A Study of Framing Effects in a New Risk Aversion Experiment

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Abstract

Risk aversion experiments such as those by Holt and Laury (2002 and 2005) measure risk aversion by examining responses of experimental subjects who are confronted with single-sheet paper displays of probability-ordered arrays of choices in which "real" money is at risk. As an alternative to this approach, the findings reported in this paper were obtained using a modified adventure-type video game to offer the choices presented by the HL experiment embedded in a more realistic scenario. The decisions are confronted first by our experimental subjects in a sequential and unordered manner. Then, later in the experiment, subjects are instructed to examine the results of their decisions in an array that shares the simultaneous and probability-ordered characteristics of the standard laboratory protocol. Subjects then had the option of altering their decisions before their payment was determined. The results indicate that decisions made in a sequential and unordered manner exhibit less risk aversion and higher degrees of decision inconsistency.

I. Introduction

Management of the risk-return tradeoff is a--or perhaps, *the*--central issue in the study of finance. Von Neumann and Morgenstern (1944) initiated formalization of this area with expected utility theory. Within this framework the degree of curvature of the utility function expresses the individual's degree of risk aversion. Over the succeeding 60 odd years, expected utility theory has been extended in many directions in an effort to refine and generalize its outcomes. In recent years, risk aversion has been the subject of numerous field and laboratory experiments that, among other things, serve as tests of the oft-used risk-neutrality assumption (e.g. Binswanger 1980; Kachelmeier and Shehata 1992; Beetsma et al 2001; Harrison et al 2007). These studies predominantly have found participants to be moderately risk averse rather than risk neutral as assumed in some theoretical models. The validity of early risk aversion studies was questioned, as they involved hypothetical or quite small payoffs. To address some of these concerns, studies by Holt and Laury (2002 and 2005) [hereafter HL] compared hypothetical and real, increasingly higher, payoff levels within a single study. They found that real, higher payoffs led to greater degrees of risk aversion and that most subjects exhibited decision consistency.

Our study was conducted using a novel methodology. We first trained, then had participants play, a non-violent, adventure-style video game. We obtained permission to modify a game that was originally designed to study NATO peacekeeping teams' behavior by BBN Technologies under contract to the U. S. military (BBN Technologies 2006). The system includes a data logging function that records all game behavior in a Sequel database and also provides a utility for statistical analysis of the data. We modified the NATO game as a first illustration (in a civilian rather than military context) of the use of this system for academic research. In this study, we use the game to replicate the HL experiment for measuring risk

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aversion. This allowed us to gather new evidence regarding one of the fundamental questions that has been asked about this body of research, namely, the impact of framing effects on the measurement of risk aversion (Anderson, et al 2007). It also allows us to illustrate the potential of this promising new methodological tool. In the pages that follow, the HL experiments are explained in more detail, followed by a description of the experiments we conducted to validate our methodology and examine the HL results. Some of the most notable outcomes of these experiments are then reviewed, with an emphasis on the impact of certain framing effects on risk aversion measurement.

II. The Holt Laury Experimental Methods and Outcomes

In the first HL experiment, 212 subjects were provided with 10 pairs of choices (hereafter referred to as "Decision Pairs") on a single sheet of paper, as shown in Table 1. The first 9 of these Decision Pairs present choices between a safer "Choice Set A" and a riskier "Choice Set B." Moving from the top of the page downward, the Decision Pairs offer increasingly higher probabilities of obtaining the higher prize. Most subjects' decisions exhibit safer choices (Choice Set A) at the top of the page and riskier choices (Choice Set B) on the lower part of the page. For the first 4 Decision Pairs, Choice Sets A have the higher expected value. For Decision Pairs 5 through 9, Choice Sets B have higher expected values. Decision Pair 10 does not involve risk but served as a test to see if subjects understood the game. Within this framework, switching from side A to side B between the 4^{th} and 5^{th} pair of choices indicates risk neutrality; switching beyond this point (lower on the page) indicates risk aversion and switching before this point (higher on the page) indicates risk prone behavior. Switching from side to side more than once indicates decision inconsistency.

HL counted the number of safe "A" choices as the variable of interest for their study. They also found 13.2% of the 208 subjects in their first study to be inconsistent. They disregarded the inconsistency, however, believing it to have little influence on their outcomes (Holt and Laury 2002 p. 1648f). Subjects' rewards were hypothetical in some cases and real in others. The real rewards were in multiples of 1x, 20x, 50x, and 90x base amounts for Set A ($2.00 or $1.60) and Set B ($3.85 or $0.10). In the experiments most comparable to ours the payments were Set A ($40.00 or $32.00) and Set B ($77.00 or $2.00). Players were actually paid using a "random round" payment method. In this method, players roll a 10-sided die first to see which of the 10 Decision Pairs will be used to determine their payoff and roll again to determine the size of the payoff. For example, if their first roll produced a 4, then Decision Pair 4 would be used as the basis of the payoff. Decision Pair 4 has a 40% chance of the higher value and a 60% chance of the lower value. Suppose the subject had selected Choice Set A for Pair 4. When they rolled the die the second time, a roll of 1-4 yielded the higher payoff ($40.00), whereas a roll of 5-10 yielded the lower payoff ($32.00). Had the subject selected Choice Set B, a roll of 1-4 would have yielded the higher payoff of $77.00 and a roll of 5-10 the lower payoff of $2.00.

