On Myopic Loss Aversion *

Piotr Evdokimov
ITAM

March 20, 2019

Abstract

It has been widely documented in laboratory experiments that subjects act more risk-averse when they make their decisions frequently (e.g., one as opposed to several decisions at a time), a phenomenon dubbed "myopic loss aversion" by Benartzi and Thaler (1995). The present paper uses two new experiments to show that this standard pattern of behavior can be reversed. The results cannot be explained by mental accounting or loss aversion but are consistent with the hypothesis that behavior is less random when the stakes are higher.

1 Introduction

To understand the idea behind myopic loss aversion (MLA), consider the following anecdote, relayed in Samuelson (1963):

> [...] a few years ago I offered some lunch colleagues to bet each $200 to $100 that the side of a coin *they* specified would not appear at the first toss. One distinguished scholar - who lays no claim to advanced mathematical skills - gave me the following answer:
>
> "I won't bet because I would feel the $100 loss more than the $200 gain. But I'll take you on if you promise to let me make 100 such bets."

*The author thanks Simon Board, Gary Charness, David Cooper, Yoram Halevy, Joshua Miller, Pietro Ortoleva, Nat Wilcox, the brown bag participants at ITAM, the seminar participants at Chapman University, and the participants of the 2017 International ESA Meeting for helpful comments. The financial support of the Asociación Mexicana de Cultura A.C. is acknowledged.

In the years following Samuelson (1963), several experiments (Gneezy and Potters 1997, Thaler et al. 1997, Benartzi and Thaler 1999, Haigh and List 2005, and Fellner and Sutter 2009) have shown that people are less willing to take frequent than infrequent risks. Prominently, this observation has been used by Benartzi and Thaler (1995) to explain the equity premium puzzle. Thus, the reduced willingness to take risks associated with evaluating an investment portfolio over relatively short time periods (e.g., years as opposed to decades) is consistent with a large equity premium.

The present paper shows experimentally that the conclusions of Gneezy and Potters (1997)-type studies can be reversed. To understand how, let Choice H[1] denote the choice between a risky option (e.g., a high mean, high variance lottery) and a safe option (e.g., a certain amount). Let Choice L[2] denote the choice between two instances of the risky option in Choice H and two instances of the safe option in Choice H. Note that every MLA experiment has this Choice H-Choice L structure, as does the thought experiment in Samuelson (1963). One feature shared by most prior studies of MLA is that the risky option is relatively attractive, i.e., has substantially higher expected returns than the safe one.[3] What the present paper shows is that subjects are more willing to take risks in Choice H than in Choice L, i.e., show myopic loss seeking, when the risky option is unattractive, i.e., has a substantially lower expected value than the safe option ($P < 0.001$ with $N = 187$).[4]

The accepted interpretation of prior studies of MLA, such as Gneezy and Potters (1997), is to assume that the DM has a utility function of the following form:

$$u(x) = \begin{cases} x & \text{if } x \geq 0 \\ \lambda x & \text{if } x < 0 \end{cases} \tag{1}$$

Letting $\lambda = 2.5$, this generates a negative expected utility for the gamble (\$200, 0.5; -\$100, 0.5) and a positive expected utility for the gamble (\$400, 0.25; \$100, 0.50; -\$200, 0.25) implied by accepting to play (\$200, 0.5; -\$100, 0.5) twice in Samuelson's thought experiment. Similar calculations are used in other experiments in the MLA literature to argue that a loss-averse decision maker is more willing to take risks in when the decisions are broadly framed. The behavioral literature refers to the question how decisions are framed (one vs. several at a time, for example) as mental accounting.

[1] "H" for "high frequency."
[2] "L" for "low frequency."
[3] In Thaler et al. (1997), for instance, the subjects choose between simulated stocks and bonds.
[4] In the experiment, the risky option is a binary gamble, while the safe option is a sure amount that can be either high or low.

The results reported in the present paper challenge this accepted interpretation. Greater willingness to take risks cannot be attributed to mental accounting (because more broadly framed decisions sometimes induce a smaller willingness to take risks) or loss-averse preferences (because no accepted form of loss-averse preferences will predict a greater willingness to take risks in Choice L *if and only if* the risky decision is attractive). The latter point is argued in more detail in Section 4.

On the other hand, the results are consistent with a wide class of stochastic choice models or the hypothesis that people sometimes make mistakes.[5] Intuitively, assume that the DM is risk-neutral on average but sometimes trembles. If the risky option is attractive, she is more likely to choose it than the safe option in both Choice H and Choice L. Notice, however, that the stakes are higher in Choice L, which in most models of stochastic choice will imply that the random element will have less of an impact on behavior. The probability of choosing the risky option will therefore be higher in Choice L. If the risky option is unattractive, the random element having less of an influence implies that the probability of choosing the safe option is higher in Choice L, as observed in the present experiment. While the suggestion that prior experimental results in the MLA literature is consistent with some models of stochastic choice is not new (Blavatskyy and Pogrebna, 2010), this is not the main contribution of the present paper. The main, empirical, contribution is to present results that challenge the standard, behavioral model of myopically loss-averse behavior.

2 Experimental Design

This paper reports two studies, an initial between-subjects study conducted in September 2016 (N=87) and a within-subjects replication conducted in May 2018 (N=100). Both studies were designed to be as simple as possible, be relatable to existing MLA experiments in the literature, and provide reasonably high incentives to the subjects. Both studies are similar to Benartzi and Thaler (1999) in that they use simple binary gambles. They are similar to Gneezy and Potters (1997) in that subjects made nine decisions, one decision at a time, in the high frequency condition and three decisions at a time in the low frequency condition.

