 1 (Quizzes) - solutions

Figure 1.52: z-tree screenshot of Part 1 (Quizzes) - payment

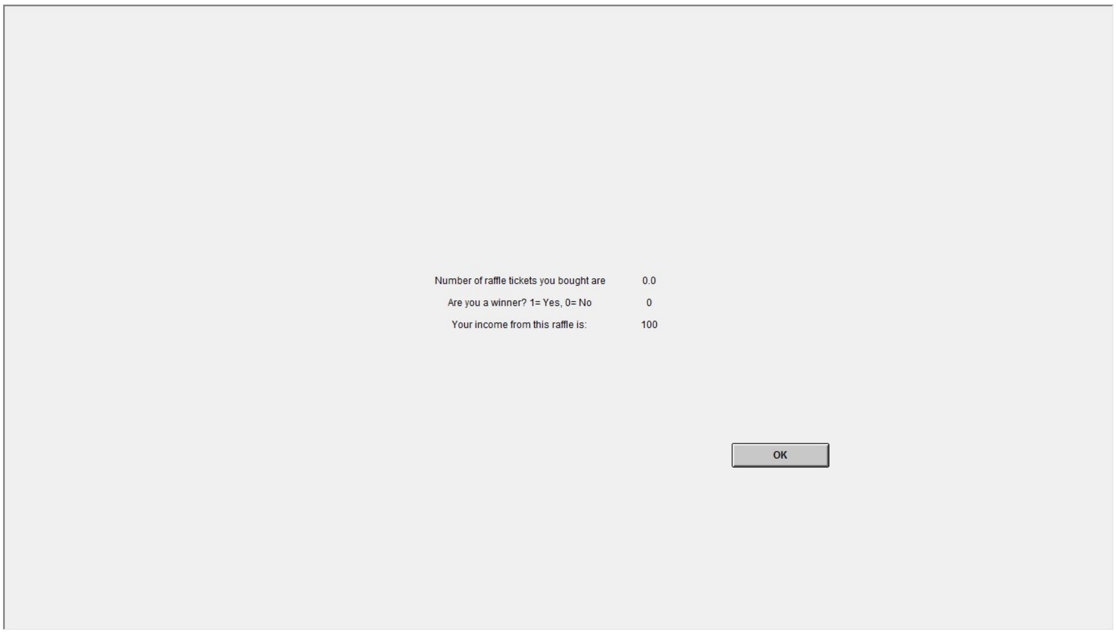
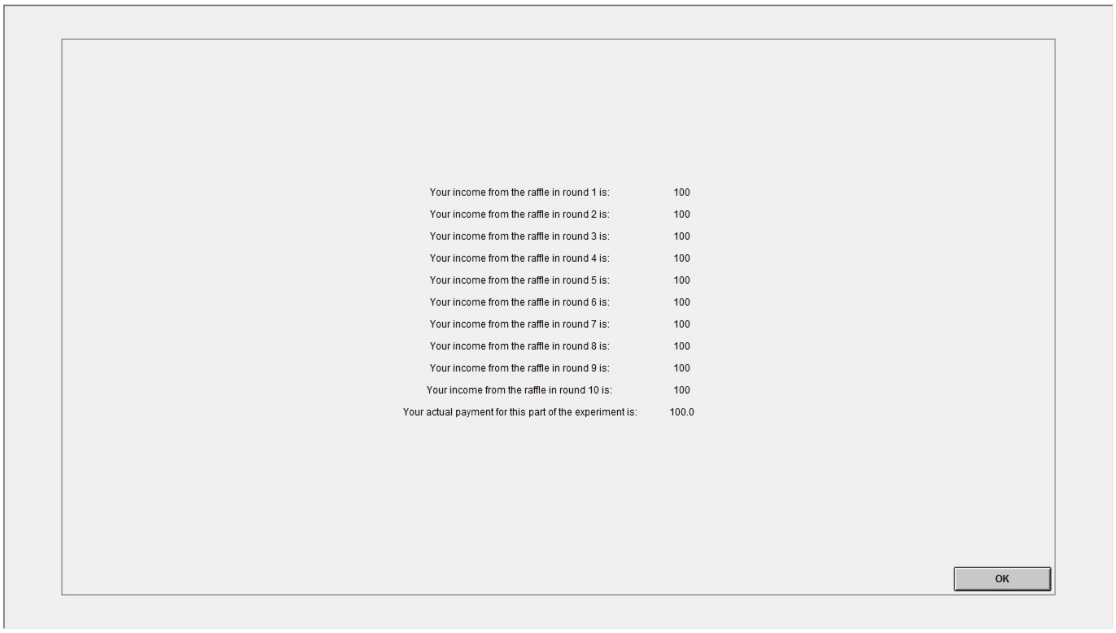


