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Abstract

We report on two laboratory experiments testing for the presence of loss aversion, separate from risk aversion, in decisions involving risk and intertemporal choice. Both experiments utilize an asset legitimacy protocol to control for 'house money' effects. In our first experiment, we augment the Holt-Laury risk preference elicitation protocol to address the effects of loss aversion. In our second experiment, we explore loss aversion using a discount rate elicitation protocol that controls for risk preferences. Our results show that loss aversion can be separated from risk preferences and has a profound effect in decision-making.

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1. Introduction

Some 25 years after the seminal research of Tversky and Kahneman (1991) and Kahneman, Knetch and Thaler (1991), economic research continues to identify loss aversion as an important element in decision-making across a wide range of domains. More recently, Dimmock and Kouwenberg (2009), Leung and Tsang (2013), Rees-Jones (2014) and Engstrom et al (2015) have found significant evidence of loss aversion in household portfolio decisions and tax compliance. Engstrom et al (2015) and Rees-Jones (2014) demonstrate how loss aversion can lead tax payers to shift their finances and claim deductions, behavior that is independent of audit probabilities and has the potential of pushing losses into future consumption. From a macroeconomic perspective, Bowman et al (1999) find that loss aversion can affect consumption and savings patterns, a mechanism that Santoro et al (2014) argue can affect the efficacy of monetary policy with respect to output and inflation. From a policy perspective, Thaler and Bernartzi (2004) and Lusardi (1999) have articulated the importance of taking into account the effects of loss aversion in the design of retirement policy and employee savings programs.

However, the concept of loss aversion poses a problem in that loss aversion may interact with risk and time preferences, making it difficult to ascertain true preference parameters regarding risk and intertemporal discounting. For example, saving for retirement requires delaying present consumption (an intertemporal decision), reducing consumption below current levels (an aspect that may involve loss aversion) and potential risk in future consumption (an aspect that may involve risk aversion). Given these elements are observed in a single savings outcome, it is unclear whether the inferred discount rate is purely related to time preferences or also has embedded in it aspects of loss aversion and risk aversion. To this end, our experiments were designed with an eye towards differentiating between these motives.

Loss aversion also poses problems for experimental research given that the resources used to incentivize experiments are provided by the experimenter. Can a decision environment be created in the laboratory in which individuals may experience a real sense of loss? This poses a challenge for researchers trying to delineate the effects of loss aversion in controlled experiments. For this reason, we employ a protocol that creates a strong sense of asset legitimacy, thereby making the decision environment favorable to participants coding some potential outcomes as losses.

In this paper we report on two laboratory experiments, each designed to test for the presence of loss aversion separate from risk aversion. To implement loss aversion, we use an *asset legitimacy protocol* developed in Morrison and Oxoby (2013) to avoid 'house money' bias in the laboratory. In the current study, we use this protocol in conjunction with the well-known risk-preference elicitation framework of Holt and Laury (2002, 2005) and separately with a design from Laury et al (2012) to elicit intertemporal discount rates. In both of these experiments, we find that loss aversion plays a role in decision-making, significantly augmenting the effects of risk and time preferences.

Loss Aversion and the Importance of Controlling for 'House Money' Bias

Loss aversion occurs when individuals place greater weight on outcomes that lie in the domain of losses (relative to some reference point) than outcomes that lie in the domain of gains (Tversky and Kahneman ,1991; Kahneman, Knetch and Thaler, 1991). An implication of loss aversion is that individuals are less inclined to engage in a risky choice, or to defer current consumption into the future, if a loss is incurred relative to the present level of income or utility. As an example, suppose an individual declines purchasing for $20 (of her own money) a lottery ticket with a 70% chance of winning $35 dollars and a 30% chance of winning $3.50. If the decision is due to loss aversion, we infer that she views the lottery outcome of $3.50 as a net loss of $16.50 relative to her reference state income at the time the decision is made. She then assigns a higher (negative) utility to the possible loss of $16.50 than to the prospective net gain of $15 if she wins the lottery. However, we could also attribute her unwillingness to purchase the lottery ticket as evidence of risk aversion: the lottery has an expected value of $25.55 but is risky, whereas not purchasing the lottery means retaining $20 with certainty. How then can we meaningfully separate out the roles played by risk aversion and loss aversion in her decision? In order to separate out these effects, we need to ask her to make another choice that is identical in expected value terms but for which all payoffs lie in the domain of gains.

For example, we could present her with a choice of receiving $20 (with certainty) or a lottery ticket with a 70% chance of winning $35 and a 30% chance of winning $3.50. From a risk perspective, the choice is still between a certain amount and a risky prospect with a known expected value, however there is no role now for loss aversion.

In order to implement loss aversion in a laboratory experiment, we must create the possibility that some choices result in a loss relative to an individual's reference-state income. However, a problem exists because decisions in economics experiments are incentivized using dollars supplied by the experimenter, and as a consequence, participants in the experiment may not regard these dollars as part of their reference-state income. A 'house money' bias is created if individuals do not perceive they are making decisions with their own money and therefore do not view any reduction in experiment dollars as a real loss. To control for 'house money' bias, Morrison and Oxoby (2013) develop an *asset legitimacy protocol* whereby individuals begin by earning money in the laboratory but then retain this money for a period of time before returning to the lab. When they return, they bring an amount of money equal to their lab earnings with them and then complete incentivized tasks for which the money they have brought is at stake. This protocol places the earned lab dollars firmly within an individual's reference-state income so that the money at stake in the decision is regarded as their own money. Other studies have employed a similar approach (requiring participants hold on to financial resources for an extended period of time prior to the experiment) including Bosch-Domenenech and Silvestre (2010), Rosenboim and Shavbit (2012) and Cardenas et al (2014). In particular, Cardenas et al (2014) use this approach to test whether 'house money' bias affects measures of risk aversion, finding that individuals who retained money for 21 days and spent a portion of it prior to the experiment demonstrated greater risk aversion than those who had not spent the money. They conclude that a 'house money' bias may play a small role in laboratory experiments involving risky decisions.[3]

3 Other researchers have explored the ways in which house money effects and loss aversion can affect decision-making in experiments. For example, Cherry et al (2002) and Oxoby and Spraggon (2008) find that legitimizing assets significantly reduces contributions in a dictator game. Similarly, Clark (2002), Harrison (2007), and Oxoby and Spraggon (2009, 2013) demonstrate how house money effects can influence decision-making in public goods experiments.