Each session of each study had the following procedural features in common. After handing in their consent forms, the subjects were handed out their instructions, which can be found in the appendix. The instructions were then read out loud to the subjects. At this point, the subjects were allowed an opportunity to ask questions. After all the questions were privately answered,

[5] The source of randomness in a stochastic choice model is not necessarily mistake-driven. For instance, the DM might randomize on purpose.

the subjects made practice decisions (three practice decisions in Treatment H of Study 1, one practice decision in Treatment L of Study 1, one practice decision in both treatments of Study 2). It was understood that any decisions made at this point would not count for the subjects' earnings. Following the practice decisions, subjects made decisions for real money. After all the decisions were made, each subject was privately paid.

Aside from the obvious difference in designs (between vs. within), the main difference between the two studies is that the subjects were paid for every decision in the between-subject study, while a single payoff-relevant decision was drawn randomly for each subject in each treatment of the within-subject study. The subjects thus received no feedback about what their earnings would be until they received their earnings at the end of the experiment. Paying subjects for every decision is consistent with the design in Gneezy and Potters (1997) and other prior studies in the MLA literature, while selecting payoff-relevant decisions at random is consistent with modern experimental procedures as outlined in Azrieli et al. (2018). The payoffs in the two studies (i.e., the lotteries and sure amounts) differed slightly so as to make the overall earnings comparable. Unlike Study 1, Study 2 included a show up fee of 60 pesos.

2.1 Study 1 (Between-subject; N=87)

Each session in Study 1 was randomly assigned into either Treatment H1 (high decision frequency) or Treatment L1 (low decision frequency). In Treatment H1, each subject was randomly assigned a personal winning outcome (heads or tails) in the beginning of the session. The subjects were then told that they will make several decisions between a sure amount and a lottery that pays 30 pesos with probability 50% and 0 pesos with probability 50%. At the time of the experiment, a 15km Uber ride from the author's house to the airport cost around 80 pesos.

In any given round, after every subject in the session made his or her decision, the researcher flipped a 10 peso coin. If any subject chose the lottery and the outcome of the coin flip matched his or her personal winning outcome, 30 pesos were added to the subject's earnings. If any subject chose the lottery and the outcome of the coin flip did not match his or her personal winning outcome, nothing was added to the subject's earnings for the decision. If any subject chose the certain amount, the certain amount was added to the subject's earnings. Every subject made three practice decisions with a certain amount of 15 before making decisions for real money.

When making decisions for real money, each subject was randomly assigned an order of the following four certain amounts: 10, 13, 16, 19. The subjects did not know what certain amounts they will face before making their decisions. They also made three decisions for each certain amount. For example, a subject with the order (13, 16, 10, 19) first made three choices between the fixed lottery and a certain amount of 13, then three choices between the fixed lottery and a certain amount of 16, then three choices between the fixed lottery and a certain amount of 10, and then three choices between the fixed lottery and a certain amount of 19. This block structure was borrowed from Gneezy and Potters (1997) to make Treatment H1 and Treatment L1 as similar as possible. Following every decision, each subject waited for all other subjects' decisions to be made. The researcher then flipped a coin, announced the outcome out loud, asked one of the participants in the room to verify the outcome, and entered the outcome of the coin flip into his computer. The computer software then calculated each subject's earnings and displayed it on the subject's screen.

In Treatment L1, as in Treatment H1, each subject was randomly assigned a personal winning outcome (heads or tails) in the beginning of the session. They were then told that they will make several decisions between a sure amount and *three plays* of the lottery in Treatment H1. In any given round, after every subject in the session made his or her decision, the researcher flipped a 10 peso coin *three times*. As in Gneezy and Potters (1997), the three outcomes were announced together after all three coin flips were made. This was done to facilitate the evaluation of the three lotteries in an aggregated way. If any subject chose the certain amount, the certain amount was added to the subject's earnings. If any subject chose the three lotteries, he or she was paid 30 pesos for each instance of the researcher's coin flip agreeing with the subject's personal winning outcome. For example, if the outcome was "two heads, one tails" and the subject's personal winning outcome was heads, the subject was paid 60 pesos. Each subject made one practice decision with a certain amount of 45 before making decisions for real money.

When making decisions for real money, each subject was randomly assigned an order of the following four certain amounts: 30, 39, 48, 57. Note that dividing these certain amounts by three we obtain the certain amounts in Treatment H1. The subjects did not know what certain amounts they will face before making their decisions. Each subject made one decision for each certain amount. Following each decision, each subject waited for all other subjects' decisions to be made. The researcher then flipped three coins, announced the outcomes out loud, asked one of the participants in the room to verify the outcomes, and entered them into his computer. The computer software then calculated each subject's earnings and displayed it on the subject's screen.

2.2 Study 2 (Within-subject; N=100)

Study 2 also had two treatments, Treatment H2 (high decision frequency) and Treatment L2 (low decision frequency). Every subject participated in one of the treatments in the first half of the experiment and in the remaining treatment in the second half of the experiment, without knowing what will happen in the second half of the experiment ahead of time. Thus, the instructions for the second half of the experiment were received only after the first half of the experiment was completed. Every session was randomly assigned to either begin with Treatment H2 or with Treatment L2, so that all subjects in a single session participated in the two treatments in the same order. As in Study 1, each subject was randomly assigned a personal winning outcome (heads or tails) in the beginning of the session.