Figure 1.53: z-tree screenshot of Part 2 (Experience) - choice input

Figure 1.54: z-tree screenshot of Part 2 (Experience) - feedback



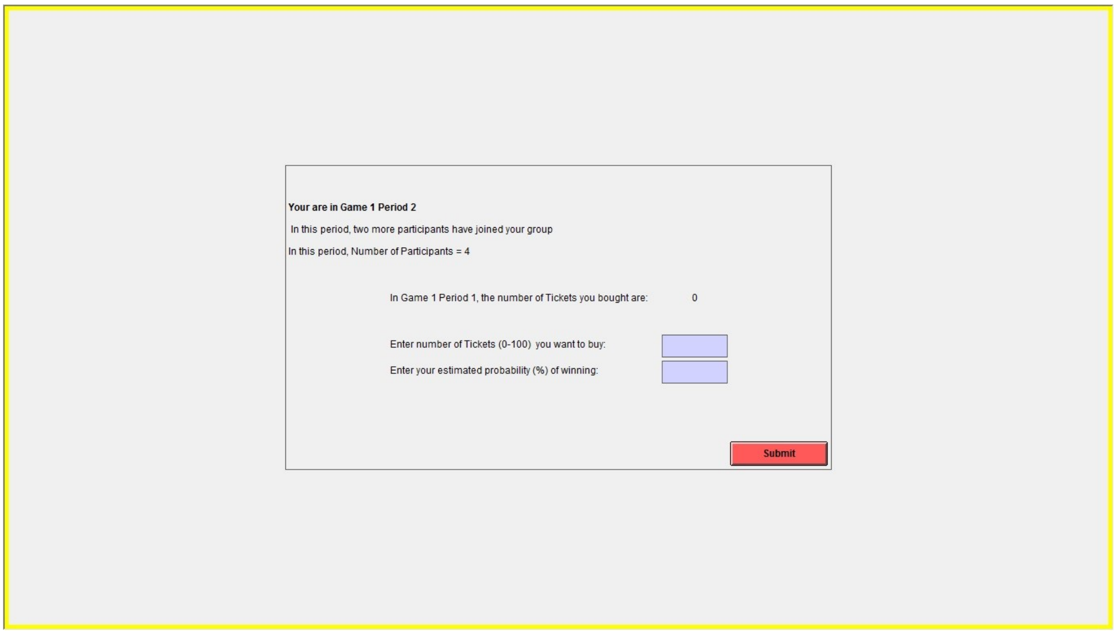
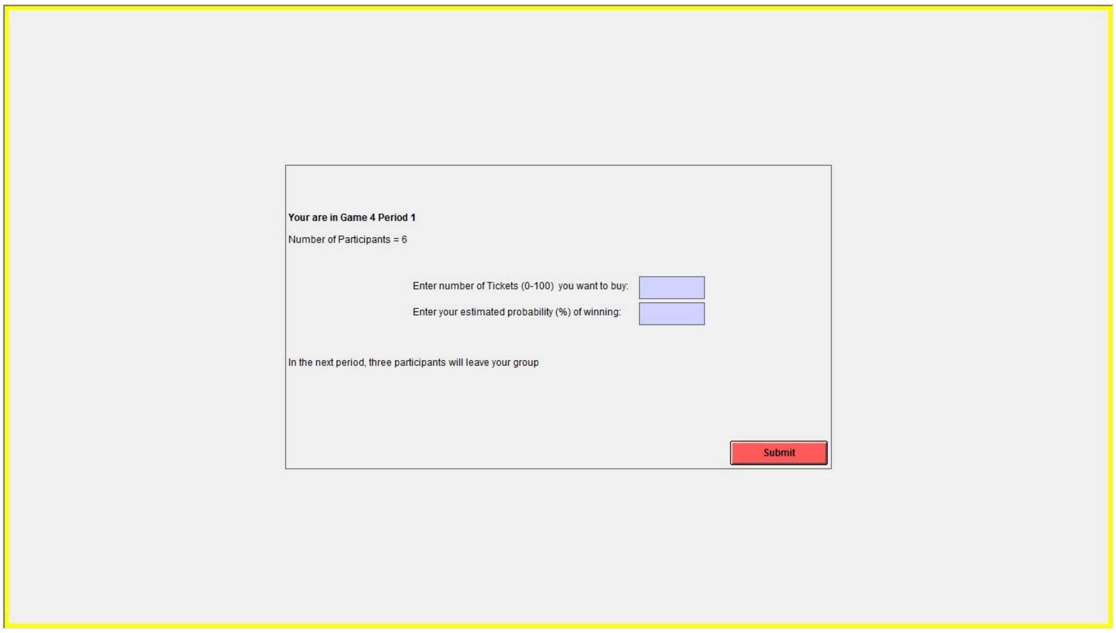