2. Experiments

We recruited from the student population at a large Canadian university using the online recruiting system by Greiner (2004) and the experiments were conducted using the software developed by Fischbacher (2007).

We employed the asset legitimacy protocol of Morrison and Oxoby (2013) in the experiments that follow. In this protocol, all experiments began with participants completing a twenty-question quiz consisting of questions from the Graduate Record Exam. Participants were told that they would earn $20 if they correctly answered at least ten questions and $10 otherwise. This threshold was chosen based on experience in previous experiments to ensure that most (if not all) participants earned $20 while requiring they exerted significant effort in the exam. In all of the experiments below, all participants did sufficiently well on the quiz to earn $20. Participants were also paid a $5 participation fee irrespective of the decisions they made.

In each of our experiments a control group and a treatment group completed both hypothetical and incentivized decision tasks to elicit their preferences. For the control group, both tasks were completed in a single session immediately after completing the quiz. In the treatment group, participants completed the experiment in two sessions. In the first session, they completed the quiz and the hypothetical decision task and were then paid their earnings. Treatment group participants then retained this money for one week before returning for a second session in which they completed the incentivized decision task (in which the $20 from the previous session was at stake). To implement this, participants returning for a second session were asked to bring $20 to use in the session. The overall design is illustrated in Figure 1. The $5 participation fee was paid to participants in the control group at the end of their session and was paid to the treatment group at the end of the second session (providing an incentive to return).

FIGURE 1: ASSET LEGITIMACY PROTOCOL DESIGN

	CONTROL GROUP	TREATMENT GROUP
SESSION 1	COMPLETE QUIZ – EARN \$20 ↓ COMPLETE HYPOTHETICAL DECISION TABLE ↓ COMPLETE INCENTIVIZED DECISION TABLE ↓ CONCLUSION AND FINAL PAYMENT (INCLUDING \$5 SHOW-UP FEE)	COMPLETE QUIZ – EARN \$20 ↓ COMPLETE HYPOTHETICAL DECISION TABLE ↓ PAYMENT OF \$20 ↓ ↓
		↓
SESSION 2 (one week after Session 1)		COMPLETE INCENTIVIZED DECISION TABLE ↓ CONCLUSION AND FINAL PAYMENT (INCLUDING \$5 SHOW UP FEE)

A critique of this design is that participants in the control group make all their decisions in a single session whereas participants in the treatment group make incentivized decisions one week later in a second session. This asymmetry may create differences in decision-making that are not attributable to loss aversion. To address this concern, we will provide evidence from additional sessions in which this asymmetry in design is eliminated (i.e. both the control and treatment groups participate in two sessions). As shown below, this change does not affect our results.

2.1 Holt-Laury Revisited

In our first experiment, we test for influence of loss aversion in risky decisions by revisiting the risk-preference elicitation framework of Holt and Laury (2002, 2005) to include our asset legitimacy protocol described above. The timing of decisions and payments experiment is illustrated in Figure 2.

FIGURE 2: HOLT-LAURY RISK PREFERENCE ELICITATION UTILIZING AN ASSET LEGITIMACY PROTOCOL

	CONTROL GROUP	**TREATMENT GROUP**
SESSION 1	COMPLETE QUIZ – EARN $20 ↓ **COMPLETE HYPOTHETICAL HOLT-LAURY DECISION TABLE** ↓ **COMPLETE INCENTIVIZED DECISION TABLE** ↓ CONCLUSION AND FINAL PAYMENT (INCLUDING $5 SHOW-UP FEE)	COMPLETE QUIZ – EARN $20 ↓ **COMPLETE HYPOTHETICAL HOLT-LAURY DECISION TABLE** ↓ PAYMENT OF $20 ↓ ↓
		↓
SESSION 2 (one week after Session 1)		**COMPLETE INCENTIVIZED DECISION TABLE** ↓ CONCLUSION AND FINAL PAYMENT (INCLUDING $5 SHOW UP FEE)

Our decision tasks in this experiment follow Holt and Laury (HL 2002, 2005), asking individuals to make choices between ten pairs of lotteries (Tables 1 and 2). In each lottery pair, the first lottery (Option A) has a smaller spread relative to the second lottery (Option B). The defining feature of the HL mechanism is that expected values in early decisions favor Option A while the expected values in later decisions favor Option B, providing a predicted 'cross-over point' for risk neutral individuals. By inference, those who continue to prefer the safer option (A) beyond the risk neutral cross-over point display risk-aversion. In their initial experiment, Holt and Laury (2002) find approximately two thirds of participants display risk-averse preferences, even for very small dollar amounts.

In our control group, participants completed the quiz to earn $20 and were asked the following two questions regarding their perception of ownership over the $20 they had earned (answered using a 1 to 7 scale representing 'strongly disagree' to 'strongly agree'):

> Asset Legitimacy Question 1: I am entitled to the money I received for participating in the experiment.
>
> Asset Legitimacy Question 2: I earned the money I am receiving for participating in the experiment

After answering this question, participants completed a hypothetical scaled-up version of the risk preference elicitation decision table in Holt and Laury (2002; Table 1) where the expected value of Option A exceeds Option B in decisions 1-4 and falls below that of Option B in decisions 5-10. The purpose of this decision task is to give a comparable measure of risk preferences among participants in the control and treatment groups.

TABLE 1: HYPOTHETICAL VERSION OF THE HOLT-LAURY (2002) DECISION TABLE.