Subjects in treatment H2 made decisions between a sure amount and a lottery that pays 60 pesos with probability 50% and 0 pesos with probability 50%. One practice decision was made with a sure amount of 30 pesos, after which six decisions were made with real monetary incentives. Every subject made two incentivized decisions with each of the following sure amounts: 20, 30, and 40. The order was randomized between 20, 30, and 40 in the first three decisions and, likewise, between 20, 30, and 40 in the last three decisions. The subjects did not know what certain amounts they will face before making their decisions. The subjects were informed that only one of the decisions would count for their monetary earnings, and that they would not find out which decision counts until the end of the experiment.

After completing all of the decisions in Treatment H2, the subjects that started with Treatment H2 received the instructions for Treatment L2. In Treatment L2, the subjects made decisions between a sure amount and *three plays* of the lottery in Treatment H2. After making one practice decision with a sure amount of 90 pesos, every subject made two incentivized decisions with each of the following sure amounts: 60, 90, and 120. Note that dividing these certain amounts by three we obtain the certain amounts in Treatment H2. The subjects did not know what certain amounts they will face before making their decisions and were informed that only one of the incentivized decisions will count for their earnings. After completing all of the decisions in Treatment L2, the subjects that started with Treatment L2 received the instructions for Treatment H2.

The coin flip announcements in Study 2 were handled in the same was as those in Study 1. After all decisions in both of the treatments were made, the subjects received their earnings and feedback about which decision rounds were selected to be payoff-relevant.

3 Results

Data for Study 1 was collected in September 2016 at ITAM over the course of six sessions (three each with Treatment H1 and Treatment L1) from 87 subjects (46 in Treatment H and 41 in Treatment L). Average earnings were approximately 188 pesos, slightly less than 10 dollars at the time the experiment was run. Each session lasted close to 30 minutes on average.

The results are shown in Table 1 (a),[6] where the variable s represents the safe amount in each decision in Treatment H1 and the safe amount divided by three in Treatment L1. Safe decisions were more likely in Treatment H1 when the lottery was attractive, which mirrors the findings of previous MLA experiments, and more likely in Treatment L1 when the lottery was unattractive. As explained in the introduction (see also Section 4), these results are inconsistent with loss aversion and mental accounting.

To study the significance of these findings, we can compare the empirical distributions of making the safe choice in Treatment H1 and Treatment L1 for each value of s. The difference in distributions is significant at a 5% level according to a Fisher's exact test both when $s = 13$ and when $s = 19$. Same levels of significance are obtained with t-tests using subject-clustered errors or logit regressions (one regressions for each value of s) of a decision dummy against a Treatment L1 dummy with subject-clustered errors. The statistical comparisons are represented by the stars in Table 1 (a).

Data for Study 2 was collected from 100 subjects on May 2, 2018 at ITAM in four experimental sessions. Average earnings were approximately 206.7 (including the 60 peso show-up fee), and each session lasted around 45 minutes on average. The results are shown in Table 1 (b).[7] As in Study 1, safe decisions were more likely in Treatment H2 when the lottery was attractive and more likely in Treatment L2 when the lottery was unattractive.

Comparing the empirical distributions of making the safe choice in Treatment H2 and Treatment L2 for each value of s, we find a significant difference at a 1% level according to a Fisher's exact when $s = 20$ and a significant difference at a 5% level when $s = 40$. The same levels of significance are obtained with t-tests using subject-clustered errors or logit regressions. Because Study 2 was implemented within subjects, we can also evaluate the significance of the effects using regressions with subject fixed effects. This produces the same levels of significance ($P < 0.01$ when $s = 20$ and $P < 0.05$ when $s = 40$) whether or not the standard errors are clustered at the level of the subject. Overall, the results of Study 2 are qualitatively similar to those of Study 1.

We can also analyze the results of Study 1 and Study 2 together. To this end, the observations with $s = 10$ and $s = 13$ in Study 1 and $s = 20$ in Study 2 can be pooled together as observations where the lottery was attractive. Similarly, the observations with $s = 16$ and $s = 19$ in Study 1 and $s = 40$ in Study 2 can be pooled as those where the lottery was unattractive. The pooled data is reported in Table 1 (c).

[6] Only the incentivized decisions are included in the analysis.

[7] As in Table 1 (a), the variable s represents the safe amount in each decision in Treatment H2 and the safe amount divided by three in Treatment L2.

(a) Study 1 (E.V. of lottery = 15 pesos):

s	10	13	16	19
Treatment H1	**17%**	**24%**	45%	60%
	(23/138)	**(33/138)**	(62/138)	(83/138)
		$\vee$		$\wedge$
Treatment L1	7%	7%	**49%**	**78%**
	(3/41)	(3/41)	**(20/41)**	**(32/41)**

(b) Study 2 (E.V. of lottery = 30 pesos):

s	20	30	40
Treatment H2	**18%**	47%	79%
	(35/200)	(93/200)	(157/200)
	$\vee$		$\wedge$
Treatment L2	7%	43%	**87%**
	(14/200)	(85/200)	**(173/200)**

(c) Both studies:

	Attractive lottery	Unattractive lottery
Treatments H1 and H2	**19%**	63%
	(91/476)	(302/476)
	$\vee$	$\wedge$
Treatments L1 and L2	7%	**78%**
	(20/282)	**(225/282)**

Table 1: **The probabilities of making the safe choice in the experiment.** When the lottery is attractive, subjects were more risk-averse in the high frequency treatments, but when the lottery is unattractive the result was reversed. The $\vee$ and $\wedge$ symbols denote differences that are significant at a level of at least 5%.