Figure 1.55: z-tree screenshot of Part 2 (Experience) - payment

Figure 1.56: z-tree screenshot of Part 3 (Group Size Change) - choice input Game 1, Period 1



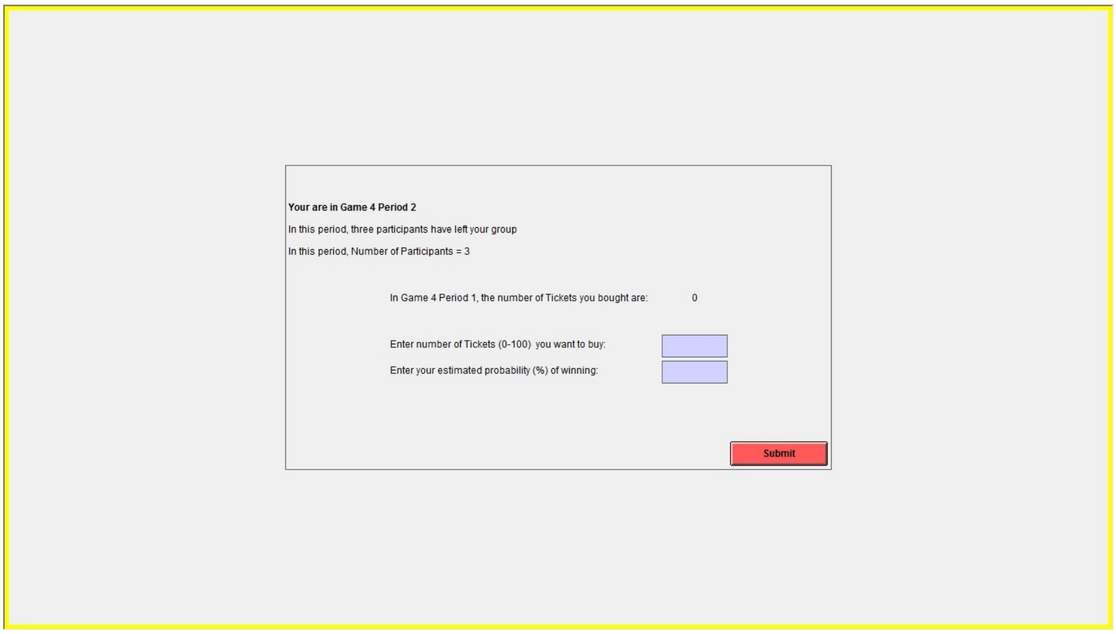
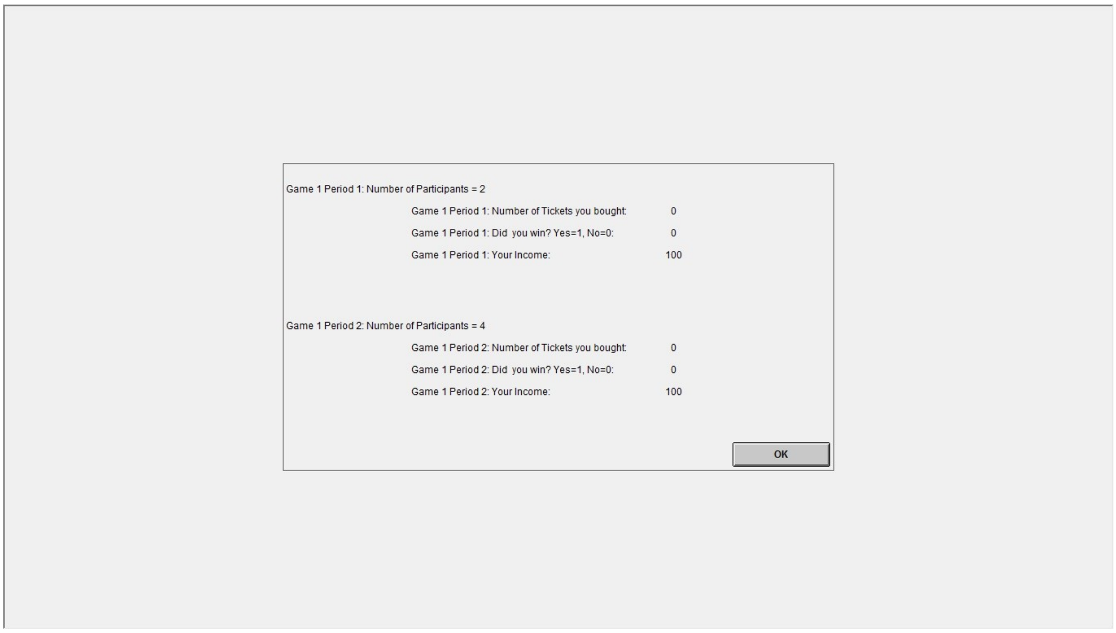


