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Publication Date

2003-02-20

Portfolio Choice and Risk Attitudes: An Experiment

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February 20, 2003

Abstract: We study the following basic intuition: when faced with a decision how to split their investment between a risky lottery and an asset with a fixed return, people increase the proportion invested in the risky option the more they like the lottery. We find counter-examples to this, and in fact we find no simple relation between preferences between lotteries and the fraction invested in them. We use three well-documented biases (ambiguity aversion, the illusion of control and myopic loss aversion) to show this. First we replicate the previous results in a laboratory experiment with financial incentives, and then test whether participants are willing to explicitly pay a small sum of money in line with the bias (pay for less ambiguity, more perceived control, or more frequent information about portfolio performance). We then study how portfolio choice depends on these biases.

With the parameters chosen, the illusion of control was eliminated when participants were asked to pay to gain more control, and the bias did not affect investment behavior (i.e., participants invested in a risky option the same fraction when faced with more or less control). In the ambiguity treatment, people were willing to pay for less ambiguity, but again the level of ambiguity did not influence investment. Finally, in the myopic loss aversion treatment participants were willing to pay money to have more freedom to choose, even though (in line with the documented bias) they invested less when having more freedom to change their investment.

Keywords: Ambiguity aversion, behavioral finance, illusion of control, lotteries, myopic loss aversion, portfolio choice, risk attitudes

JEL Codes: B49, C91, D81, G11, G19

Acknowledgements: We thank Richard Thaler, Martin Weber and seminar participants for their comments and suggestions. We gratefully acknowledge research support provided by the UCSB Dept. of Economics and the Chicago GSB. All errors are our own.

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INTRODUCTION

Standard finance theory presumes that investors are rational, in the sense that they successfully identify and process relevant information in the course of reaching optimal decisions. In recent years, however, a body of empirical evidence suggests that there are systematic departures from predicted behavior. The empirical evidence challenges the dominant paradigm of efficient markets, according to which all relevant information is already reflected in the price of financial assets. Cognitive biases may distort perceptions and cause market prices to deviate from fundamental value. This issue is prominent in the financial community — professional players in financial markets are keen to find an advantage to exploit, so identifiable ‘irrational’ regularities carry a premium.

Behavioral finance is concerned with psychological influences in financial decision-making and markets. Investors make decisions while staying afloat in a sea of uncertainty. When predictability is low, people may be prone to unjustified beliefs that may survive and even flourish in such an environment.¹ People may resort to ‘rules of thumb’, on a conscious or subconscious level. To the extent that psychological influences are present, the question of which of these actually risk attitudes and portfolio choice is economically important. A key issue is whether any such influences disappear when monetary incentives are present.

There is an ongoing debate over the need to incorporate biases into theoretical finance. Fama (1998), for example, notes that studies have demonstrated both systematic over-reaction

¹ It might seem natural to assume that investors who behave “irrationally” (e.g., manifest biases in information processing) can be exploited and driven from the market over time; however, several theoretical models (e.g., Kyle and Wang, 1997; Benos, 1998; Gervais and Odean, 2001; Hirshleifer and Luo, 2001) demonstrate that, for example, overconfidence can persist in the long run.

and under-reaction to information.² Fama concludes that these models do not produce “rejectable predictions that capture the menu of anomalies better than market efficiency” (p. 8), that “long-term return anomalies are sensitive to methodology” (p. 2), and that anomalies are roughly split between under- and over-reaction, as would be expected under the efficient markets hypothesis. On the other hand, Hirshleifer (2001) points out that “economists such as Adam Smith, Irving Fisher, John Maynard Keynes, and Harry Markowitz thought that individual psychology affects prices,” (p. 1) and concludes that “psychology-based asset pricing theory has promise of capturing [human fallibility], though at this point we are at an early stage.” (p. 43)

An important line of research in behavioral finance uses field data to address this issue, establishing that investors may depart systematically from rational behavior.³ In particular, these papers find evidence of biases leading to poorer returns than would otherwise be obtained. While field studies are extremely useful, it may be difficult or impossible to isolate specific influences with field data. Laboratory experiments provide a means to test the effects of information and processing biases on risk attitudes and consequent portfolio choice, permitting the researcher to change each variable in a controlled and systematic manner, while retaining explicit financial incentives; this approach can provide direct evidence on the issue under consideration. Nevertheless, while a modest number of studies have been conducted in the past decade, the field of experimental behavioral finance is still in its infancy.

In this paper we study the following basic intuition: when faced with a decision how to split their investment between a risky lottery and an asset with a fixed return, people will

² DeBondt and Thaler (1985) find that past stock winners tend to be future losers, attributing long-term return reversals to investor over-reaction. On the other hand, Michaely, Thaler, and Womack (1995) suggest that stock prices under-react to the negative information in dividend omissions. Barberis, Shleifer and Vishny (1998) and Daniel, Hirshleifer and Subramanyam (1998) provide behavioral models that account for investors under-reacting to some events and yet over-reacting to others.

³ See for example, DeBondt and Thaler (1985); Heath, Huddart and Lang (1998); Odean (1999).

increase the proportion invested in the risky option the more they like the lottery. We find counter example to this, and in fact we find that no simple relation exist. To show this we conduct a systematic experimental comparison of three of the most prominent biases documented in the literature. *Ambiguity aversion* (Ellsberg, 1961) is the desire to avoid unclear circumstances, even when this will not increase the expected utility. *The illusion of control* (Langer, 1975) is concerned with greater confidence in one's predictive ability or in a favorable outcome when one has a higher degree of personal involvement, even when one's involvement is not actually relevant. *Myopic loss aversion* (Benartzi and Thaler, 1995) combines loss aversion (Kahneman and Tversky 1979; Tversky and Kahneman 1992) and a tendency to evaluate outcomes frequently. This combination leads investors to be more willing to invest a greater proportion of their portfolio in risky assets if they evaluate their investments less frequently.