Comparing the empirical distributions of making the safe choice when the lottery was attractive, the difference between the H treatments and the L treatments is significant at a $P < 0.001$ level. The difference when the lottery was unattractive is also significant at a $P < 0.001$ level. Neither of the significance levels is affected by the form of the statistical comparison (e.g., a Fisher's exact test, a t-test with subject-clustered errors, a logit regression with subject-clustered errors). These results can be summarized as follows:

Main Result. *Narrow framing leads to a smaller willingness to take risks if the lottery is attractive and a greater willingness to take risks if the lottery is unattractive.*

Because this result holds in Study 2, it is not driven by differences between subjects. Because it holds in Study 1, it is not driven by experimenter demand effects or order effects in how the treatments were presented. Because of the differences in how the two studies were implemented, the result is robust to paying subjects for every decision or having one payoff-relevant decision selected at random, and it is robust to subtle changes in payment amounts or the presence of a show-up fee.

4 Discussion

The results above are consistent with stochastic choice but not standard models of loss aversion.[8] Assume first that the reference point is given by s for every decision in Treatment H1 and Treatment H2 and $3s$ for every decision in Treatment L1 and Treatment L2. Let the prize amount from the lottery (30 in Study 1, 60 in Study 2) be denoted by P, and let subjects' reference-dependent utility be defined as follows:

$$u(x|r) = \begin{cases} x - r & \text{if } x - r \geq 0 \\ \lambda(x - r) & \text{if } x - r < 0 \end{cases} \tag{2}$$

It follows that the expected utility from picking the lottery in Treatment H1 and Treatment H2 is:

$$EU(\text{Lottery}|s) = \frac{P - s}{2} - \frac{\lambda s}{2} = \frac{P - s(1 + \lambda)}{2}, \tag{3}$$

[8]As discussed in more detail below, this holds regardless of whether the reference point in each decision is given by the sure amount or the lottery, as in as in Kőszegi and Rabin (2006). Functional form assumptions are beside the main point, which is that randomness matters.

while the expected utility from picking the three lotteries in Treatment L is:

$$EU(\text{Three lotteries}|3s) = \frac{3(P-s)}{8} + \frac{3(2P-3s)}{8} + \frac{3\lambda(P-3s)}{8} - \frac{\lambda(3s)}{8} = \\ = \frac{9P - 12s + \lambda(3P-12s)}{8}. \quad (4)$$

Notice that $EU(\text{Three lotteries}|3s) > 3EU(\text{Lottery}|s)$ if and only if $\lambda > 1$. Thus, loss aversion with a deterministic reference point–which is assumed in all prior studies of MLA–predicts the DM to be more risk-averse in the H treatments for any value of s.[9] The same conclusion is obtained if we assume that that the reference point is given by the expectation of the lottery in each decision.

Another possibility is that the lottery itself served as a reference point, as in Kőszegi and Rabin (2006). In this case, we may assume that the utility of a gamble F given a referent lottery G is given by:

$$U(F|G) = \int\int u(x|r)dF(x)dG(r) \quad (5)$$

with $u(x|r)$ determined as in Equation 2. Let G_1 denote the lottery with a 50% chance of earning P pesos, and assume that G_1 served as a stochastic referent.[10] It's easy to check that $U(G_1|G_1) = U(0.5P|G_1)$ for any $\lambda > 1$.[11] Thus, the certainty equivalent of the referent lottery is $0.5P$. I.e., a loss averse DM is predicted to appear risk-neutral in Treatment H1 and Treatment H2. Now consider Treatment L, and denote by G_2 the lottery which pays $3P$ with probability 1/8, $2P$ with probability 3/8, P with probability 3/8, and 0 with probability 1/8. If we assume that the DM uses G_2 as an expectations-based reference point, it can be shown that for any $\lambda > 1$,

$$U(G_2|G_2) < U(3P|G_2)$$

[9] It's worth noting that the linearity assumption is unnecessary for this qualitative prediction. Assume, for example, that the utility function is concave for gains and convex for losses (Tversky and Kahneman, 1992):

$$u(x|r) = \begin{cases} (x-r)^\alpha & \text{if } x - r \geq 0 \\ -\lambda\big(-(x-r)\big)^\alpha & \text{if } x - r < 0 \end{cases}.$$

Then the risky option is chosen in Treatment H1 or Treatment H2 if and only if $\left(\frac{P-s}{s}\right)^\alpha > \lambda$, and in Treatment L1 or Treatment L2 if and only if $\frac{(3P-3s)^\alpha + 3(2P-3s)^\alpha}{(3s)^\alpha + 3(3s-P)^\alpha} > \lambda$. For any $\sigma \in (0,1]$, the threshold in remains greater in Treatment L1 than in Treatment H1 when $s \in \{10, 13\}$, equal to one in both treatments when $s = 15$, and below one in both treatments when $s \in \{16, 19\}$. Similarly, the threshold is greater in Treatment L2 than in Treatment H2 when $s = 20$ and below one in both treatments when $s = 40$.

[10] This assumption is reasonable, as the lottery was fixed in every decision of every treatment.

[11] See Sprenger (2015) for the general argument using binary gambles.

Thus, a loss-averse DM is predicted to appear more risk-averse in the L treatments than in the H treatments for any $\lambda > 1$. While the prediction is qualitatively the opposite to that suggested by deterministic reference points, note that neither stochastic nor deterministic reference points can accommodate a result where loss-averse subjects appear more risk-averse in Treatment L for low values of s and more risk-averse in Treatment H for high values of s.