Decision	Option A Details									Option B Details								Difference in expected values
1	A	10%	chance of	$200	and a	90%	chance of	$160		A	10%	chance of	$385	and a	90%	chance of	$10	$116.50
2	A	20%	chance of	$200	and a	80%	chance of	$160		A	20%	chance of	$385	and a	80%	chance of	$10	$83.00
3	A	30%	chance of	$200	and a	70%	chance of	$160		A	30%	chance of	$385	and a	70%	chance of	$10	$49.50
4	A	40%	chance of	$200	and a	60%	chance of	$160		A	40%	chance of	$385	and a	60%	chance of	$10	$16.00
5	A	50%	chance of	$200	and a	50%	chance of	$160		A	50%	chance of	$385	and a	50%	chance of	$10	-$17.50
6	A	60%	chance of	$200	and a	40%	chance of	$160		A	60%	chance of	$385	and a	40%	chance of	$10	-$51.00
7	A	70%	chance of	$200	and a	30%	chance of	$160		A	70%	chance of	$385	and a	30%	chance of	$10	-$84.50
8	A	80%	chance of	$200	and a	20%	chance of	$160		A	80%	chance of	$385	and a	20%	chance of	$10	-$118.00
9	A	90%	chance of	$200	and a	10%	chance of	$160		A	90%	chance of	$385	and a	10%	chance of	$10	-$151.50
10	A	100%	chance of	$200	and a	0%	chance of	$160		A	100%	chance of	$385	and a	0%	chance of	$10	-$185.00

Following this hypothetical decision task, control group participants completed an incentivized version of the risk preference elicitation task (Table 2) wherein participants are asked to indicate their preference between $20 with certainty (Option A) or a lottery in which the high and low payoffs are held constant but the probabilities of the payoffs change systematically (Option B). The $20 participants had earned in the quiz were at stake in these decisions; if a participant chose Option A they were choosing to retain the $20 they had already earned while choosing the lottery meant giving up their $20 earnings for an uncertain return. Participants were told their payment for the experiment would be based on their response to a randomly selected question from Table 2. All control group participants were paid in cash at the conclusion of the incentivized task and received $5 as a show-up fee independent of any decisions.

TABLE 2: MODIFIED AND INCENTIVIZED HOLT-LAURY (2002) DECISION TABLE

Decision	Option A		Option B								Option B Expected value	Difference in expected values
1	$20.00		A	0.1	chance of	$ 35	and a	0.9	chance of	$3.50	6.65	$13.35
2	$20.00		A	0.2	chance of	$ 35	and a	0.8	chance of	$3.50	9.80	$10.20
3	$20.00		A	0.3	chance of	$ 35	and a	0.7	chance of	$3.50	12.95	$7.05
4	$20.00		A	0.4	chance of	$ 35	and a	0.6	chance of	$3.50	16.10	$3.90
5	$20.00		A	0.5	chance of	$ 35	and a	0.5	chance of	$3.50	19.25	$0.75
6	$20.00		A	0.6	chance of	$ 35	and a	0.4	chance of	$3.50	22.40	-$2.40
7	$20.00		A	0.7	chance of	$ 35	and a	0.3	chance of	$3.50	25.55	-$5.55
8	$20.00		A	0.8	chance of	$ 35	and a	0.2	chance of	$3.50	28.70	-$8.70
9	$20.00		A	0.9	chance of	$ 35	and a	0.1	chance of	$3.50	31.85	-$11.85
10	$20.00		A	1.0	chance of	$ 35	and a	0.0	chance of	$3.50	35.00	-$15.00

Participants in the treatment group engaged in the same sequence of events up to the completion of the hypothetical decision task (Table 1). At this point, treatment group participants were paid $20 in cash and asked to attend a second session in one week's time to continue the experiment. Participants were told that they needed to bring $20 (equal to the amount earned in the first session) to be used in the session and that they would receive a $5 show up fee in the second session and have the opportunity to receive additional money.

In the session 2, each treatment group participant was asked to put $20 of their own money into an envelope labeled with their participant ID and collected by the experimenter. In addition to the asset legitimacy questions above, participants were also asked if the $20 cash they put in the envelope was the same cash received in session 1. As our focus is on creating a sense of ownership over the money, this question sought to identify if participants retained the actual cash from the first session or spent that money and brought their own funds to session 2. Participants then completed the incentivized task (Table 2) and were paid in cash (according to a single decision drawn at random from their completed decision table) plus a $5 show-up fee.

Results

Fifty-five individuals participated in the experiment, with 24 and 31 participants in the control and treatment groups. All participants (control and treatment groups) expressed a high degree of ownership over the $20 they earned in the quiz, as represented by their answers to the asset legitimacy questions. The mean Likert scale score (standard deviation) in the control and treatment conditions were 5.27 (0.79) and 5.42 (0.84) and we find no differences in the distribution of these responses across conditions (Wilcoxon $p>0.40$). All participants in the treatment group indicated that the $20 cash they brought to the second session was not the same money they had received in the session 1 suggesting that money they had earned had been spent in the intervening week.[4]