For each of these biases we first replicate the bias using real monetary incentives. We then test whether people are willing to pay money in line with the bias, or are they closer to the rational model when incentives are present. With the procedure we chose, the willingness to actually *pay* for this preference varies across biases. The great majority of investors pay to indulge their preference with either ambiguity aversion or myopic loss aversion, but less than 10% pay to roll a determinative die themselves.⁴

We then turn to study how the preferences between lotteries in the different treatments affect portfolio choice. We have participants allocate their investment capital between an asset with a sure return and a risky asset with a higher expected rate of return. In fact, there is very little variation in investment behavior across any of the illusion of control or ambiguity aversion

⁴ We do not make a general claim regarding these biases and how they survive financial incentives. We only choose arbitrary parameters for the biases to investigate the relationship between how much a person like a lottery and how much she is willing to invest in it.

treatments. In contrast, the results found in previous experimental studies of myopic loss aversion suggest that participants invest *less* in their preferred option.

The main conclusion we draw from these findings is that the relation between which procedure or lottery people prefer, and how much they are willing to actually invest in this lottery is not trivial at all; sometimes people are not willing to pay even small amounts of money in line with the bias, and the bias does not influence their portfolio choice (illusion of control); in other cases, people may be willing to pay money in line with the bias, but yet it does not influence their portfolio choice (ambiguity aversion); finally, in some cases people are willing to pay money in line with the bias, but invest *less* with the option they prefer (myopic loss aversion)!

BACKGROUND

In this paper we start with the bias at issue, and ask how it affects financial decisions. Three psychological biases that are pertinent to risk attitudes and financial markets are ambiguity aversion, the illusion of control and myopic loss aversion (henceforth MLA). We provide simple tests for both the existence of these phenomena in financial decision-making and their persistence in the face of a clear financial disincentive. We now discuss these biases in turn, and review the relevant empirical and experimental work.

Ambiguity aversion

Knight (1921) distinguishes between risk and uncertainty, with risk being quantifiable in terms of explicit probabilities. The Savage (1954) axioms preclude any role for vagueness in a

rational theory of choice. The famous Ellsberg (1961) paradox provides persuasive examples in which people prefer to bet on known distributions.⁵ In one decision task, urn 1 contains 50 red and 50 black balls whereas urn 2 contains 100 red and black balls in unknown proportions. People prefer to make bets with respect to the 50-50 urn. Ellsberg argues that it is not only subjective probability that matters, but also the vagueness or ambiguity of the event in question (see Camerer and Weber, 1992 for a review of the literature on variations of the Ellsberg paradox). This observed behavior is called a paradox because it violates Savage's axioms.

Ambiguity aversion has attracted considerable interest, as it is rare (outside games of chance) to know precise probabilities when buying a security, filing a lawsuit, or choosing a graduate program. Yet evidence is somewhat mixed concerning the effect of ambiguity aversion on financial decision-making. Heath and Tversky (1991) test whether ambiguity aversion is a factor only in the realm of chance events, or whether it also extends to uncertainty about knowledge of world events. They find that people prefer to bet on chance when they do not feel confident, but prefer to rely on their vague beliefs in situations where they feel particularly knowledgeable or confident. Thus, perceived self-confidence or competence can trump one's aversion to ambiguity.

Sarin and Weber (1993) test whether ambiguity aversion can survive market incentives and feedback, using market experiments with sealed-bid and double-oral auctions and sophisticated subjects (graduate business students and bank executives). Each participant faced both clear and vague bets about the color of a tennis ball to be drawn from an opaque urn, sometimes making both bets in the same market and sometimes in different markets. There is a pronounced decrease for individual bids and market prices with lotteries featuring ambiguous

⁵ The "Web of Science" showed 601 citations of Ellsberg's paper in July 2002.

probabilities relative to bids and prices with lotteries where these probabilities are known. This affect was substantially stronger with the sealed-bid auction mechanism, while the double-auction results are less compelling. Nevertheless, ambiguity aversion shows definite effects in a market setting with monetary incentives and feedback.

Fox and Tversky (1995) test the relationship between risk and uncertainty using a series of studies involving Ellsberg's two-color and three-color problems, temperatures in near and far cities, stock prices, and inflation rates. They note that previous tests had used a within-subject design in which participants compared ambiguous and clear alternatives, and propose a comparative ignorance hypothesis. Both between-subject and within-subject elicitation are used to test whether an awareness of missing information is *per se* sufficient to affect real bets with monetary incentives. The studies provide evidence that ambiguity aversion is "present in a comparative context in which a person evaluates both clear and vague prospects, [but] ... seems to disappear in a noncomparative context in which a person evaluates only one of these prospects in isolation." This result will be important when we will compare investment behavior of people in a noncomparative context.

The illusion of control

Langer (1975) defines the illusion of control as "an expectancy of a personal success probability inappropriately higher than the objective probability would warrant." Langer finds that choice, task familiarity, competition, and active involvement all lead to inflated confidence beliefs. For example, Langer found that people who were permitted to select their own numbers in a lottery game (hypothetically) demanded a higher price for their ticket than did people who were assigned random numbers. Since this initial study, many other researchers have found that

people often perceive more control than they actually have, make causal connections where none exist, and report surprisingly high anticipated predictive ability of chance events.⁶

Presson and Benassi (1996) perform a meta-analysis of 53 experiments on the illusion of control and make a distinction between illusory control and illusory prediction. They find much greater effect sizes in experiments “that measured participants’ perception of their ability to **predict** outcomes, as opposed to participants’ ability to **control** outcomes.” In fact, the authors point out (p. 496): “Oddly enough, few experiments have actually measured illusory control in the sense that participants judge the extent to which they directly affect outcomes.” Nevertheless, there is a sense that some people do have some preference for direct control – for example, many craps players care who rolls the dice at the table, and some strongly prefer to roll the dice themselves.

The predictive aspect of the illusion of control readily extends to the more general notion of overconfidence. In the behavioral finance literature (e.g., Kyle and Wang, 1997; Odean, 1999), an overconfident investor has historically been defined as one who overestimates the precision of his information signals.⁷ Overconfidence is most likely to manifest in environments with factors associated with skill and performance and some significant elements of chance.