To see how the experimental results can be accommodated by a random utility model, assume that the DM's utility is given by $U = EU + \epsilon$, where EU is the expected utility of the prospect being evaluated and ϵ is an i.i.d. error term with a logistic distribution. It follows that:

$$P(\text{Lottery}) = \frac{1}{1 + \exp(EU(s) - EU(\text{Lottery}))}$$

and

$$P(\text{Three lotteries}) = \frac{1}{1 + \exp(EU(3s) - EU(\text{Three lotteries}))}$$

Assume that $EU(3s) - EU(\text{Three lotteries}) < EU(s) - EU(\text{Lottery})$ for low values of s and $EU(3s) - EU(\text{Three lotteries}) > EU(s) - EU(\text{Lottery})$ for high values of s, which holds for a wide class of utility functions. It holds, for example, if the decision maker is risk-neutral. Then, the probability of choosing the lottery is smaller in Treatment H for low values of s and smaller in Treatment L for high values of s.

It has been argued that random utility models lead to biased estimates of preference parameters, and that random parameter models can provide a better alternative (Apesteguia and Ballester, 2018). While estimating preference parameters is not the goal of the present paper, it is not difficult to show that a random parameter model can predict the observed pattern of results. To see this, assume that the DM's preferences are as in Equation 2, with the caveat that the λ parameter is subject to shocks.[12] Assume for simplicity that the shocks follow the logistic distribution. Then, the probability that the lottery is chosen over c in Treatment Hi ($i \in \{1, 2\}$) is given by:

$$P(\text{Lottery}) = P(\lambda + \epsilon < \lambda(s, Hi)) = \frac{1}{1 + \exp(\lambda - \lambda(s, Hi)))},$$

where $\lambda(s, Hi)$ makes the decision maker indifferent between playing the lottery and choosing the sure amount in Treatment Hi. Similarly, the probability that the lottery is chosen over $3s$ in

[12] Other functional forms can also accommodate the experimental results.

Treatment Li is:

$$P(\text{Three lotteries}) = P(\lambda + \epsilon < \lambda(3s, Li)) = \frac{1}{1 + \exp(\lambda - \lambda(3s, Li)))}.$$

It follows that, for a given s, $P(\text{Lottery}) > P(\text{Three lotteries})$ if and only if $\lambda(s, Hi) > \lambda(3s, Li)$. Intuitively, if $\lambda(s, Hi) > \lambda(3s, Li)$, there are less shocks to λ that can switch the decision to the safe option in Treatment H than in Treatment L. It easy to check that this condition holds for attractive lotteries while the opposite condition holds for unattractive lotteries in experiment.

4.1 Additional Evidence of Randomness in Behavior

Table 2 provides additional evidence of randomness in the present experiment. The table classifies subjects in each treatment into three categories: (1) inconsistent, (2) non-monotonic, and (3) deterministic. Inconsistent subjects are those that make different choices when presented with the same question several times, as in Agranov and Ortoleva (2017).[13] Agranov and Ortoleva (2017) interpret such behavior as arising from a preference for randomization. Non-monotonic subjects are those for whom the probability of choosing the sure amount is non-monotonic in the sure amount. Such behavior is consistent with the stochastic choice models outlined above for particular draws of ϵ. The remaining, deterministic, subjects are those for whom the probability of choosing the sure amount is monotonic in the sure amount. Note that their behavior is also consistent with a stochastic model for particular draws of ϵ.

	Treatment H1	Treatment L1	Treatment H2	Treatment L2
Inconsistent	82.61%	-	59%	51%
Non-monotonic	-	17.07%	-	-
Deterministic	17.39%	82.93%	41%	49%

Table 2: Additional evidence of randomness.

In Treatment H1, behavior of only 17.39% of the subjects is consistent with a deterministic model. While this number is larger in Treatment L1, recall that this treatment did not give subjects an opportunity to be inconsistent since each subject faced each particular choice problem only once. For a more powerful test, consider Treatments H2 and L2, where every subject faced

[13]Recall that subjects made three choices for each sure amount in Treatment H1, and two choices for each sure amount in Treatments H2 and L2. Treatment L1 did not give subjects an opportunity to be inconsistent.

every choice problem two times. We find that behavior of 41% of the subjects in Treatment H2 and 49% of the subjects in Treatment L2 is consistent with a deterministic model.

Since Experiment 2 was implemented within subjects, we can also compare behavior of each subject across treatments. We find that only 54% of subjects fell into the same category in both treatments of Experiment 2, further providing evidence in favor of a stochastic model. Moreover, of the subjects whose behavior is consistent with a deterministic model in Treatment H2, 46.34% show inconsistent behavior in Treatment L2. Of the subjects whose behavior is consistent with a deterministic model in Treatment L2, 55.1% show inconsistent behavior in Treatment H2. All of these results are consistent with the hypothesis that individual behavior in the experiment was to some extent driven by randomness.

5 Conclusion

The results of this paper suggest that the accepted interpretation of the effect of segregating lottery decisions on behavior should be reconsidered. While the paper focuses on the evaluation period effect in MLA experiments, there are several promising avenues for future work. Other well-established behavioral regularities that have been given a deterministic explanation may possibly be reinterpreted through the lens of stochastic choice. Consider, for example, the following two problems from Kahneman and Tversky (1979):

Problem 7:

Option A: A payoff of 6000 with probability 45%, Option B: A payoff of 3000 with probability 90%.

Problem 8:

Option A: A payoff of 6000 with probability 0.1%, Option B: A payoff of 3000 with probability 0.2%.

Kahneman and Tversky (1979) find that subjects are more likely to choose B in Problem 7 and A in problem 8. This is inconsistent with expected utility because if $0.45u(6000) > 0.90u(3000)$, then $0.001u(6000) > 0.002u(3000)$. Because the stakes in Problem 7 are substantially higher than in Problem 8, a RUM can provide at least a partial account of these results. Thus, if there is a random component to the DM's utility function, this random component will have more of an influence in the latter problem. A risk-averse DM will therefore be more likely to choose Option B in Problem 7 than in Problem 8. The same intuition applies to Problems 3, 4, 5, and 6 in Kahneman and Tversky (1979). Future research should explore the extent to which stochastic choice can account for these and similar patterns of behavior in the judgment and decision making literature.