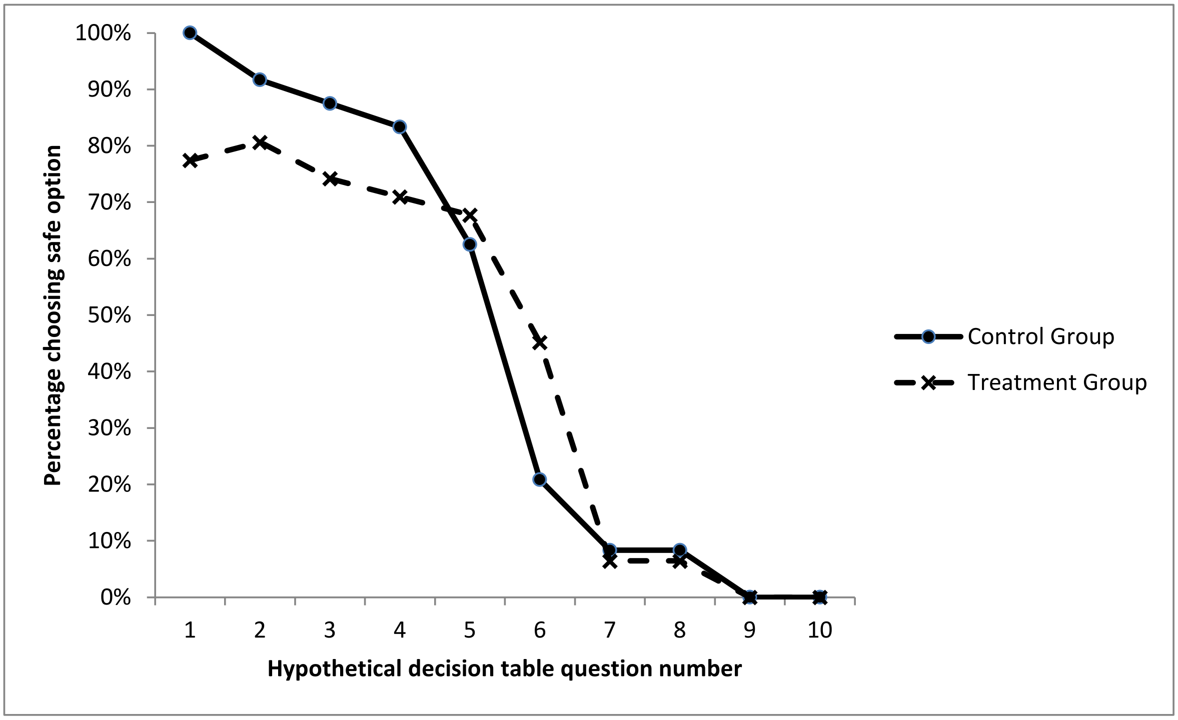
Table 3 provides a summary of our main results regarding risk behavior, which are illustrated in Figures 3 and 4. Figure 3 shows the percentage of participants choosing the safe option (Option A) in the hypothetical decision task for the control and treatment groups. While all participants displayed risk-aversion, we cannot reject the hypothesis that responses in the control and treatment conditions are drawn from the same distribution (Wilcoxon $p > 0.4$). In other words, in answering Table 1 all participants displayed similar risk preferences in the hypothetical decision task.

TABLE 3: SUMMARY RESULTS

	Hypothetical Holt-Laury Decision Task		Incentivized Decision Task	
Group	Control	Treatment	Control	Treatment
Average Crossover point	5.63	5.33	5.42	7.93
Mann-Whitney Test	$p > 0.4$		$p < 0.01$	

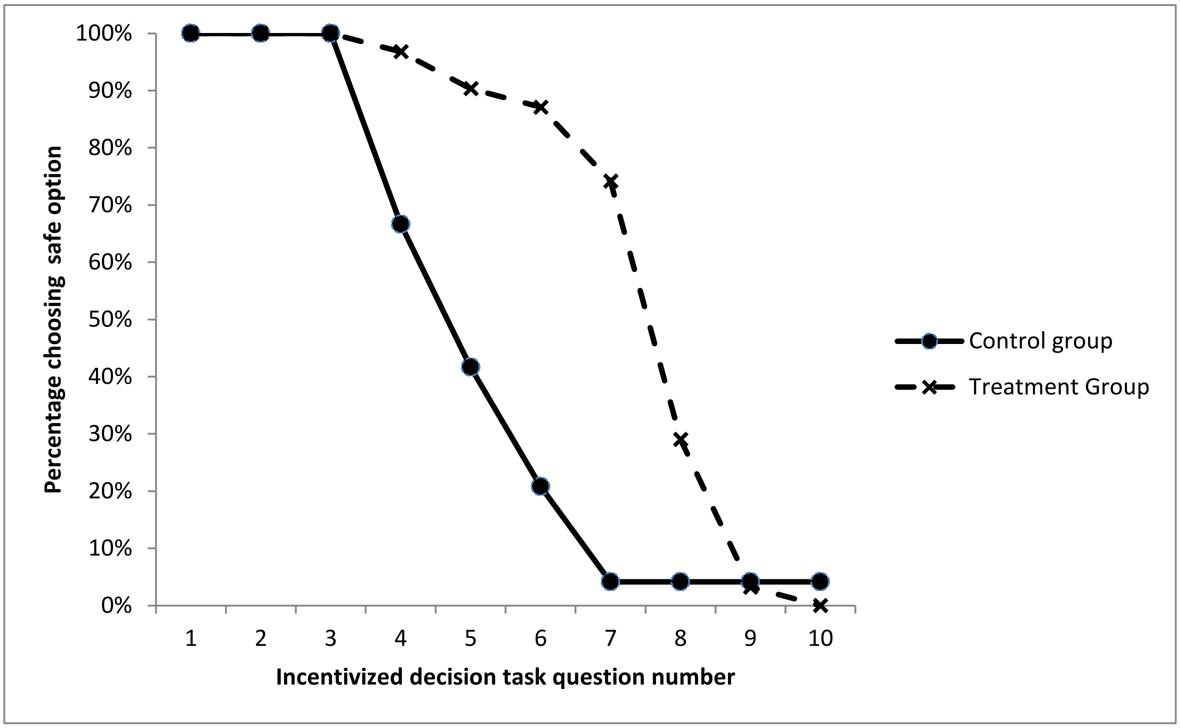
[4] Participants were between the ages of 17 and 26 (average 20.8) and 55% were male. In an analysis of the data with respect to demographic information we found no gender or age differences (cf. Coller and Williams, 1999; McLeish and Oxoby, 2007). Three participants in the treatment condition only participated in the first session, yielding an attrition rate of 7.6%.