Two recent experimental studies investigate overconfidence in investment behavior and employ more direct measurement of overconfidence. Dittrich, Güth & Maciejovsky (2001) allow participants to choose an investment portfolio, and define overconfidence as the consistently higher evaluation of one’s own choice over the optimal portfolio, as well as risk-

⁶ Benassi, Rohner, Reynolds & Sweeney (1981) find (p. 25) that “the introduction of objectively irrelevant factors (e.g., active involvement) into a chance task will lead people nevertheless to perceive (and behave as if) they can exert control over the task.”

⁷ An overconfident investor need not overestimate the precision of all signals; for example, in the Daniel, Hirshliefer & Subrahmanyam (1998) model, overconfidence is only present with respect to private information signals.

averse and risk-seeking portfolios. They find that overconfidence increases with task complexity and decreases with uncertainty. Biais, Hilton, Mazurier & Pouget (2002) explicitly measure one's disposition toward overconfidence by administering psychological tests, and find that overconfident traders do tend to overestimate the precision of their signals and earn relatively low profits in the accompanying experimental trading session.

Nevertheless, none of the studies mentioned explicitly address the illusion of control, and to our knowledge this phenomenon has not been tested in an investment experiment in which decisions are implemented with real money. There are a number of reasons why an individual might be overconfident (e.g., a general predisposition, or a belief specific to a particular situation), and we are interested rather in the effect of direct participation in the process leading to a financial outcome on the corresponding risk attitudes and portfolio choice. Our design accommodates both the control and prediction aspects of the illusion of control.

Myopic loss aversion

Myopic loss aversion is a combination of two well documented behavioral phenomena. The first is *loss aversion*, which is a major ingredient in prospect theory (Kahneman and Tversky, 1979; Tversky and Kahneman, 1992). According to prospect theory, the carrier of value is *change* relative to a reference level. Loss aversion is the tendency to weight negative changes from the reference level (losses) more heavily than positive changes (gains). The second phenomenon is *mental accounting* (Thaler, 1985). The aspect of mental accounting in play in relation to MLA is myopia, or the observation that people tend to evaluate their investment portfolio frequently, even when the investment is for the long run. Loss aversion combined with a tendency to focus on short-run outcomes gives MLA.

To illustrate MLA, assume that the investment portfolio's value follows a random walk with a positive drift. Since people evaluate their portfolio frequently, they observe the short-term losses (say from one period to the other); because they are more sensitive to losses than to gains, they are negatively affected by the short-term changes. Hence, the expected utility received from the portfolio is lower when the investor observes the frequent random changes.

One of the most interesting puzzles in finance is the equity premium puzzle, first discussed by Mehra and Prescott (1985). This premium reflects the difference in returns between equities (stocks) and risk-free assets such as government bonds or bills, and it has historically been quite large. This puzzle is difficult to resolve within the standard neoclassical model; Benartzi and Thaler (1995) propose an explanation based on MLA. Thaler, Tversky, Kahneman and Schwartz (1997) and Gneezy and Potters (1997) use experimental designs in which the frequency of the evaluation period (and opportunity to make investment choices) is varied. The shorter the evaluation period, the noisier the asset price, and the more likely it is that a sale will result in a loss relative to the most recently-observed wealth level. The main finding is that investors are more willing to invest a greater proportion of their portfolio in risky assets if they evaluate their investments less frequently; people who received the most frequent feedback took less risk and earned less money.⁸

EXPERIMENTAL METHOD

We conducted our experiments in classes at the University of California at Santa Barbara and the Graduate School of Business of the University of Chicago. A total of 275 people were involved in our sessions, with each person in exactly one of our 10 treatments. We handed out a

one-page instructions/decision sheet to the students in the class; these are presented in Appendix A. Every sheet had an identification number written on two corners of the page. Each person is confronted with a relatively straightforward decision task, deciding how much of their \$10 endowment to invest in a risky asset and how much to keep. Participants were told that 10% of the decision sheets would be chosen for actual implementation and payment.

We now describe the treatments according to the bias they investigate.

The illusion of control: We had four different treatments in which we studied this issue. In all treatments the roll of a 6-sided die determines the value of the risky asset; the investor picks three “success numbers”; if any of these comes up, the amount invested pays 2.5 for every unit invested. Allowing the participant to choose (or predict) winning numbers gives scope to the predictive element of the illusion of control. The investor also chooses the number of units to invest in the risky asset. In the first treatment, the investor rolls the die; in a second treatment, the experimenter rolls the die. In the third treatment, the investor chooses who rolls the die, and needs not pay anything to get his or her wishes. Finally, in the fourth treatment, the investor chooses the die-roller, but must pay five units from the 100-unit allocation to personally roll the die.

Ambiguity aversion: In our next four treatments, the risky asset is successful if the investor correctly identifies the color of a marble that he or she will (blindly) draw from an opaque bag. In one treatment, there were 50 red marbles and 50 black marbles in the bag; in a second treatment, there were 100 balls with an undisclosed distribution of red and black marbles. Our

⁸ While replicating these results successfully using the same lotteries, Langer and Weber (2001) found some conflicting results about the relationship between the evaluation period and risk-taking using different lotteries.

third treatment mentioned both bags, and permitted the investor a free choice between them; in the fourth treatment, this choice was also given, but it cost five units to choose from the bag with the known 50-50 distribution of marbles.

Myopic loss aversion: Our last two treatments examine the alternative evaluation periods used in Gneezy and Potters (1997). In the first of these, the investor chooses one of two plans: 1) to be informed of the value of the risky asset each period and make allocations every period, or 2) to be informed of the value of the risky asset after a block of three periods, and make an investment choice for a block of three periods at a time. In the latter case, this same choice is offered, but every-period information and investment opportunity costs five units out of each 100 units of endowment.