Figure 1.57: z-tree screenshot of Part 3 (Group Size Change) - choice input Game 1, Period 2

Figure 1.58: z-tree screenshot of Part 3 (Group Size Change) - choice input Game 4, Period 1



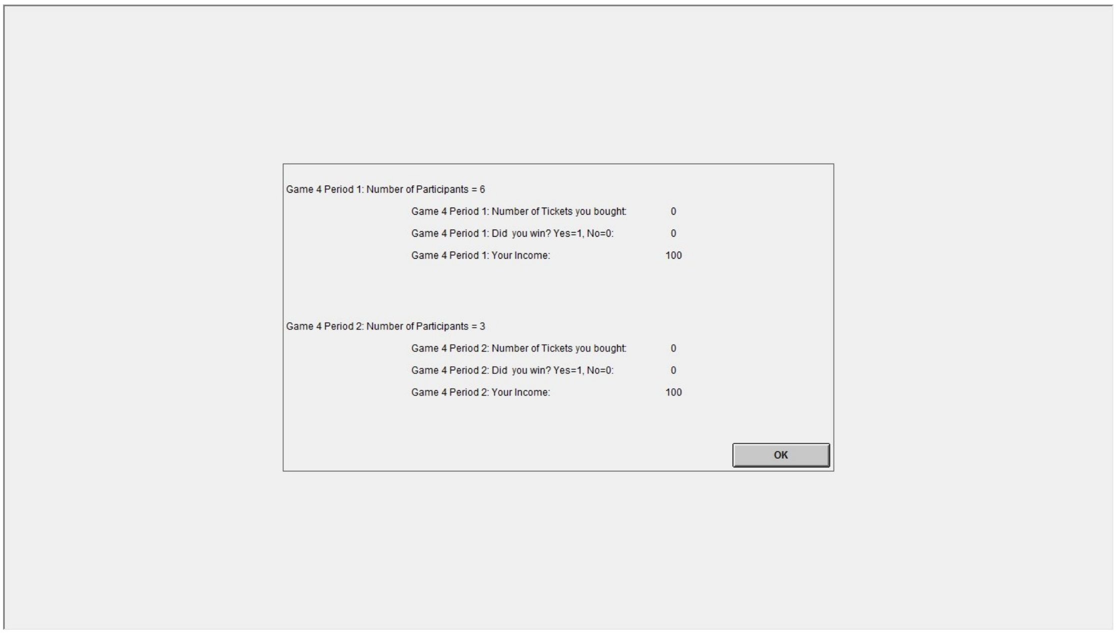
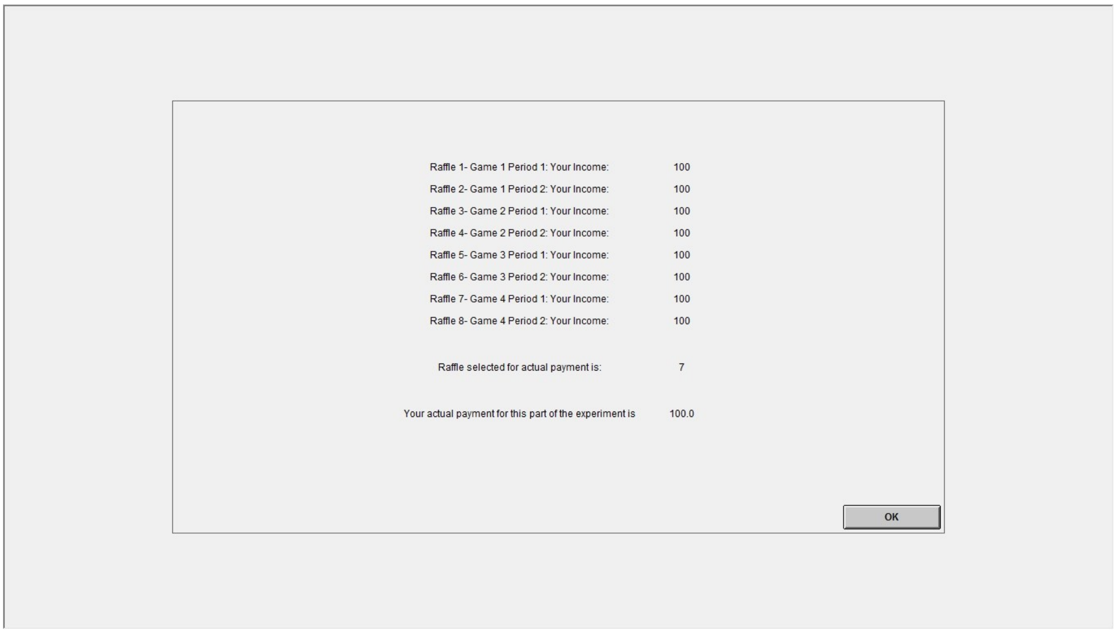


