

PORTFOLIO CHOICE AND RISK ATTITUDES: AN EXPERIMENT

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Using financial incentives, we study how portfolio choice (how much to invest in a risky asset) depends on three well-known behavioral phenomena: ambiguity aversion, the illusion of control, and myopic loss aversion. We find evidence that these phenomena are present and test how the level of investment is affected by these motivations; at the same time, we investigate whether participants are willing to explicitly pay a small sum of money to indulge preferences for less ambiguity, more control, or more frequent feedback opportunities to choose the investment level. First, the observed preference for “control” did not affect investment behavior and in fact disappeared when participants were asked to actually pay to gain more control. Second, while people were indeed willing to pay for less ambiguity, the level of ambiguity did not influence investment levels. Finally, participants were willing to pay to have more frequent feedback opportunities to change their portfolio, even though prior research has shown that people invest less in risky assets (and earn less) in this case. (JEL B49, C91, D81, G11, G19)

I. INTRODUCTION

Suppose an investor is faced with a decision concerning how to allocate financial resources between a risky lottery (asset) with a higher expected return and an asset with a fixed and guaranteed lower return. Is the choice of portfolio independent of preferences outside the standard neoclassical model? In experiments with financial incentives, we study how portfolio choice depends on three well-documented behavioral phenomena: ambiguity aversion, the illusion of control, and myopic loss aversion. We also investigate whether participants are willing to explicitly pay a small sum of money to indulge such preferences (pay for more perceived control, less ambiguity, or more frequent opportunities to change the portfolio based on feedback about its performance).

While standard finance theory presumes that investors successfully identify and process information relevant to reaching optimal

decisions, in recent years a body of empirical evidence suggests that there are systematic departures from this behavior. Behavioral finance is concerned with psychological influences in financial decision making and markets. Investors make decisions while trying to stay 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, it is economically important to consider which of these actually affect risk attitudes and portfolio choice. A key issue is whether any such influences disappear when monetary incentives are present.

We pursue a systematic experimental comparison of three of the most prominent behavioral

1. It might seem natural to assume that investors who behave “irrationally” (e.g., do not process information optimally) can be exploited and driven from the market over time; however, several theoretical models (e.g., Benos, 1998; Gervais and Odean, 2001; Hirshleifer and Luo, 2001; Kyle and Wang, 1997) demonstrate that, for example, overconfidence can persist in the long run.

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ABBREVIATION

MLA: Myopic Loss Aversion

phenomena documented in the literature. 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. *Ambiguity aversion* (Ellsberg 1961) is the desire to avoid unclear circumstances, even when this will not increase the expected utility. *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.

We show that these phenomena are present with monetary incentives and also investigate whether people are willing to pay money to accommodate such preferences, or whether they are closer to the rational model when incentives are present. With the procedure we chose, the willingness to actually *pay* for such preferences depends on the preference. The great majority of investors pay for less ambiguity or more frequent feedback/investment opportunities, but fewer than 10% pay to roll a determinative die themselves.²

We then examine 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 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. People are generally unwilling to pay even small amounts of money to indulge the illusion of control, and it does not influence their portfolio choice; people are generally willing to pay money for less ambi-

guity, but having less ambiguity does not influence their portfolio choice; finally, in some cases people are willing to pay money for more frequent feedback and opportunities to change their portfolio, but, again, previous studies have shown that people invest *less* with this additional information and greater flexibility!

II. BACKGROUND

In this article, we start with the phenomenon at issue, and ask how it affects financial decisions. 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 in turn, and review the relevant empirical and experimental work.

A. 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. 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 of 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

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

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 probabilities relative to bids and prices with lotteries where these probabilities are known. This effect 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 non-comparative context in which a person evaluates only one of these prospects in isolation." This result will be important when we compare investment behavior of people in a noncomparative context.

B. *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.³

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 (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.⁴ 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, and Maciejovsky (2001) allow participants to choose an investment

3. Benassi et al. (1981, 25) find 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."

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

portfolio, and define overconfidence as the consistently higher evaluation of one's own choice over the optimal portfolio, as well as risk-averse and risk-seeking portfolios. They find that overconfidence increases with task complexity and decreases with uncertainty. Biias et al. (2005) 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 addresses 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.