We drew numbers and matched these up with the identification numbers on the decision sheets to determine the investors chosen for actual payoff. Implementation of the investment instructions was done in private and the resulting earnings were paid in cash. Average earnings follow from the average investment percentage in the risky asset. As this rate was about 70% overall, the average person selected for payment earned about \$11.75.

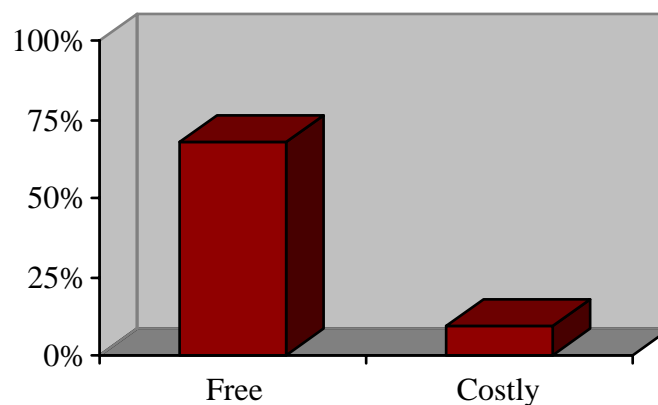
RESULTS

We find very different effects for the three biases under consideration. In each case, people manifest a definite preference for one condition. However, whether this preference

survives a price surcharge and whether it affects investment behavior varies considerably across these biases. Our full data set is presented in Appendix B.⁹

We first consider the illusion of control. Here people choose three success numbers from the six possible outcomes of the die. In treatment 1, they decide whether to roll the die themselves or to have the experimenter roll the die; in this treatment, there is no charge for either choice. At the same time, the investor chooses what portion of his or her endowment to invest in the risky asset. In treatment 7, the set-up is precisely the same, except that it now costs 5% of the investor's endowment for him or her to roll the die. In Figure 1, we show the percentage of participants who choose to roll the die in these two cases:

Figure 1 - Preference for Control



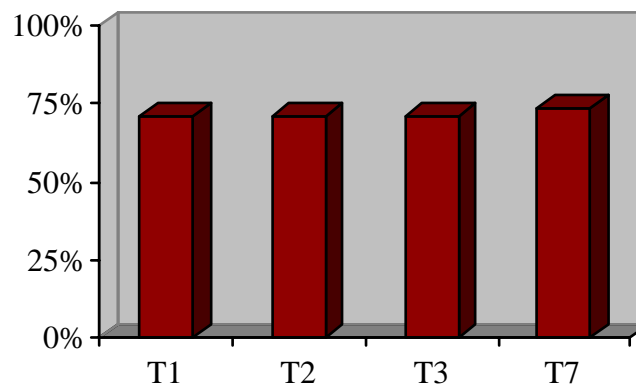
When it is free to exercise a preference for control, we find that 25 (68%) of 37 people in this treatment chose to roll the die; if people were indifferent, we should expect 50% choosing to roll themselves. The binomial test (Siegel and Castellan, 1988) finds the proportion choosing to

⁹ We also collected information concerning gender, although we did not do so in some early sessions. We see a strong gender effect: On average, males invest 75.27% and females invest 60.25%. A Wilcoxon rank-sum test gives $Z = 4.52$, $p = 0.00000$. This finding is discussed at length in Charness and Gneezy (in preparation).

roll is significantly different than the random prediction ($Z = 2.14$, $p = 0.016$, one-tailed test). However, when it costs 5% to exercise this preference, the proportion choosing to roll drops dramatically – only two of 22 (9%) people pay the price. This change in proportions is quite significant ($Z = 4.36$, $p = 0.00001$) by the test of the difference of proportions (Glasnapp and Poggio, 1985).

If the illusion of control leads to greater confidence in successful outcomes, we should expect a higher proportion to be invested in the risky asset when the investor directly controls the outcome. Figure 2 shows the investment percentage in each of the four treatments regarding the illusion of control:

Figure 2 - Investment %, Illusion T's

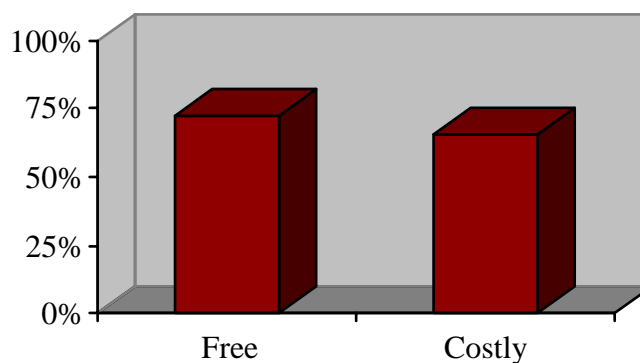


We see very little variation across these treatments. In treatment 1 (free choice), average proportion invested in the risky asset is 70.6%. In treatment 2 (investor rolls) this proportion is 70.5%, while in treatment 3 (experimenter rolls) this is 70.6%; there is a small increase to 73.5% in treatment 7 (costly choice). None of these proportions differ substantially or significantly,

using the Wilcoxon-Mann-Whitney rank-sum test (Siegel and Castellan, 1988). There is virtually no difference in the direct between-subjects test of investment percentage (treatment 2 vs. treatment 3). We also see very little difference in investment percentage between investors who chose to roll and who chose to have the experimenter roll. Pooling the data in treatments 1 and 7, we find that the proportions invested are 71.6% and 71.9%, respectively.