Figure 1.59: z-tree screenshot of Part 3 (Group Size Change) - choice input Game 4, Period 2

Figure 1.60: z-tree screenshot of Part 3 (Group Size Change) - payment



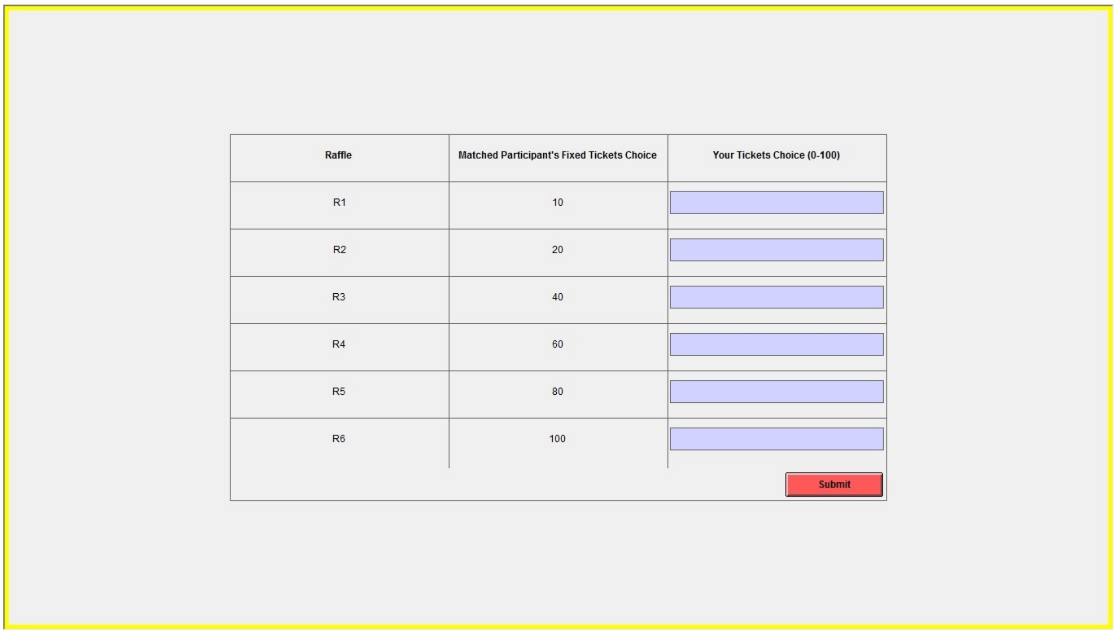
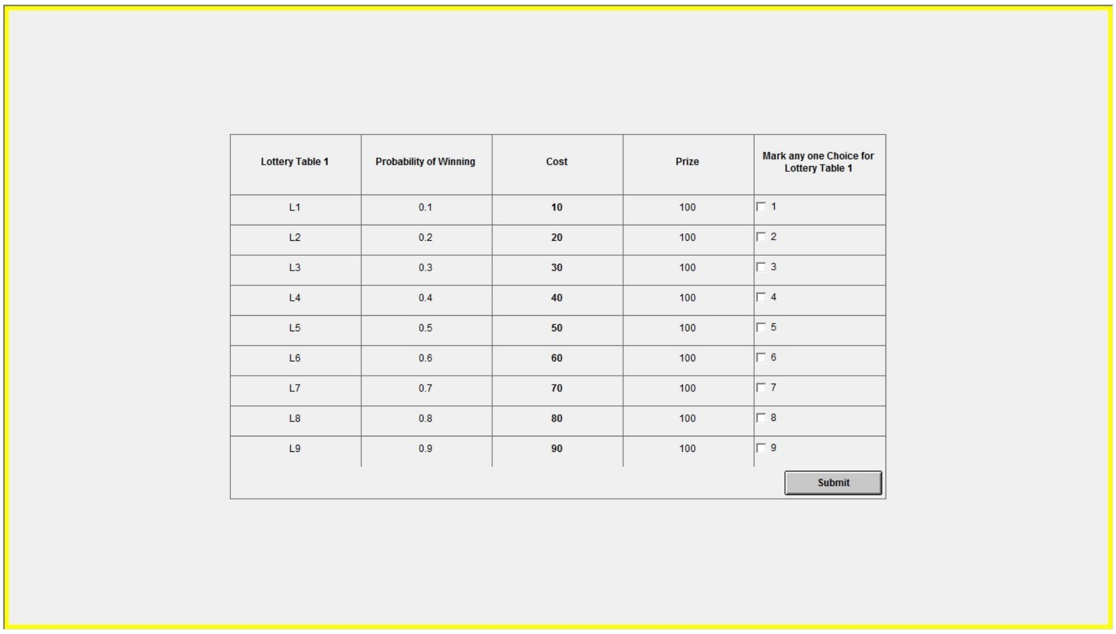