C. Myopic Loss Aversion

Myopic loss aversion (henceforth, "MLA") 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 et al. (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.⁵

III. 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 1 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, and participants were instructed

5. Two studies have attempted to delve further into whether this phenomenon is driven by the information feedback or by decisions being binding for longer periods of time. Langer and Weber (2001) replicate MLA when both features are present. However, Bellemare et al. (2004) find that decreasing the information feedback alone leads to higher investment, while Langer and Weber (2004) find an *increase* in investment with restricted feedback. More research is needed to determine the interaction of the two influences.

to tear off one of these corners. Each person was confronted with a relatively straightforward decision task, deciding how much of a \$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 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.

We now describe each treatment according to the phenomenon it investigates, and we identify some predictions as given below.

A. The Illusion of Control

We had four different treatments in which we studied this issue. In all treatments, the roll of a six-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 one treatment (T2), the investor rolls the die; in a second treatment (T3), the experimenter rolls the die. In a third treatment (T1), the investor chooses who rolls the die, and need not pay anything to get his or her wishes. Finally, in the fourth treatment (T7), the investor chooses the die-roller, but must pay 5 units from the 100-unit allocation to personally roll the die. Thus, if we observe a preference to personally roll the die in T1, we would test to see if this preference for control still persists at a cost.

In a certain sense, T1 is the most attractive option since both those people who wish to roll the die and those people who want the experimenter to roll the die get their wishes freely. Thus, we might expect a higher investment rate in T1 than in T2 or T3. In addition, if there is a preference for control, more people presumably get their wish in T2 than in T3, so

we might expect a higher investment rate in T2. Of course, the null hypothesis is that investment is the same in each treatment. The predictions vis-à-vis T7 are less clear; although this is ex ante a less attractive option than T1, an investor who has already paid money to roll the die might feel the need to justify this expenditure by investing more heavily.

B. 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 (T5), there were 50 red marbles and 50 black marbles in the bag; in a second treatment (T6), there were 100 balls with an undisclosed distribution of red and black marbles. A third treatment (T4) mentioned both bags and permitted the investor a free choice between them; in the fourth treatment (T8), this choice was also given, but it cost 5 units to choose from the bag with the known 50-50 distribution of marbles.

Here again, in a certain sense T4 is the most attractive option since both those people who like ambiguity and those people who dislike ambiguity get their wishes freely. Thus, we might expect a higher investment rate in T4 than in T5 or T6. In addition, if there is ambiguity aversion, people are presumably happier with the lottery in T5 than in T6, so we might expect a higher investment rate in T5. Once again, the null hypothesis is that investment is the same in each treatment, and the predictions across T4 and T8 are unclear.

C. Myopic Loss Aversion

Our last two treatments examine the alternative evaluation periods used in Gneezy and Potters (1997).⁶ In the first treatment (T9), the investor chooses one of the 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

6. Variations of this design were used to show the effect of the investment horizon on market prices (Gneezy, Kapteyn, and Potters 2003), the possible negative effect of emotions (Shiv et al. 2005), that teams are also prone to such influence (Sutter 2007), and that professional traders are affected by the investment horizon even more than students (Haigh and List 2005).

an investment choice for a block of three periods at a time. In the second treatment (T10), this same choice is offered, but every-period information and investment opportunity costs 5 units of each 100 units of endowment. In line with previous studies, we might expect people who choose to be informed each period in T9 to invest more in the risky asset than people who do not.

IV. RESULTS

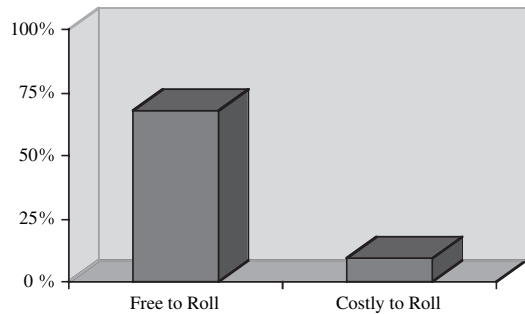
We find very different effects for the phenomena under consideration. In each case, people manifest a definite preference for one condition. However, whether such preferences survive a price surcharge and whether they affect investment behavior varies considerably according to the particular phenomenon. Our full data set is presented in Table A1.⁷

A. *The Illusion of Control*

In T1, people 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 T7, the setup 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:

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 roll is significantly different than the random prediction ($Z = 2.14$, $p = .016$, one-tailed test). Thus, even a rather transparent illusion is enough to have a significant effect on behavior. However, when it costs 5% to exercise this preference, the proportion choosing to roll drops dramatically—only 2 of

FIGURE 1
Preference for Control



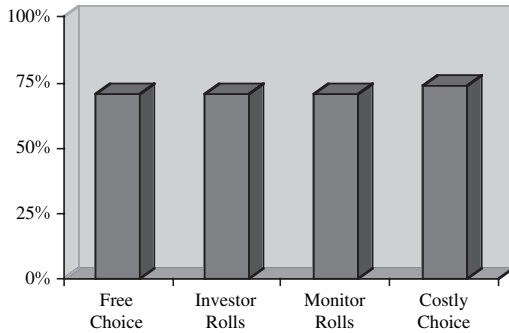
22 (9%) people pay the price. This change in proportions is quite significant ($Z = 4.36$, $p = .00001$) by the test of the difference of proportions (Glasnapp and Poggio 1985), so that it seems that the preference for control is not very deep or strong.

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.

We see very little variation across these treatments. When there is a free choice about rolling the die, the average proportion invested in the risky asset is 70.6%. When the investor rolls, this proportion is 70.5%, while when the monitor rolls this is 70.6%; there is a small increase to 73.5% when it costs 5 units to roll the die. None of these proportions differ 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 (investor rolls vs. monitor rolls). Restricting our attention to those treatments where people could choose who rolls the die, we 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 T1 and T7, we find that the proportions invested are 71.6% and 71.9%, respectively. Thus, we cannot reject the null hypothesis of no difference in investment percentage, and the preference for control that we find does not appear to affect investment behavior.

7. 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 $Z = 4.52$, $p = .00000$. This finding is discussed at length in Charness and Gneezy (2007).

FIGURE 2
Investment % in Illusion Treatments

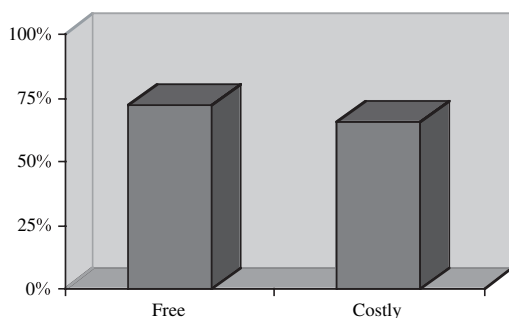


B. Ambiguity Aversion

In our ambiguity aversion treatments, people chose a success color (red or black). In T4, 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 T8, the setup 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:

When it is free to choose from the bag with the known distribution, 18 of 25 (72%) people chose to do so; this proportion is statistically significant from randomness ($Z = 2.20, p = .014$, one-tailed binomial test), so that we have evidence of ambiguity aversion. Charging 5% for indulging this preference reduced this proportion only slightly: 17 of 26 investors (65%)

FIGURE 3
Preference for Known Distribution



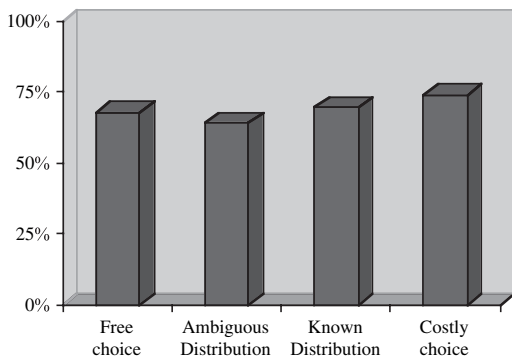
pay for the right to choose from the known distribution. This proportion is still marginally significantly different from random behavior ($Z = 1.57, p = .058$, one-tailed test), so that the preference for reduced ambiguity survives a modest cost; the difference between the two observed proportions is not statistically significant ($Z = 0.51$).