FIGURE 3: PERCENTAGE OF PARTICIPANTS CHOOSING THE LESS RISKY OPTION IN HYPOTHETICAL DECISION TABLE



However, as indicated in Table 3 and Figure 4, we find a difference in responses to the incentivized decision table and can reject the hypothesis that responses in the control and treatment conditions are drawn from the same distribution (Wilcoxon $p < 0.01$). That is, relative to the control condition, participants in our treatment condition were less willing to give up the $20 in their possession to participate in a lottery, even when the lottery offered a higher probability of receiving $35. This type of behavior is consistent with individuals coding their previously earned $20 as a potential loss in the lottery, consequently requiring significantly larger returns to bear risk in the lottery. This result is consistent with previous literature exploring loss aversion, asset legitimacy, and risky choice (e.g., Bosch-Domenenech and Silvestre, 2010, Rosenboim and Shavbit, 2012, and Cardenas et al, 2014).

FIGURE 4: PERCENTAGE OF PARTICIPANTS CHOOSING THE SAFE OPTION IN INCENTIVIZED DECISION TABLE.



Discussion

Our first experiment is similar to Cardenas et al (2014) but has notable design differences. First, all the participants in our experiment (in both control and treatment groups) earned money to be used in the risk preference elicitation task. While other researchers have required participants to earn money as a solution to the ‘house money’ bias problem (e.g., Bosch-Domenenech and Silvestre, 2010, Rosenboim and Shavbit, 2012) we find a significant difference in the elicited risk preferences of the treatment group and control group participants even though *all* participants earned their money. Moreover, our results suggest that participants in our treatment group spent all the money they had initially received (i.e., all reported bringing different money that that received in the first session). Cardenas et al focus on the importance of individuals having received payment from the experimenters in advance of the experimental session, and spending that some of that money (an average of 35%) prior to completing risk preference tasks. Thus, our design may provide a stricter test of loss aversion by more explicitly avoiding the house money effects in other experiments.

Our experiment required the treatment group take part in two sessions, relative to the single sessions of our control group and Cardenas et al (2014). This aspect of our design allows us to compare the risk preferences of the two groups in the first session and query participants on their sense of asset legitimacy. Interestingly, we find that both treatment and control group participants display the commensurate degrees of risk aversion (in the hypothetical decision task) and feelings of asset legitimacy. This is contrasted with significantly different decision making in our incentivized task, suggesting that the degree of house money bias can be highly nuanced, going beyond the simple act of earning resources (as in Cherry et al, 2002, and Oxoby and Spraggon, 2013) and fundamentally requiring an individual to have used a resource for it to truly be viewed as "their money."

A further strength of our design is in the use of the methodology of Holt and Laury (2002, 2005). As discussed by Harrison and Rutström (2008), measures of risk aversion may be sensitive to the particular mechanism used to elicit preferences. By using the HL mechanism, we not only demonstrate the robustness of the results in Cardenas et al (2014), but we also can relate our findings to the broader literature using the Holt-Laury methodology.

2.2 Intertemporal Choice

In our second experiment, we explore the role of loss aversion in an intertemporal decision making context with an eye towards delineating the effects of risk aversion from loss aversion and time discounting. Saving money requires a loss of current income in return for income in the future, a decision which inherently casts the reduction in current consumption in the domain of losses and raises the potential for the influence of loss aversion. Further, there are also potential risks around the final payoff of future income. The confounding of risk preferences, intertemporal discounting, and loss aversion presents a difficulty for researchers seeking to identify the individual effects of these three motives in decision-making. Morrison and Oxoby (2013) demonstrated the effects of loss aversion in intertemporal choice in a largely risk-free environment, but were unable to rule out the technical possibility of risk aversion as an alternative explanation for their results. Related, Laury et al (2012) develop a discount rate elicitation procedure to control for risk preferences in which individuals are asked to make a series of choices between two lotteries: Lottery A occurring in the near future and Lottery B occurring in the more distance future. The payoffs are the same for each lottery (invariant across decision pairs), and while Lottery A is the same in each decision pair (same probabilities and expected value), in Lottery B, the probability of winning the high payoff increases with each successive decision.

This protocol permits Laury et al (2012) to delineate between intertemporal and risk effects in decision making. Formally, let I represent a constant level of consumption per period, p_t and p_{t+1} represent the probabilities of winning the highest payoff (x) in lotteries A and B, and β represent the discount rate. Following Laury et al (2014), we can write the present value of expected utility for each lottery:

$$PV_A = p_t U(I+x) + (1-p_t)U(I) + \beta U(I) \tag{1}$$

$$PV_B = U(I) + \beta\left[p_{t+1}U(I+x) + (1-p_{t+1})U(I)\right] \tag{2}$$

Letting $U(I)=0$, $U(I+x)=1$, and assuming linearity in probabilities, an individual will be indifferent between the two lotteries when

$$\beta = \frac{p_t}{p_{t+1}} \tag{3}$$

From equation (3), it is apparent that the discount rate does not depend upon the curvature of the utility function. Laury et al (2012) find that elicited discount rates using this lottery-based procedure are significantly lower compared to mechanisms that do not control for risk preferences.

In our second experiment, we combine this approach from Laury et al (2014) with the asset legitimacy protocol from Morrison and Oxoby (2013) to explore the effects of loss aversion in intertemporal decision making while controlling for risk preferences. The structure of the experiment is presented in Figure 5.