In our ambiguity aversion treatments, people chose a success color (red or black). In treatment 4, they decide whether to select a ball from the bag with the known 50/50 distribution or the bag with an unknown distribution; there is no charge for either choice. The investor also chooses the portion of his or her endowment to invest in the risky asset. In treatment 8, the set-up is precisely the same, except that it now costs 5% of the investor's endowment to select from the bag with the known distribution. Figure 3 shows the proportion of people who prefer the known distribution in these two cases:

Figure 3 - Pref. for Known Distribution

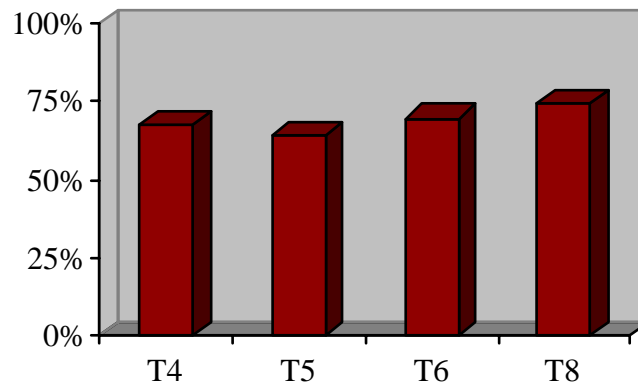


When it is free to choose from the bag with the known distribution, 18 of 25 (72%) people chose to roll the die; this proportion is statistically significant from randomness ($Z = 2.20$,

$p = 0.014$, one-tailed test). Charging 5% for indulging this preference reduced this proportion only slightly: 17 of 26 investors (65%) pay for the right to choose from the known distribution; this reduction is not statistically significant ($Z = 0.51$, $p = 0.31$, one-tailed test).

If ambiguity aversion leads to greater confidence in successful outcomes with a more definite distribution, we might expect a higher proportion to be invested in the risky asset when the investor chooses from the known distribution. Figure 4 shows the investment percentage in each of the four treatments regarding ambiguity aversion:

Figure 4 - Investment %, Ambiguity T's



Once again, we see little variation across these treatments. In treatment 4 (free choice), average proportion invested in the risky asset is 67.7%. In treatment 5 (known only) this proportion is 64.0%, while in treatment 6 (unknown only) this is 69.5%; there is again a small increase to 74.0% in treatment 7 (costly choice).¹⁰ None of these proportions differ substantially or significantly ($Z = 0.88$ for the comparison between treatments 5 and 8, the largest difference). Note that for the direct between-subjects comparison (treatments 5 vs. 6), the slight difference in

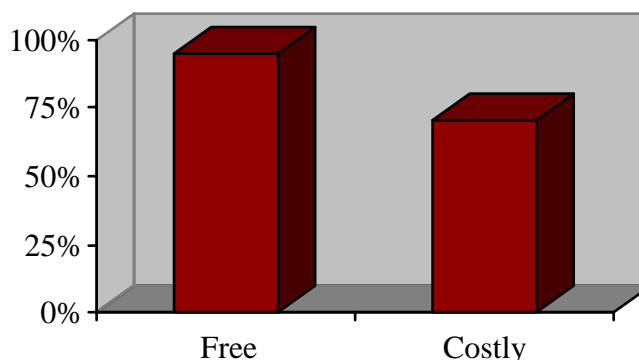
¹⁰ Note that the proportion invested in treatments 7 and 8 is slightly higher than in the corresponding treatments (1 and 4), perhaps reflecting the salience of the monetary charge for making use of the mechanism generally preferred.

investment rates goes in the opposite direction from the prediction, and is in any case not statistically significant ($Z = -0.27$).¹¹ With ambiguity aversion, we do find a difference in behavior in treatments 4 and 8 between investors who chose the known distribution and who chose the unknown distribution. Pooling these data, the proportions invested are 69.0% and 79.4%, respectively. However, this difference goes in the opposite direction from the prediction! The test statistic $Z = -1.95$ shows 5% significance on a two-tailed test, and certainly does not provide support for the hypothesis that people invest less when there is a higher degree of ambiguity.

In our myopic loss aversion treatments, either people invest and receive information every period or they invest and receive information only in 3-period blocks. For each investment decision over the nine periods, the investors chosen for actual payment also choose the portion of their endowments to invest in the risky asset. In treatment 9, the choice is free; in treatment 10, the set-up is precisely the same, except that it now costs 25 points for the every-period plan. Figure 5 shows the proportion of people who prefer the every-period plan in these two cases:

¹¹ It could be quite interesting to investigate whether there are differences in investment behavior in a within-subjects test of ambiguity aversion. In line with the Fox and Tversky (1995) comparative ignorance hypothesis and the Sarin and Weber (1993) empirical support, we might expect to see differential investment rates when the ambiguity is highlighted for each subject. This issue of relative evaluation is a hot topic in marketing and business psychology, as Hsee, Loewenstein, Blount and Bazerman (1999) has shown that people tend to make very different decisions depending on whether alternatives are evaluated separately or together. An additional treatment could be identical to treatment 4, except that the investor would be told that a coin flip will determine whether he or she draws from Bag A or Bag B, and would be asked for investment decisions in each case.

Figure 5 - Pref. for Every-period Plan



When the choice of plan is free, we find that 19 of 20 (95%) people in this treatment chose the plan offering information and investment every period; this proportion is statistically significant ($Z = 4.02$, $p = 0.0001$, one-tailed test). Even when a charge is imposed, 14 of 20 investors (70%) choose the every-period plan. While this represents a statistically significant decrease ($Z = 2.08$, $p = 0.019$, one-tailed test) from the free case, the great majority of people are willing to pay a clear and positive cost to receive information and invest every period.

We only obtained portfolio choices for the four of the 40 participants in treatments 9 and 10 who were chosen for actual payoff implementation, since going through nine periods of choices for each of 40 people would have been quite time-consuming. Thus, we instead rely on the studies mentioned near the end of section 2, since these studies establish that people invest less in the risky asset when they act every period. In particular, we note that the design in Gneezy and Potters (1997) is very similar to our treatment 9, except that participants were not offered a choice of plans, but were instead assigned one plan or the other. There the average investment percentage was 39% for the every-period plan and 49% for the block plan; this difference was statistically significant at the 5% level.

DISCUSSION

It is important to test the degree to which a psychological bias persists given clear financial disincentives, and how it affects portfolio choice. Table 1 below presents a summary of the results.