If people feel that they have a greater chance for success with less ambiguity or if they experience negative outcomes more keenly with ambiguity, 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:

Once again, we see little variation across these treatments. With free choice about known or unknown distribution, the average proportion invested in the risky asset is 67.7%. When the distribution is known this proportion is 64.0%, while with ambiguity the proportion is 69.5%; there is again a small increase to 74.0% when getting a known distribution is costly. None of these proportions differ significantly ($Z = 0.88$ for the comparison between T5 and T8, the largest difference). Note that for the direct between-subjects comparison (ambiguous vs. known distribution), the slight difference in investment rates goes in the *opposite* direction from the prediction, and is in any case not statistically significant ($Z = -0.27$).⁸ 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

8. 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 relevant topic in marketing and business psychology, as Hsee et al. (1999) have 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 4
Investment % in Ambiguity Treatments



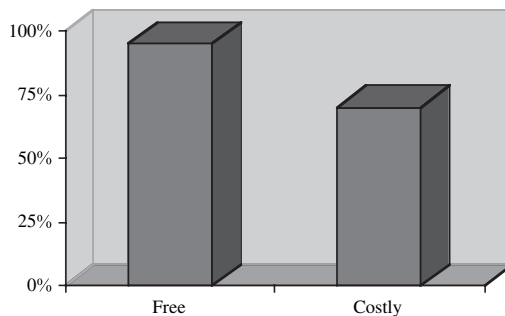
$Z = -1.95$ shows 5% significance on a two-tailed test, and certainly does not provide support for the hypothesis that people invest less when there is a higher degree of ambiguity.

C. Myopic Loss Aversion

In our MLA treatments, either people invest and receive information every period or they invest and receive information only in three-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 setup 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.

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 significantly different from random behavior ($Z = 4.02$, $p = .0001$, one-tailed binomial test). Even when a charge is imposed, 14 of 20 investors (70%) choose the every-period plan, with this proportion being significantly different from the 50% expected with random choice ($Z = 1.79$, $p = .037$, one-tailed test). While this represents a substantial (and significant: $Z = 2.08$, $p = .019$, one-tailed test) decrease compared to when the every-period plan is free, the great majority of people are willing to pay a clear and positive cost to receive information and invest every period.

FIGURE 5
Preference for Every-Period Plan



We only obtained portfolio choices for the four participants in T9 and T10 who were chosen for actual payoff implementation since one could only choose one's plan as the periods unfolded in real time after being given feedback, for each of 40 people (and giving them separate feedback after each interval) would have been impractical in our setting.⁹ Thus, to establish the presence of MLA, we rely on the studies mentioned near the end of Section II since these studies all 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 T9, except that participants 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.

V. DISCUSSION

It is important to test the degree to which nonstandard, but prevalent, preferences such as the illusion of control, ambiguity aversion, or MLA persist given clear financial incentives, and how these preferences affect portfolio choice. Table 1 presents a summary of the results.

All of these phenomena are replicated with our design (or a similar one, in the case of

9. To gather data on an individual's plan, we had to give them feedback and wait for a choice many times; doing so for 40 people (individually, so we could record their choices before the outcome occurred) would have been quite impractical (and expensive). Unfortunately, the data from the four people chosen have not survived, but we recall nothing unusual about these observations.

TABLE 1
Summary of Results

| | Prefer One Mechanism? | Willing to Pay for Preference? | Difference in Investment? |
|-----------|-----------------------|--------------------------------|---------------------------|
| Illusion | Yes | No | No |
| Ambiguity | Yes | Yes | No |
| MLA | Yes | Yes | Yes |

MLA). However, there is considerable variation in the degree to which each survives a cost and to which each affects investment choices.

We chose a weak form of the illusion of control, which was nevertheless sufficient to cause a significant majority of people to choose control when it costs nothing. However, this preference is overwhelmed when a cost is introduced, and the issue of control does not affect investment behavior. The version of ambiguity aversion we chose was stronger in the sense that it survives a small cost, but it nevertheless did not influence investment. Finally, MLA also survives a small cost, but people invest less in the risky asset, and so earn less on average than they would by tying their hands and closing their eyes.

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.

APPENDIX A

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: 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.

T3: 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.

T4: 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 the 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: 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.

T6: 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.

T7: 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.

T8: 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 the 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.

T9: 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.

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 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)

T10: 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 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)

APPENDIX TABLE A1

Raw Data

| | 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 |

continued

APPENDIX TABLE A1
Continued

| | T1 | | | T2 | | | T3 | | | T4 | | | T5 | | | T6 | | | T7 | | | T8 | | |
|----|-----|---|---|-----|---|-----|----|-----|---|----|-----|----|-----|----|-----|----|-----|-----|----|---|--|----|--|--|
| 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 | | | | | | | | | | | | | | | | | | | | | | |

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