FIGURE 5: INTERTEMPORAL DISCOUNT RATE ELICITATION UTILIZING AN ASSET LEGITIMACY PROTOCOL

	CONTROL GROUP	**TREATMENT GROUP**
SESSION 1	COMPLETE QUIZ – EARN $20 ↓ **COMPLETE HYPOTHETICAL DISCOUNT RATE ELLICITATION TABLE** ↓ **COMPLETE INCENTIVIZED DISCOUNT RATE TABLE** ↓ CONCLUSION AND FINAL PAYMENT (INCLUDING $5 SHOW-UP FEE)	COMPLETE QUIZ – EARN $20 ↓ **COMPLETE HYPOTHETICAL DISCOUNT RATE ELLICITATION TABLE** ↓ PAYMENT OF $20 ↓ ↓
		↓
SESSION 2 (one week after Session 1)		**COMPLETE INCENTIVIZED DISCOUNT RATE TABLE** ↓ CONCLUSION AND FINAL PAYMENT (INCLUDING $5 SHOW UP FEE)

To incorporate Laury et al (2012) with our asset legitimacy protocol, we constructed both a hypothetical and an incentivized discount rate elicitation task where participants were asked to make 20 choices between two options. The hypothetical decision task (Table 4) replicates Laury et al (2012) and shows the implied annual effective interest rate (AEIR; not shown to participants). Here, Option A is a constant lottery in three weeks and Option B is a lottery in twelve weeks. The expected value of Option B increases in each decision, thereby compensating for the impatience experienced over the 12-week delay. The point at which individuals start choosing Option B over Option A provides a measure of the intertemporal discount rate without depending on risk preferences.[5] For our purposes, the role of this hypothetical decision table is to test whether the elicited preferences of our control and treatment groups differ with respect to the Laury et al procedure when there are no payoffs in the domain of losses.

[5] Laury et al (2012) find that in a standard discount rate elicitation task, subjects choose the sooner lottery an average of 13 times out of the 20 decisions indicating a strong reluctance to save. By contrast using the their procedure which accounts for risk preferences they find that subjects choose the sooner option an average of 7.9 times out of 20 decisions.

TABLE 4: HYPOTHETICAL DISCOUNT RATE ELICITATION TABLE

Decision	Option A Details Lottery A pays out in three weeks		Option B Details Lottery B pays out in 12 weeks	AEIR
1	50% chance of $200		50% chance of $200	0:00
2	50% chance of $200		50.1% chance of $200	1.01
3	50% chance of $200		50.2% chance of $200	2.02
4	50% chance of $200		50.4% chance of $200	4.08
5	50% chance of $200		50.5% chance of $200	6.18
6	50% chance of $200		50.7% chance of $200	8.33
7	50% chance of $200		50.9% chance of $200	10.52
8	50% chance of $200		51.1% chance of $200	12.75
9	50% chance of $200		51.2% chance of $200	15.02
10	50% chance of $200		51.4% chance of $200	17.35
11	50% chance of $200		51.6% chance of $200	19.72
12	50% chance of $200		51.8% chance of $200	22.13
13	50% chance of $200		52% chance of $200	25.22
14	50% chance of $200		52.2% chance of $200	28.39
15	50% chance of $200		52.7% chance of $200	34.97
16	50% chance of $200		53.6% chance of $200	49.15
17	50% chance of $200		54.5% chance of $200	64.82
18	50% chance of $200		56.9% chance of $200	111.54
19	50% chance of $200		59.4% chance of $200	171.46
20	50% chance of $200		64.7% chance of $200	346.79

Source: Laury et al (2012) [6]

Table 5 presents the incentivized decisions made by participants in the experiment. These differ in three ways from the Laury et al (2012) elicitation mechanism. First, Option A is a certain cash amount ($20), equal to the amount of money earned by each participant in the GRE quiz portion of the experiment. Second, the high payoff in the Option B lottery is double the certain cash amount in Option A. Third, the payout from Option A is immediate; there is no front-end delay. Our reason for this is to ensure that the decision environment creates a clear loss of current income if Option A is selected, whereas a front end delay would mute this effect. Despite these changes, our elicitation mechanism is still invariant to risk preferences. Writing out the present value of expected utility for each of the options in our incentivized decision task, we obtain:

[6] See Laury et al (2012); Task P decision table, p216.

$$PV_A = U(I+20) + \beta U(I) \quad (4)$$

$$PV_B = U(I) + \beta\left[p_{t+1}U(I+40) + \left(1 - p_{t+1}\right)U(I)\right] \quad (5)$$

Letting U(I) = 0 and U(I+20) = 1, an individual will be indifferent between the two options when

$$\beta = \frac{1}{p_{t+1}U(I+40)} \quad (6)$$

As with Laury et al (2012), equation (6) shows that β is independent of the curvature of the utility function.[7] Following Laury et al (2012) we increase the expected value of each successive lottery in Table 5 which creates a series of ascending annual effective interest rates, starting at zero and rising exponentially.[8] The point at which an individual starts to prefer Option B over option A provides a measure of the minimum interest rate required to induce forgoing current dollars in favor of future dollars.

[7] One difference in our experiment is that we have three points of utility; U(I), U(I+20) and U(I+40). If we assume U(I)=0 and U(I+20) =1, it follows that in order to allow for risk neutrality as well as risk aversion it must be possible for $U(I+40) = 2$ (i.e. $U(I+40)$ must be a proportionate gain in utility over $U(I+20)$). This places a lower bound restriction on p_{t+1} since β must be less than or equal to unity. If $U(I+40) = 2$, the lower bound on p_{t+1} is 0.5. For this reason, our decision table sets $p_{t+1} = 0.5$ for decision 1 with the probabilities rising for successive decisions.

[8] The AEIR is calculated as AEIR = $\left(\frac{EV_B}{EV_A}\right)^{\frac{1}{n}-1}$ where EV_A = Option A (certain cash = \$20); EV_B=expected value of Option B (lottery); $n = \frac{m}{365}$ where m = number of days separating payouts from Option A and Option B. Note: the AIERs in Laury et al range from zero to 345.2%. The reason that our AEIRs are higher than those in Laury et al is that we were forced to use a shorter time span of 21 days due to constraints imposed by the end of the university term.