Table 1

	Prefer one mechanism?	Willing to pay for their choice?	Difference in investment?
Illusion	Yes	No	No
Ambiguity	Yes	Yes	No
MLA	Yes	Yes	Yes

We see that all of these biases are replicated with the design we chose. However, there is considerable variation in the degree to which each bias either survives a price and or affects investment behavior.

We chose a very weak form of the illusion of control, and indeed it disappears when payment is introduced and it does not affect investment. The manipulation of the ambiguity aversion we chose was stronger in the sense that it survives the payment treatment, but it did not influence investment. Finally, the myopic loss aversion manipulation also survives the payment condition, but surprisingly, people invest in a manner contrary to the simple intuition that one invests more in a portfolio he or she likes more.

The main conclusion we draw from our results is that the degree of preference for a procedure or lottery does not affect behavior in an obvious and intuitive manner. In some cases there is no effect, even when people are willing to pay more for one procedure; in other cases,

the preference may even affect risky investment in a negative way; as people invest less when given the procedure they prefer. In some sense this ‘no result’ is discouraging, as it is always nicer to find a simple rule that captures general behavior. But, to quote Albert Einstein, “everything should be as simple as it is, but not simpler.” Our study is only a beginning; since the issue of risk attitudes and portfolio choice is an important empirical question, future research should aim at further delineation of the rules that connect preferences and investment choices.

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T1

T1

Instructions

Welcome to this experiment in decision-making. The experiment will take about 15 minutes, and we will choose 1 of every 10 students to be paid in cash according to the instructions below.

You are endowed with 100 points and asked to choose the portion of this amount (between 0 and 100 points, inclusive) that you wish to invest in a risky option. Those points not invested are yours to keep.

The risky investment:

There is a 50% chance that the investment in the risky asset will be successful. If it is successful, you receive 2.5 times the amount you chose to invest; if the investment is unsuccessful, you lose the amount invested.

How do we determine if the investment is successful?

The roll of a 6-sided die determines the value of the risky asset. You will be asked to choose 3 “success” numbers. **Either you or the experimenter will roll the die, at your option.**

We now ask you to indicate the number of points that you wish to invest, your 3 success numbers, and whom you wish to roll the die.

- I wish to invest _____ points
- My 3 success numbers are: _____
- I wish the die to be rolled by:
 - Me
 - The experimenter

After the decisions are made and collected, we will randomly choose 1 out of every 10 participants. The people chosen will be invited to privately implement their instructions in my office, and will be paid \$0.10 for each point they have at the end of the experiment.

T2

T2

Instructions

Welcome to this experiment in decision-making. The experiment will take about 15 minutes, and we will choose 1 of every 10 students to be paid in cash according to the instructions below.

You are endowed with 100 points and asked to choose the portion of this amount (between 0 and 100 points, inclusive) that you wish to invest in a risky option. Those points not invested are yours to keep.

The risky investment:

There is a 50% chance that the investment in the risky asset will be successful. If it is successful, you receive 2.5 times the amount invested; if the investment is unsuccessful, you lose the amount invested.

How do we determine if the investment is successful?

The roll of a 6-sided die determines the value of the risky asset. You will be asked to choose 3 “success” numbers. **You will roll the die.**

We now ask you to indicate the number of points that you wish to invest and your 3 success numbers.

- I wish to invest _____ points
- My 3 success numbers are: _____

After the decisions are made and collected, we will randomly choose 1 out of every 10 participants. The people chosen will be invited to privately implement their instructions in my office, and will be paid \$0.10 for each point they have at the end of the experiment.

Instructions

Welcome to this experiment in decision-making. The experiment will take about 15 minutes, and we will choose 1 of every 10 students to be paid in cash according to the instructions below.

You are endowed with 100 points and asked to choose the portion of this amount (between 0 and 100 points, inclusive) that you wish to invest in a risky option. Those points not invested are yours to keep.

The risky investment:

There is a 50% chance that the investment in the risky asset will be successful. If it is successful, you receive 2.5 times the amount invested; if the investment is unsuccessful, you lose the amount invested.

How do we determine if the investment is successful?

The roll of a 6-sided die determines the value of the risky asset. You will be asked to choose 3 “success” numbers. **The experimenter will roll the die.**

We now ask you to indicate the number of points that you wish to invest and your 3 success numbers.

- I wish to invest _____ points
- My 3 success numbers are: _____

After the decisions are made and collected, we will randomly choose 1 out of every 10 participants. The people chosen will be invited to privately implement their instructions in my office, and will be paid \$0.10 for each point they have at the end of the experiment.

Instructions

Welcome to this experiment in decision-making. The experiment will take about 15 minutes, and we will choose 1 of every 10 students to be paid in cash according to the instructions below.

You are endowed with 100 points and asked to choose the portion of this amount (between 0 and 100 points, inclusive) that you wish to invest in a risky option. Those points not invested are yours to keep.

The risky investment:

There is a chance that the investment in the risky asset will be successful. If it is successful, you receive 2.5 times the amount invested; if the investment is unsuccessful, you lose the amount invested.

How do we determine if the investment is successful?

There are two large opaque bags (Bag A and Bag B), with 100 balls in each bag.

- Bag A contains 50 red balls and 50 black balls
- Bag B contains 100 balls, either red or black, but the exact color distribution is unknown to you.

You will be asked to choose the “success” color (red or black), and the bag from which you prefer to draw the ball.

We now ask you to indicate the number of points that you wish to invest, your success color, and the bag from which you wish to draw the ball.

- I wish to invest _____ points
- My success color is: _____
- I wish to draw the ball from:
 - Bag A
 - Bag B

After the decisions are made and collected, we will randomly choose 1 out of every 10 participants. The people chosen will be invited to privately implement their instructions in my office, and will be paid \$0.10 for each point they have at the end of the experiment.

T5

T5

Instructions

Welcome to this experiment in decision-making. The experiment will take about 15 minutes, and we will choose 1 of every 10 students to be paid in cash according to the instructions below.

You are endowed with 100 points and asked to choose the portion of this amount (between 0 and 100 points, inclusive) that you wish to invest in a risky option. Those points not invested are yours to keep.