Figure 1.61: z-tree screenshot of Part 4 (Response Curve) - choice input

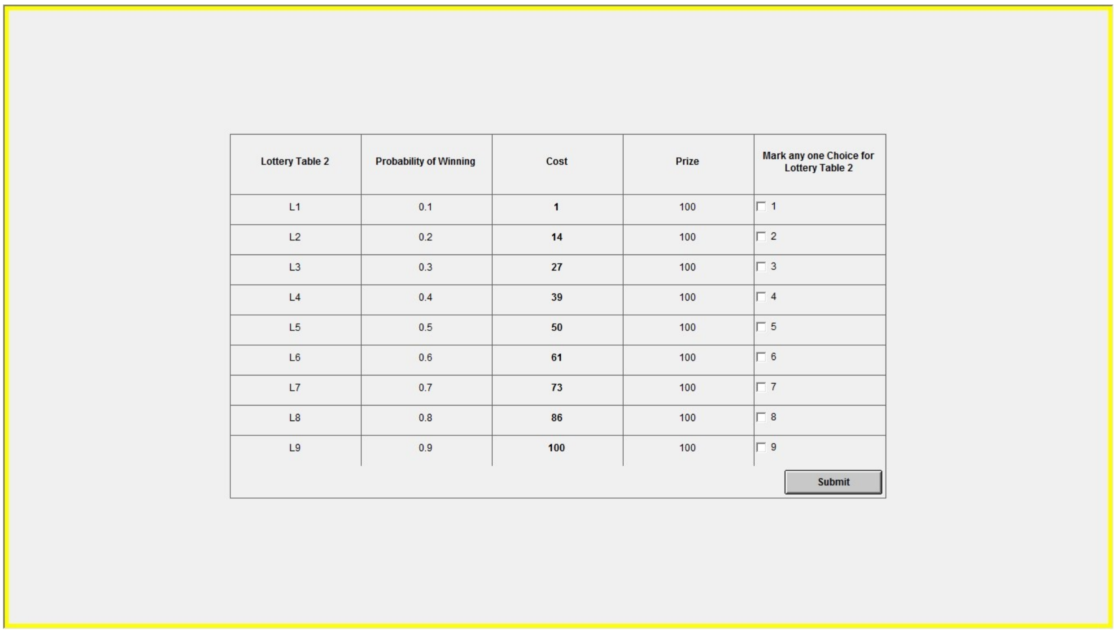
Figure 1.62: z-tree screenshot of Part 4 (Response Curve) - payment