TABLE 5: INCENTIVIZED DISCOUNT RATE ELICITATION TABLE

Decision	Option A details	Option B Details Lottery pays out in 21 days (3 weeks)								Expected Value of Option B	AEIR
1	Do not enter the lottery. Keep the $20 I have earned	A	50.0%	chance of	$40	and a	50.0%	chance of	$0	$20.0	0.000
2	Do not enter the lottery. Keep the $20 I have earned	A	50.0%	chance of	$40	and a	50.0%	chance of	$0	$20.0	0.016
3	Do not enter the lottery. Keep the $20 I have earned	A	50.1%	chance of	$40	and a	49.9%	chance of	$0	$20.0	0.031
4	Do not enter the lottery. Keep the $20 I have earned	A	50.2%	chance of	$40	and a	49.8%	chance of	$0	$20.1	0.063
5	Do not enter the lottery. Keep the $20 I have earned	A	50.2%	chance of	$40	and a	49.8%	chance of	$0	$20.1	0.080
6	Do not enter the lottery. Keep the $20 I have earned	A	50.3%	chance of	$40	and a	49.7%	chance of	$0	$20.1	0.113
7	Do not enter the lottery. Keep the $20 I have earned	A	50.4%	chance of	$40	and a	49.6%	chance of	$0	$20.2	0.148
8	Do not enter the lottery. Keep the $20 I have earned	A	50.5%	chance of	$40	and a	49.5%	chance of	$0	$20.2	0.183
9	Do not enter the lottery. Keep the $20 I have earned	A	50.5%	chance of	$40	and a	49.5%	chance of	$0	$20.2	0.201
10	Do not enter the lottery. Keep the $20 I have earned	A	50.6%	chance of	$40	and a	49.4%	chance of	$0	$20.2	0.238
11	Do not enter the lottery. Keep the $20 I have earned	A	50.7%	chance of	$40	and a	49.3%	chance of	$0	$20.3	0.275
12	Do not enter the lottery. Keep the $20 I have earned	A	50.8%	chance of	$40	and a	49.2%	chance of	$0	$20.3	0.314
13	Do not enter the lottery. Keep the $20 I have earned	A	50.9%	chance of	$40	and a	49.1%	chance of	$0	$20.4	0.354
14	Do not enter the lottery. Keep the $20 I have earned	A	51.0%	chance of	$40	and a	49.0%	chance of	$0	$20.4	0.395
15	Do not enter the lottery. Keep the $20 I have earned	A	51.2%	chance of	$40	and a	48.8%	chance of	$0	$20.5	0.501
16	Do not enter the lottery. Keep the $20 I have earned	A	51.6%	chance of	$40	and a	48.4%	chance of	$0	$20.6	0.711
17	Do not enter the lottery. Keep the $20 I have earned	A	52.0%	chance of	$40	and a	48.0%	chance of	$0	$20.8	0.946
18	Do not enter the lottery. Keep the $20 I have earned	A	53.0%	chance of	$40	and a	47.0%	chance of	$0	$21.2	1.715
19	Do not enter the lottery. Keep the $20 I have earned	A	54.0%	chance of	$40	and a	46.0%	chance of	$0	$21.6	2.784
20	Do not enter the lottery. Keep the $20 I have earned	A	56.1%	chance of	$40	and a	43.9%	chance of	$0	$22.4	6.323

Results

Sixty-two individuals participated in the experiment, with 29 and 33 participants in each of the control and treatment groups. We begin by comparing the responses of the control and treatment groups in the hypothetical decision table (Table 4). Figure 6 shows the percentage of individuals by group, choosing the earlier payout (Option A). We find no statistical difference in the decisions of participants in the control and treatment groups (Wilcoxon p > 0.5), indicative of both groups displaying similar discount rates.

Figure 6: Hypothetical decision table results: percentage of participants choosing option A

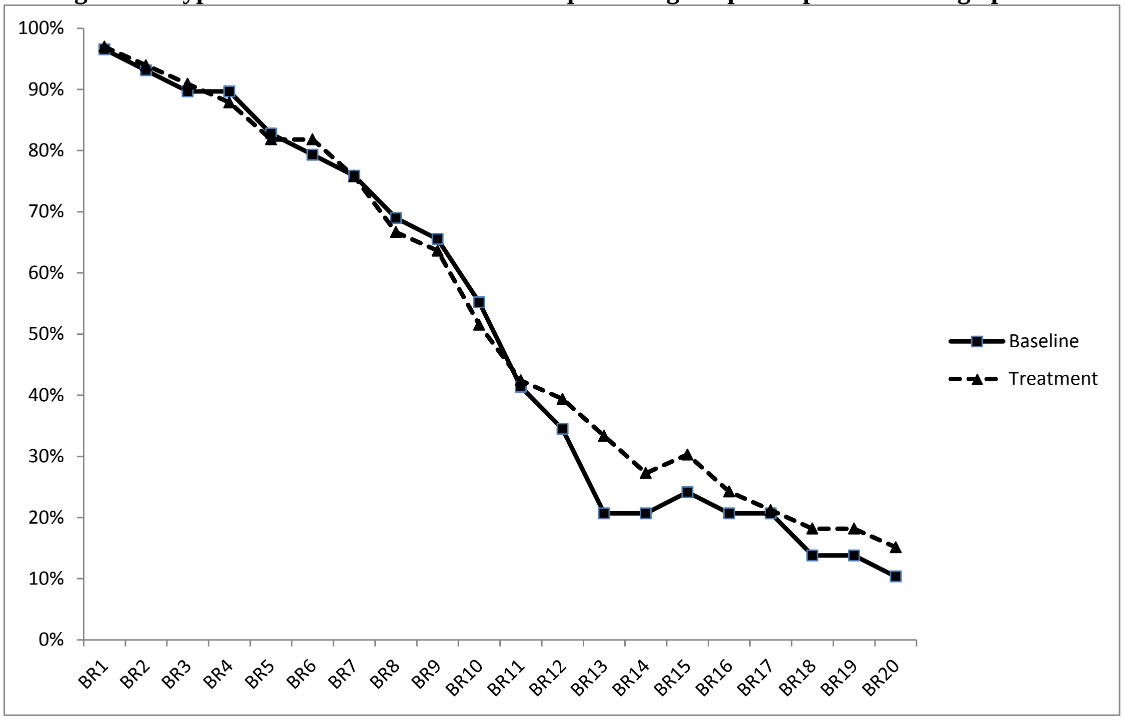
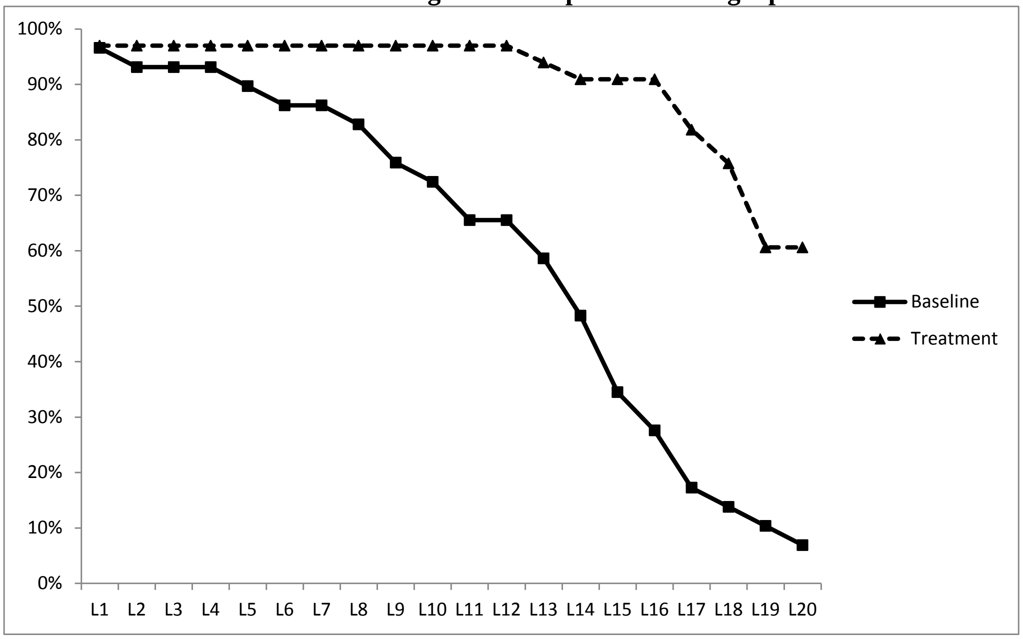