The risky investment:

There is a chance that the investment in the risky asset will be successful. If it is successful, you receive 2.5 times the amount invested; if the investment is unsuccessful, you lose the amount invested.

How do we determine if the investment is successful?

There is a large opaque bag, with 100 balls: 50 red balls and 50 black balls. You will be asked to choose the “success” color (red or black), and will draw the ball from this bag.

We now ask you to indicate the number of points that you wish to invest and your success color.

- I wish to invest _____ points
- My success color is: _____

After the decisions are made and collected, we will randomly choose 1 out of every 10 participants. The people chosen will be invited to privately implement their instructions in my office, and will be paid \$0.10 for each point they have at the end of the experiment.

Instructions

Welcome to this experiment in decision-making. The experiment will take about 15 minutes, and we will choose 1 of every 10 students to be paid in cash according to the instructions below.

You are endowed with 100 points and asked to choose the portion of this amount (between 0 and 100 points, inclusive) that you wish to invest in a risky option. Those points not invested are yours to keep.

The risky investment:

There is a chance that the investment in the risky asset will be successful. If it is successful, you receive 2.5 times the amount invested; if the investment is unsuccessful, you lose the amount invested.

How do we determine if the investment is successful?

Bag B contains 100 balls, either red or black, but the exact color distribution is unknown to you. You will be asked to choose the “success” color (red or black), and will draw the ball from this bag.

We now ask you to indicate the number of points that you wish to invest and your success color.

- I wish to invest _____ points
- My success color is: _____

After the decisions are made and collected, we will randomly choose 1 out of every 10 participants. The people chosen will be invited to privately implement their instructions in my office, and will be paid \$0.10 for each point they have at the end of the experiment.

Instructions

Welcome to this experiment in decision-making. The experiment will take about 15 minutes, and we will choose 1 of every 10 students to be paid in cash according to the instructions below.

You are endowed with 100 points and asked to choose the portion of this amount (between 0 and 100 points, inclusive) that you wish to invest in a risky option. Those points not invested are yours to keep.

The risky investment:

There is a 50% chance that the investment in the risky asset will be successful. If it is successful, you receive 2.5 times the amount you chose to invest; if the investment is unsuccessful, you lose the amount invested.

How do we determine if the investment is successful?

The roll of a 6-sided die determines the value of the risky asset. You will be asked to choose 3 “success” numbers. **Either you or the experimenter will roll the die, at your option. However, you must pay 5 points if you choose to roll the die.**

We now ask you to indicate the number of points that you wish to invest, your 3 success numbers, and whom you wish to roll the die.

- I wish to invest _____ points
- My 3 success numbers are: _____
- I wish the die to be rolled by:
 - Me
 - The experimenter

After the decisions are made and collected, we will randomly choose 1 out of every 10 participants. The people chosen will be invited to privately implement their instructions in my office, and will be paid \$0.10 for each point they have at the end of the experiment.

Instructions

Welcome to this experiment in decision-making. The experiment will take about 15 minutes, and we will choose 1 of every 10 students to be paid in cash according to the instructions below.

You are endowed with 100 points and asked to choose the portion of this amount (between 0 and 100 points, inclusive) that you wish to invest in a risky option. Those points not invested are yours to keep.

The risky investment:

There is a chance that the investment in the risky asset will be successful. If it is successful, you receive 2.5 times the amount invested; if the investment is unsuccessful, you lose the amount invested.

How do we determine if the investment is successful?

There are two large opaque bags (Bag A and Bag B), with 100 balls in each bag.

- Bag A contains 50 red balls and 50 black balls
- Bag B contains 100 balls, either red or black, but the exact color distribution is unknown to you.

You will be asked to choose the “success” color (red or black), and the bag from which you prefer to draw the ball. **However, you must pay 5 points to draw the ball from Bag A.**

We now ask you to indicate the number of points that you wish to invest, your success color, and the bag from which you wish to draw the ball.

- I wish to invest _____ points
- My success color is: _____
- I wish to draw the ball from:
 - Bag A
 - Bag B

After the decisions are made and collected, we will randomly choose 1 out of every 10 participants. The people chosen will be invited to privately implement their instructions in my office, and will be paid \$0.10 for each point they have at the end of the experiment.

Instructions

This experiment will take about 15 minutes. The instructions are simple, and if you follow them carefully, you can earn a considerable amount of money. All the money you earn is yours to keep, and will be paid to you, in cash, immediately after the experiment.

The experiment consists of 12 successive periods. In each period you will receive 100 points. You are asked to choose the portion of this amount (between 0 points and 100 points, inclusive) that you wish to invest in a risky option. The rest of the points (those you don't invest) will be accumulated in your total balance.

The risky investment: In any particular period, there is a $\frac{2}{3}$ (66.7%) probability that the investment will fail and a $\frac{1}{3}$ (33.3%) chance that it will succeed. If the investment fails, you lose the amount you invested. If the investment succeeds, you receive 2.5 (two and one-half) times the amount invested.

How do we determine if the risky asset succeeds? You choose **two** numbers from the set 1, 2, 3, 4, 5, 6. These two numbers will be your "success numbers" for the session. Please record the two success numbers on your Registration Form.

We will roll a 6-sided die at the end of each period. Your investment succeeds in that period if the die comes up one of your two success numbers.

You can choose between two investment plans:

1. At the beginning of every period, you choose the amount you wish to allocate to the risky investment in **that period**. You then learn the outcome for **that period** (recall that you start with 100 points in each period). Next, you would make an investment decision for the next period.
2. At the beginning of period 1, you choose the amount you wish to allocate to the risky investment for the **next 3 periods** (periods 1, 2, and 3). After period 3, you then learn the aggregate outcome for **these 3 periods** (recall that you start with 100 points in each period, so you have 100 points to potentially invest in each of these periods). Next, at the beginning of period 4, you would choose your investment for each of periods 4, 5, and 6; similarly, at the beginning of period 7, you would choose your investment for each of periods 7, 8, and 9, and at the beginning of period 10, you would choose your investment for each of periods 10, 11, and 12.