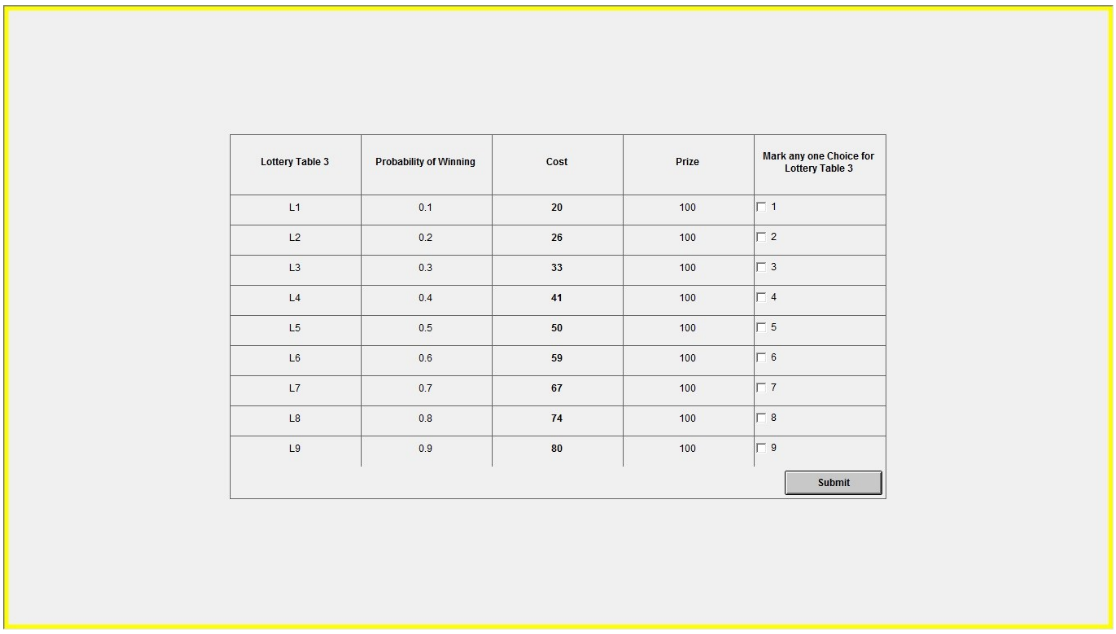
Lottery Table 1	Probability of Winning	Cost	Prize	Mark any one Choice for Lottery Table 1
L1	0.1	10	100	1
L2	0.2	20	100	2
L3	0.3	30	100	3
L4	0.4	40	100	4
L5	0.5	50	100	5
L6	0.6	60	100	6
L7	0.7	70	100	7
L8	0.8	80	100	8
L9	0.9	90	100	9

Figure 1.63: z-tree screenshot of Part 5 (Inverted Lottery Sets) - choice input Lottery Table 1

Figure 1.64: z-tree screenshot of Part 5 (Inverted Lottery Sets) - choice input Lottery Table 2



Lottery Table 2	Probability of Winning	Cost	Prize	Mark any one Choice for Lottery Table 2
L1	0.1	1	100	1
L2	0.2	14	100	2
L3	0.3	27	100	3
L4	0.4	39	100	4
L5	0.5	50	100	5
L6	0.6	61	100	6
L7	0.7	73	100	7
L8	0.8	86	100	8
L9	0.9	100	100	9