Figure 7 presents the percentage of individuals choosing option A in our incentivized task (Table 5). We observe a marked difference between the control and treatment groups where, even at very high annual effective interest rates, no more than 40% of treatment group participants were willing to forego the $20 they brought to session 2 for the chance of receiving a higher amount in three weeks' time. Table 6 summarizes these results.

TABLE 6: INCENTIVIZED DISCOUNT RATE ELICITATION RESULTS

	Hypothetical Laury et al Decision Table		Incentivized Intertemporal Decision table	
	Baseline	Returning	Baseline	Returning
Average Crossover point	10.9	11.3	13.07	18.48
Wilcoxon P values	P > 0.5		P < 0.001	

**Figure 7: Incentivized Discount Rate Elicitation Results:
Percentage of Participants Choosing Option A**



Eliminating Asymmetry in the Protocol Design

As indicated in the introduction, a potential concern with our asset legitimacy protocol is that results might be affected by the asymmetry in design wherein the control group complete all their tasks in a single session and the treatment group attend two sessions, one week apart. As a robustness check of our results, we eliminated this asymmetry in additional sessions where the control group attended two experimental sessions, as illustrated in Figure 8. Under this alternative design, the timing of the hypothetical and incentivized tasks for the control and treatment groups are identical, the only difference being that alternative control group participants do not receive the $20 they earn until the conclusion of the experiment in session 2.

FIGURE 8: ALTERNATIVE ASSET LEGITIMACY PROTOCOL FOR THE CONTROL GROUP

	ALTERNATIVE CONTROL GROUP
SESSION 1	COMPLETE QUIZ – EARN \$20 ↓ **COMPLETE HYPOTHETICAL HOLT-LAURY DECISION TABLE** ↓ ↓
	↓
SESSION 2 (one week after Session 1)	**COMPLETE INCENTIVIZED DECISION TABLE** ↓ CONCLUSION AND PAYMENT (INCLUDING \$5 SHOW-UP FEE)

There were 19 participants in this two-session version of our control treatment. As presented in Table 7, we find no differences in the results from this alternative design relative to our one-session control group.

TABLE 7 : COMPARING ORIGINAL AND ALTERNATIVE CONTROL GROUP RESULTS

	Experiment 1		Experiment 2	
	Original control group	Alternative control group	Original control group	Alternative control group
Hypothetical decision average crossover point	5.63	6.00	10.9	11.1
Wilcoxon P values	p > 0.5		p > 0.9	
Incentivized decision average crossover point	5.42	5.11	13.1	14.5
Wilcoxon P values	p > 0.6		p >0.3	

2. Conclusion

Loss aversion is recognized as an important and policy relevant behavioral phenomenon affecting a wide range of decision environments. From a policy perspective, loss aversion is increasingly viewed as a relevant phenomenon affecting environmental decisions (Olander and Thogerson, 2014), monetary policy (Santoro et al, 2014), and tax policy (Rees-Jones, 2014, Engstroom et al, 2015). As articulated by Olander and Thogerson (2014), this increased attention necessitates further research to better understand the fundamental means by which loss aversion (separate from risk aversion and other motives) affects decision-making.

To this end, we have sought to identify the effects of loss aversion in an incentivized experiment with respect to both its effects in risk behavior (experiment 1) and intertemporal decision-making (experiment 2). To this end, we conducted two experiments with the objective of measuring the effects of loss aversion, separate from risk aversion, on decisions involving risk and intertemporal choice. Using an asset legitimacy protocol designed to minimize any ‘house money’ bias in decision-making, our results show how a strict sense of asset legitimacy over resources leads to behavior consistent with loss aversion. A strength of our design has been to utilize recognized protocols (Holt and Laury, 2002, and Laury et al, 2012) for eliciting risk and time preferences. As expected in the loss aversion literature, we find that loss aversion significantly amplifies risk-avoiding behavior and, consistent with Morrison and Oxoby (2013) significantly increases elicited intertemporal discount rates.

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