In Regenwetter et al. (2011), the authors state that Luce's *twofold challenge* (Luce, 1995) is to "(a) recast a deterministic theory as a probabilistic model (or a hypothesis) and (b) properly test that probabilistic model of the theory (or the hypothesis) on available data." An open question for future work is to determine how much of subjects' behavior is driven by the assumptions made in Kahneman and Tversky (1979) when prospect theory and expected utility are recast as probabilistic models.

References

Agranov, M. and P. Ortoleva (2017): "Stochastic choice and preferences for randomization," *Journal of Political Economy*, 125, 40–68.

Apesteguia, J. and M. A. Ballester (2018): "Monotone stochastic choice models: The case of risk and time preferences," *Journal of Political Economy*, 126, 74–106.

Azrieli, Y., C. P. Chambers, and P. J. Healy (2018): "Incentives in experiments: A theoretical analysis," *Journal of Political Economy*, forthcoming.

Benartzi, S. and R. H. Thaler (1995): "Myopic loss aversion and the equity premium puzzle," *The Quarterly Journal of Economics*, 110, 73–92.

——— (1999): "Risk aversion or myopia? Choices in repeated gambles and retirement investments," *Management science*, 45, 364–381.

Blavatskyy, P. R. and G. Pogrebna (2010): "Reevaluating evidence on myopic loss aversion: aggregate patterns versus individual choices," *Theory and decision*, 68, 159–171.

Fellner, G. and M. Sutter (2009): "Causes, consequences, and cures of myopic loss aversion–An experimental investigation," *The Economic Journal*, 119, 900–916.

Gneezy, U. and J. Potters (1997): "An experiment on risk taking and evaluation periods," *The Quarterly Journal of Economics*, 631–645.

Haigh, M. S. and J. A. List (2005): "Do professional traders exhibit myopic loss aversion? An experimental analysis," *The Journal of Finance*, 60, 523–534.

Kahneman, D. and A. Tversky (1979): "Prospect theory: An analysis of decision under risk," *Econometrica: Journal of the econometric society*, 263–291.

Kőszegi, B. and M. Rabin (2006): "A model of reference-dependent preferences," *The Quarterly Journal of Economics*, 1133–1165.

Luce, R. D. (1995): "Four tensions concerning mathematical modeling in psychology," *Annual Review of Psychology*, 46, 1–26.

Regenwetter, M., J. Dana, and C. P. Davis-Stober (2011): "Transitivity of preferences," *Psychological Review*, 118, 42–56.

Samuelson, P. (1963): "A model of reference-dependent preferences," *Scientia*, 108–113.

Sprenger, C. (2015): "An Endowment Effect for Risk: Experimental Tests of Stochastic Reference Points," *Journal of Political Economy*, 123, 1456–1499.

Thaler, R. H., A. Tversky, D. Kahneman, and A. Schwartz (1997): "The effect of myopia and loss aversion on risk taking: An experimental test," *The Quarterly Journal of Economics*, 647–661.

Tversky, A. and D. Kahneman (1992): "Advances in prospect theory: Cumulative representation of uncertainty," *Journal of Risk and Uncertainty*, 5, 297–323.

6 Instructions Appendix

6.1 Treatment H1

Instructions

In this experiment, you will make a number of choices between a lottery and a certain amount. The lottery will always be the same: 30 pesos with probability 50% and 0 pesos with probability 50%. The certain amount will vary. For example, one possible choice may be between the lottery described above and a certain amount of 15 pesos.

Whenever you choose the lottery, we will determine your earnings based on an outcome of a coin flip. Every participant in this room has been assigned a winning outcome. Any coin flip will result in a 30 peso prize for you personally if its outcome is:

HEADS

Please note that your personal winning outcome, HEADS, will be fixed throughout the experiment.

Every time you make a decision, the researcher will flip the coin and show you the outcome. If you choose the certain amount, the certain amount will be added to your earnings. If you choose the lottery and the outcome of the coin flip matches your personal winning outcome, 30 pesos will be added to your earnings. Your overall earnings will always be displayed on your computer screen.

Example 1:

Your choice was between the lottery and a certain amount of 15, and you chose the certain amount. In this case, regardless of the outcome of the researcher's coin flip, 15 pesos will be added to your earnings.

Example 2:

Your choice was between the lottery and a certain amount of 15, and you chose the lottery. The researcher flipped the coin and the outcome of the coin flip was TAILS. In this case, 0 pesos will be added to your earnings.

Example 3:

Your choice was between the lottery and a certain amount of 15, and you chose the lottery. The researcher flipped the coin and the outcome of the coin flip was HEADS. In this case, 30 pesos will be added to your earnings.

Please raise your hand if you have any questions.

You will now play a practice trial in which the certain amount of 15. The practice trial is there to help you understand how the experiment works; the outcome of this trial will not count for your earnings.

6.2 Treatment L1

Instructions

In this experiment, you will make a number of choices between a certain amount and playing the same lottery three times. The lottery will always be: 30 pesos with probability 50% and 0 pesos with probability 50%. The certain amounts will vary. For example, one possible choice may be between playing the lottery above three times and a certain amount of 45 pesos.