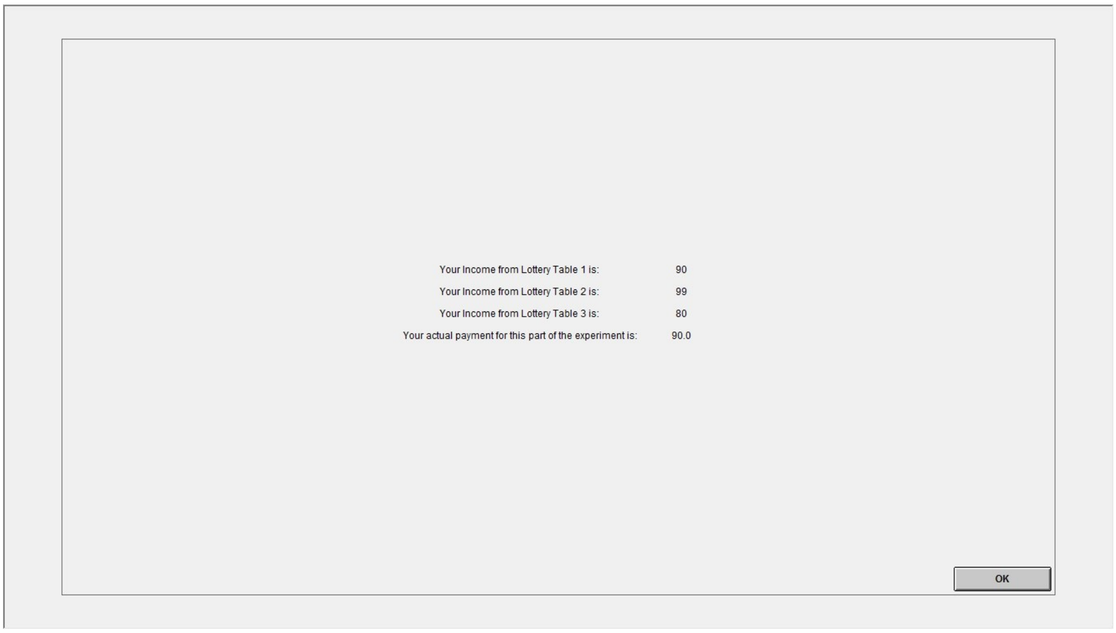


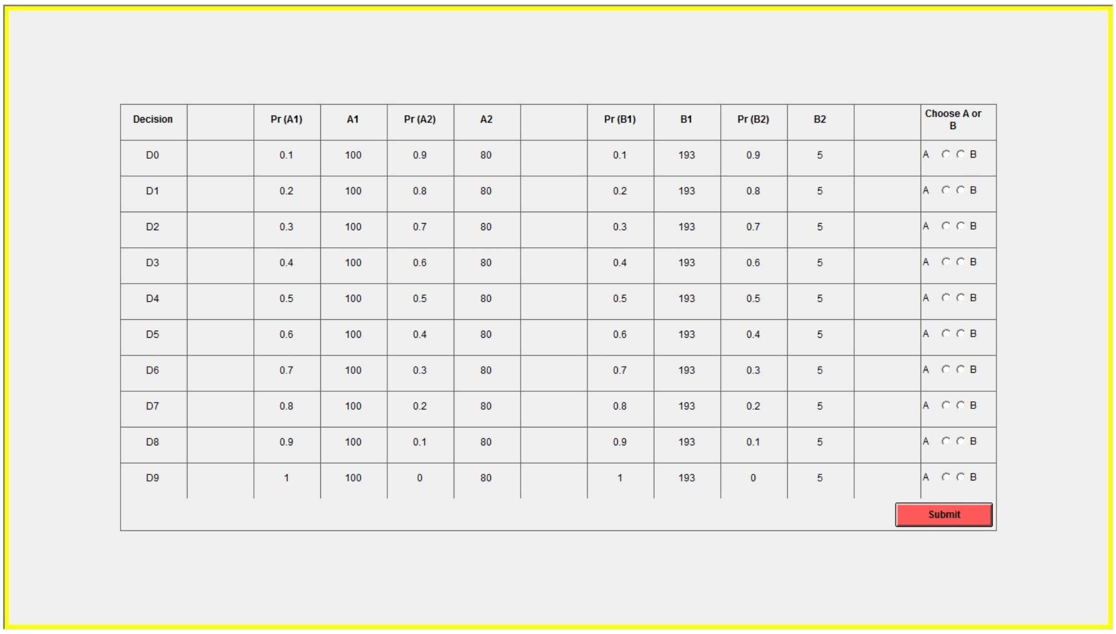
Lottery Table 3	Probability of Winning	Cost	Prize	Mark any one Choice for Lottery Table 3
L1	0.1	20	100	1
L2	0.2	26	100	2
L3	0.3	33	100	3
L4	0.4	41	100	4
L5	0.5	50	100	5
L6	0.6	59	100	6
L7	0.7	67	100	7
L8	0.8	74	100	8
L9	0.9	80	100	9

Submit

Figure 1.65: z-tree screenshot of Part 5 (Inverted Lottery Sets) - choice input Lottery Table 3

Figure 1.66: z-tree screenshot of Part 5 (Inverted Lottery Sets) - payment





Decision		Pr (A1)	A1	Pr (A2)	A2		Pr (B1)	B1	Pr (B2)	B2		Choose A or B
D0		0.1	100	0.9	80		0.1	193	0.9	5		A ◯ ◯ B
D1		0.2	100	0.8	80		0.2	193	0.8	5		A ◯ ◯ B
D2		0.3	100	0.7	80		0.3	193	0.7	5		A ◯ ◯ B
D3		0.4	100	0.6	80		0.4	193	0.6	5		A ◯ ◯ B
D4		0.5	100	0.5	80		0.5	193	0.5	5		A ◯ ◯ B
D5		0.6	100	0.4	80		0.6	193	0.4	5		A ◯ ◯ B
D6		0.7	100	0.3	80		0.7	193	0.3	5		A ◯ ◯ B
D7		0.8	100	0.2	80		0.8	193	0.2	5		A ◯ ◯ B
D8		0.9	100	0.1	80		0.9	193	0.1	5		A ◯ ◯ B
D9		1	100	0	80		1	193	0	5		A ◯ ◯ B

Figure 1.67: z-tree screenshot of Part 6 (Measuring Risk Aversion) - choice input