Your total earnings for the experiment are the sum of the earnings in each of the 12 periods. You will be paid \$1 for each 100 points you will accumulate.

We will randomly choose 1 person out of every 10 (10% of the participants) for actual investment choices. However, we ask each person to indicate whether he or she would prefer investment plan 1 or 2, should he or she be selected.

Please circle your choice below

I prefer: PLAN 1 (every period) PLAN 2 (every 3 periods)

Instructions

This experiment will take about 15 minutes. The instructions are simple, and if you follow them carefully, you can earn a considerable amount of money. All the money you earn is yours to keep, and will be paid to you, in cash, immediately after the experiment.

The experiment consists of 12 successive periods. In each period you will receive 100 points. You are asked to choose the portion of this amount (between 0 points and 100 points, inclusive) that you wish to invest in a risky option. The rest of the points (those you don't invest) will be accumulated in your total balance.

The risky investment: In any particular period, there is a $2/3$ (66.7%) probability that the investment will fail and a $1/3$ (33.3%) chance that it will succeed. If the investment fails, you lose the amount you invested. If the investment succeeds, you receive 2.5 (two and one-half) times the amount invested.

How do we determine if the risky asset succeeds? You choose **two** numbers from the set 1, 2, 3, 4, 5, 6. These two numbers will be your "success numbers" for the session. Please record the two success numbers on your Registration Form.

We will roll a 6-sided die at the end of each period. Your investment succeeds in that period if the die comes up one of your two success numbers.

You can choose between two investment plans:

1. At the beginning of every period, you choose the amount you wish to allocate to the risky investment in **that period**. You then learn the outcome for **that period** (recall that you start with 100 points in each period). Next, you would make an investment decision for the next period.
2. At the beginning of period 1, you choose the amount you wish to allocate to the risky investment for the **next 3 periods** (periods 1, 2, and 3). After period 3, you then learn the aggregate outcome for **these 3 periods** (recall that you start with 100 points in each period, so you have 100 points to potentially invest in each of these periods). Next, at the beginning of period 4, you would choose your investment for each of periods 4, 5, and 6; similarly, at the beginning of period 7, you would choose your investment for each of periods 7, 8, and 9, and at the beginning of period 10, you would choose your investment for each of periods 10, 11, and 12.

If you wish to choose investment plan 2 for the session, you must pay 25 points. It costs nothing if you wish to choose investment plan 1.

Your total earnings for the experiment are the sum of the earnings in each of the 12 periods. You will be paid \$1 for each 100 points you will accumulate.

We will randomly choose 1 person out of every 10 (10% of the participants) for actual investment choices. However, we ask each person to indicate whether he or she would prefer investment plan 1 or 2, should he or she be selected.

Please circle your choice below

I prefer: PLAN 1 (every period) PLAN 2 (every 3 periods)

	T1			T2			T3			T4			T5			T6			T7			T8		
1	45	0	M	100	M	100	F	90	0	F	20	M	45	F	100	0	M	95	1	M				
2	100	1	M	35	M	75	M	65	0	M	100	F	100	M	50	0	F	65	1	M				
3	32	0	F	25	M	60	F	80	1	F	50	M	100	M	100	0	M	100	1	M				
4	50	1	M	75	F	73	M	50	1	M	100	F	80	F	100	0	M	75	0	M				
5	50	0	F	60	M	100	M	50	1	M	50	M	25	F	100	0	F	90	0	M				
6	60	1	M	100	M	100	M	50	1	M	30	M	80	M	70	0	F	50	1	F				
7	25	1	F	60	F	85	F	50	1	M	60	M	100	F	50		M	100	0	F				
8	100	1	M	100	M	95	M	90	0	M	50	M	80	M	80	1	F	25	1	F				
9	33	1	F	25	F	100	M	100	0	F	100	F	100	M	80	0	M	80	1	F				
10	100	1	M	25	F	100	M	75	1	M	50	M	75	F	75	0	M	95	1	F				
11	60	1	M	70	F	50	M	100	1	M	75	M	50	M	50	0	F	100	1	M				
12	70	1	F	55	M	25	M	75	1	M	100	M	55	M	50	0	M	100	0	M				
13	50	0	M	40	F	100	M	60	0	F	12	F	50	M	50	0	F	100	1	M				
14	100	1	M	100	M	20	M	75	1	M	50	F	60	F	75	0	F	5	1	F				
15	30	0	M	100	M	50	F	50	1	M	100	M	70	M	100	0	M	100	1	M				
16	100	1	F	75	M	100	M	100	1	M	50	F	75	F	100	0	M	45	1	M				
17	60		F	100	M	75	M	100	1	M	100	M	50	F	100	0	M	50	0	M				
18	100	0	M	50	F	50	M	50	1	F	50	M	50	M	100	0	M	50	0	M				
19	70	1	F	50	M	50	M	100	1	M	50	F	75	M	100	0	M	100	0	M				
20	75	1	F	100	M	0	M	0		F	50	M	15	M	50	0	F	100	0	M				
21	25	0	M	100	M	46	F	50	1	M	100	M	75	F	10	1	M	100	0	M				
22	100	0	M	75	M	70	M	50	1	M	50	M	100	M	0	0	F	40	1	F				
23	100	1	M	100	M	75	M	100	1	M	40	F	90	F	100	0	M	100	1	M				
24	100	1	M	96		100	M	50	1	F	100	M	38	M				50	1	F				
25	100		M	75		78	F	100	0	M			70	M				10	1	M				
26	100	0	M	100		66	M	100	0	M			100	M				100	1	M				
27	50	0	M	30		75																		
28	100	1		100		45																		
29	50	1		0		50																		
30	70	1		25		100																		
31	65	1		80		70																		
32	75	1		100		75																		
33	70	0		100		100																		
34	100	1				10																		
35	40	1				40																		
36	50	1				75																		
37	50	1				100																		
38	100	1				100																		
39	100	0																						