Whenever you choose the lottery, we will determine your earnings based on an outcome of three coin flips. Every participant in this room has been assigned a winning outcome. Any coin flip will result in a 30 peso prize for you personally if its outcome is:

HEADS

Please note that your personal winning outcome, HEADS, will be fixed throughout the experiment.

After you make your decision, the researcher will flip three coins and show you their outcomes. If you choose the certain amount, the certain amount will be added to your earnings. If you choose playing the lottery three times and one of the coin flips matches your personal winning outcome, 30 pesos will be added to your earnings. If you choose playing the lottery three times and two of the coin flips match your personal winning outcome, 60 pesos will be added to your earnings. If you choose playing the lottery three times and three of the coin flips match your personal winning outcome, 90 pesos will be added to your earnings. Your overall earnings will always be displayed on your computer screen.

Example 1:

Your choice was between playing the lottery three times and a certain amount of 45, and you chose the certain amount. In this case, regardless of the outcome of the researcher's coin flip, 45 pesos will be added to your earnings.

Example 2:

Your choice was between playing the lottery three times and a certain amount of 45, and you chose the lottery. The researcher flipped the three coins and the outcome of every coin flip was TAILS. In this case, 0 pesos will be added to your earnings.

Example 3:

Your choice was between playing the lottery three times and a certain amount of 45, and you chose the lottery. The researcher flipped the three coins and the outcome of every coin flip was HEADS. In this case, 90 pesos will be added to your earnings.

Please raise your hand if you have any questions.

You will now play a practice trial in which the certain amount of 45. The practice trial is there to help you understand how the experiment works; the outcome of this trial will not count for your earnings.

6.3 Treatment H2, first half

Instructions

Welcome to the experiment! Please refrain from asking any questions out loud beginning now. If you have a question, raise your hand and the researcher will answer the question in private.

Every participant in this room has been assigned a personal winning outcome. Your personal winning outcome is:

HEADS

In this part of the experiment, you will make a decision in **SIX (6)** tasks. Only **ONE OUT OF SIX (1 out of 6)** of these tasks will be randomly selected to count for your earnings. The other tasks will not count for your earnings. You will not find out which task counts until the end of the experiment.

In each of the six tasks, the researcher will flip a coin. The researcher will announce the coin flip as: "This is the coin flip for task 1" or "This is the coin flip for task 2" or "This is the coin flip for task 3," and so on. Therefore, you will see the outcome of the coin flip in each task.

Before you see the outcome of the coin flip in each task, you will decide between;

(i) Receiving a fixed payment, and
(ii) Having your payment determined by the coin flip.

If a task is selected to count for your earnings **and** you choose to receive the fixed payment in this task, the fixed payment will be added to your earnings at the end of the experiment.

If a task is selected to count for your earnings **and** you choose to have your payment determined by the coin flip in this task, **60 pesos** will be added to your earnings if the researcher's coin flip in this task matches your personal winning outcome.

Thus, if a task is selected to count for your earnings and you choose to have your payment determined by the coin flip in this task,

(a) 0 pesos will be added to your earnings if the researcher's coin flip in this task does not match your personal winning outcome,
(b) 60 pesos will be added to your earnings if the researcher's coin flip in this task matches your personal winning outcome.

FLIP PAGE FOR EXAMPLES

1NH

Example 1:

You chose a fixed payment of 30 in the task that was selected to count for your earnings. In this case, regardless of the outcome of the researcher's coin flip, 30 pesos will be added to your earnings.

Example 2:

You chose to have your payment determined by the coin flip in the task that was selected to count for your earnings. The outcome of the coin flip by the researcher in this task was **TAILS**. In this case, 0 pesos will be added to your earnings.

Example 3:

You chose to have your payment determined by the coin flip in the task that was selected to count for your earnings. The outcome of the coin flip by the researcher in this task was **HEADS**. In this case, 60 pesos will be added to your earnings.

Please raise your hand if you have any questions.

You will now have a **practice task**. The practice task is there to help you understand how the experiment works. The outcome of this task will **not** count for your earnings.

6.4 Treatment L2, first half

Instructions

Welcome to the experiment! Please refrain from asking any questions out loud beginning now. If you have a question, raise your hand and the researcher will answer the question in private.

Every participant in this room has been assigned a personal winning outcome. Your personal winning outcome is:

HEADS

In this part of the experiment, you will make a decision in **SIX (6)** tasks. Only **ONE OUT OF SIX (1 out of 6)** of these tasks will be randomly selected to count for your earnings. The other tasks will not count for your earnings. You will not find out which task counts until the end of the experiment.

In each of the six tasks, the researcher will flip three coins. The researcher will announce the coin flips as: "These are the coin flips for task 1" or "These are the coin flips for task 2" or "These are the coin flips for task 3," and so on. Therefore, you will see the outcome of three coin flips in each task.

Before you see the outcome of the three coin flips in each task, you will decide between;

(i) Receiving a fixed payment, and
(ii) Having your payment determined by three coin flips.

If a task is selected to count for your earnings **and** you choose to receive the fixed payment in this task, the fixed payment will be added to your earnings at the end of the experiment.

If a task is selected to count for your earnings **and** you choose to have your payment determined by the three coin flips in this task, **60 pesos** will be added to your earnings for each of the researcher's coin flips in this task that matches your personal winning outcome.

Thus, if a task is selected to count for your earnings and you choose to have your payment determined by the three coin flips in this task,

(a) 0 pesos will be added to your earnings if none of the researcher's coin flips in this task matches your personal winning outcome,
(b) 60 pesos will be added to your earnings if one of the researcher's coin flips in this task matches your personal winning outcome,
(c) 120 pesos will be added to your earnings if two of the researcher's coin flips in this task match your personal winning outcome,
(d) 180 pesos will be added to your earnings if three of the researcher's coin flips in this task match your personal winning outcome.

FLIP PAGE FOR EXAMPLES

1DH

Example 1:

You chose a fixed payment of 90 in the task that was selected to count for your earnings. In this case, regardless of the outcome of the researcher's coin flips, 90 pesos will be added to your earnings.

Example 2:

You chose to have your payment determined by the three coin flips in the task that was selected to count for your earnings. The outcome of every coin flip by the researcher in this task was **TAILS**. In this case, 0 pesos will be added to your earnings.

Example 3:

You chose to have your payment determined by the three coin flips in the task that was selected to count for your earnings. The outcome of every coin flip by the researcher in this task was **HEADS**. In this case, 180 pesos will be added to your earnings.

Please raise your hand if you have any questions.

You will now have a **practice task**. The practice task is there to help you understand how the experiment works. The outcome of this task will **not** count for your earnings.

6.5 Treatment H2, second half

Your personal winning outcome is still:

TAILS

In this part of the experiment, you will make a decision in another **SIX (6)** tasks. Only **ONE OUT OF SIX (1 out of 6)** of these additional tasks will be randomly selected to count for your earnings. The other tasks in this part of the experiment will not count for your earnings. You will not find out which task counts until the end of the experiment.

In each of the six tasks, the researcher will flip a coin. The researcher will announce the coin flip as: "This is the coin flip for task 1" or "This is the coin flip for task 2" or "This is the coin flip for task 3," and so on. Therefore, you will see the outcome of the coin flip in each task.

Before you see the outcome of the coin flip in each task, you will decide between;

(i) Receiving a fixed payment, and
(ii) Having your payment determined by the coin flip.

If a task is selected to count for your earnings **and** you choose to receive the fixed payment in this task, the fixed payment will be added to your earnings at the end of the experiment.

If a task is selected to count for your earnings **and** you choose to have your payment determined by the coin flip in this task, **60 pesos** will be added to your earnings if the researcher's coin flip in this task matches your personal winning outcome.

Thus, if a task is selected to count for your earnings and you choose to have your payment determined by the coin flip in this task,

(a) 0 pesos will be added to your earnings if the researcher's coin flip in this task does not match your personal winning outcome,
(b) 60 pesos will be added to your earnings if the researcher's coin flip in this task matches your personal winning outcome.

FLIP PAGE FOR EXAMPLES

2NT

Example 1:

You chose a fixed payment of 30 in the task that was selected to count for your earnings. In this case, regardless of the outcome of the researcher's coin flip, 30 pesos will be added to your earnings.

Example 2:

You chose to have your payment determined by the coin flip in the task that was selected to count for your earnings. The outcome of the coin flip by the researcher in this task was **HEADS**. In this case, 0 pesos will be *added* to your earnings.

Example 3:

You chose to have your payment determined by the coin flip in the task that was selected to count for your earnings. The outcome of the coin flip by the researcher in this task was **TAILS**. In this case, 60 pesos will be added to your earnings.

Please raise your hand if you have any questions.

You will now have a **practice task**. The practice task is there to help you understand how the experiment works. The outcome of this task will **not** count for your earnings.

6.6 Treatment L2, second half

Your personal winning outcome is still:

TAILS

In this part of the experiment, you will make a decision in another **SIX (6)** tasks. Only **ONE OUT OF SIX (1 out of 6)** of these additional tasks will be randomly selected to count for your earnings. The other tasks in this part of the experiment will not count for your earnings. You will not find out which task counts until the end of the experiment.

In each of the six tasks, the researcher will flip three coins. The researcher will announce the coin flips as: "These are the coin flips for task 1" or "These are the coin flips for task 2" or "These are the coin flips for task 3," and so on. Therefore, you will see the outcome of three coin flips in each task.

Before you see the outcome of the three coin flips in each task, you will decide between;

(i) Receiving a fixed payment, and
(ii) Having your payment determined by three coin flips.

If a task is selected to count for your earnings **and** you choose to receive the fixed payment in this task, the fixed payment will be added to your earnings at the end of the experiment.

If a task is selected to count for your earnings **and** you choose to have your payment determined by the three coin flips in this task, **60 pesos** will be added to your earnings for each of the researcher's coin flips in this task that matches your personal winning outcome.

Thus, if a task is selected to count for your earnings and you choose to have your payment determined by the three coin flips in this task,

(a) 0 pesos will be added to your earnings if none of the researcher's coin flips in this task matches your personal winning outcome,
(b) 60 pesos will be added to your earnings if one of the researcher's coin flips in this task matches your personal winning outcome,
(c) 120 pesos will be added to your earnings if two of the researcher's coin flips in this task match your personal winning outcome,
(d) 180 pesos will be added to your earnings if three of the researcher's coin flips in this task match your personal winning outcome.

FLIP PAGE FOR EXAMPLES

2DT

Example 1:

You chose a fixed payment of 90 in the task that was selected to count for your earnings. In this case, regardless of the outcome of the researcher's coin flips, 90 pesos will be added to your earnings.

Example 2:

You chose to have your payment determined by the three coin flips in the task that was selected to count for your earnings. The outcome of every coin flip by the researcher in this task was **HEADS**. In this case, 0 pesos will be added to your earnings.

Example 3:

You chose to have your payment determined by the three coin flips in the task that was selected to count for your earnings. The outcome of every coin flip by the researcher in this task was **TAILS**. In this case, 180 pesos will be added to your earnings.

Please raise your hand if you have any questions.

You will now have a **practice task**. The practice task is there to help you understand how the experiment works. The outcome of this task will **not** count for your earnings.