In the first set of experiments conducted by HL, subjects completed the exercise more than once with different payoff scales. After a critique indicating the presence of order-of-play effects (Harrison et al., 2004), HL repeated their study so as to eliminate these order effects. The risk aversion measures from the second round of HL outcomes with real 20x payoffs are most comparable to those in our research. HL found that the mean number of safe choices in two rounds of 48 subjects each were 6.7 and 7.1. Very similar results from one part of our study are reported below.

TABLE I: The Paper-Based Decision Table

Circle the appropriate letter to indicate your choice from each of the ten pairs below.

Decision Pair #	Choice Set A	Choose A or B		Choice Set B
1	10% chance of $40.00 and 90% chance of $32.00	← A	B →	10% chance of $77.00 and 90% chance of $2.00
2	20% chance of $40.00 and 80% chance of $32.00	← A	B →	20% chance of $77.00 and 80% chance of $2.00
3	30% chance of $40.00 and 70% chance of $32.00	← A	B →	30% chance of $77.00 and 70% chance of $2.00
4	40% chance of $40.00 and 60% chance of $32.00	← A	B →	40% chance of $77.00 and 60% chance of $2.00
5	50% chance of $40.00 and 50% chance of $32.00	← A	B →	50% chance of $77.00 and 50% chance of $2.00
6	60% chance of $40.00 and 40% chance of $32.00	← A	B →	60% chance of $77.00 and 40% chance of $2.00
7	70% chance of $40.00 and 30% chance of $32.00	← A	B →	70% chance of $77.00 and 30% chance of $2.00
8	80% chance of $40.00 and 20% chance of $32.00	← A	B →	80% chance of $77.00 and 20% chance of $2.00
9	90% chance of $40.00 and 10% chance of $32.00	← A	B →	90% chance of $77.00 and 10% chance of $2.00
10	100% chance of $40.00 and 0% chance of $32.00	← A	B →	100% chance of $77.00 and 0% chance of $2.00

III. Our Experimental Method

The method by which the decision problem was posed to the experimental subjects in our experiment was distinctly different from that of HL. We modified an adventure-style video game to provide a scenario wherein the HL Decision Pairs and Choice Sets would be encountered as a part of the game play. Inside the game scenario, experimental subjects (solicited by email from the general student population of our university) were assigned the role of assisting the "Drug Strike Force" in the town of Santa Catarina. Their task was one of recovering illegal drugs from crates hidden by a notorious drug cartel in various locations around the town. Subjects searched their assigned areas of the town to find pairs of crates (hereafter, "Crate Pairs.") Each Crate Pair contained amounts of illegal drugs that corresponded to the Decision Pairs of the HL experiment. The player then made a decision about which ONE crate in the pair to open in order to recover the most drugs. Subjects were paid the HL 20x amounts at the end of the game for the drugs they found using the same random round protocol as the HL experiments. Subjects' payments ranged from $2.00 to $77.00 and averaged about $40.00 each.

Our Crate Pairs, Choice Sets, and payment method were identical to those of the first nine HL Decision Pairs. Because our method differed substantially from theirs, providing a richly textured context within which subjects' decisions were made, we were concerned in our first round of experiments to validate our method. As indicated above, the HL mean numbers of safe choices from the experiments that were most similar to ours were 6.7 and 7.1. Our mean number of safe choices was 6.9 – thus there was no difference between our mean number safe and the average of their mean number safe. Gender differences discovered by HL were consistent with those found by prior researchers in this area, with female mean number of safe choices being 0.5 greater (safer) than those of male subjects. Our results concurred, showing a +0.5 female difference. The percentages of inconsistent choices for the prior HL 20x studies were 7% and 10% (mean 8.5%). Our inconsistency rate was 8.3%. Thus, in view of this variety of findings (Table 2), we conclude that our experimental procedures do not induce departures from the fundamental results of other researchers in this area.

Table II
Validation Relative to Prior HL Studies

	HL 20x	*Final* LL 20x
Mean # of safe choices	6.7 & 7.1	6.9
Female difference in # of safe choices	+0.5	+0.5
Subjects with inconsistent choices	8.5%	8.3%

Aside from the contextual difference from HL, there were some additional differences in our presentation of the decision problem that were designed to examine the issue of framing. Our subjects encountered their decisions one at a time rather than simultaneously as was the case with HL's single-sheet paper presentation. Thus, they made each choice in a Decision Pair (i. e., the Crate Pairs) without reference to other decisions they had already made or would make. Further, our subjects encountered their decisions in an order determined by the search path they adopted rather than being presented with an ordered set of choices. A test of the Crate Pair "find order" indicated that no crate pairs were consistently found before or after others ($p = 0.999$). Thus, our subjects confronted their choices sequentially and randomly rather than simultaneously and in probability order.

Our video game had the additional advantage of being linked to a Sequel data base so that player actions could be recorded and studied. To take advantage of this and to examine the impacts of having sequential random choices, the in-game Drug Strike Force "Team Leader" asked subjects to search their assigned area of the town and collect drug packets in their backpacks, then meet at a rendezvous point after collecting all nine packets. At the rendezvous point, the Team Leader instructed subjects to place their drug packets in probability order. Upon completing this task, subjects noticed that the safe packets (corresponding to safer Choice Set A decisions) were purple while riskier packets (Choice Set B) were gold colored. This ordering and color coding provided a "prompt" similar to the right-side of the page, left-side of the page prompt of the HL ordered Decision Pairs. At this point the Team Leader offered the subjects the opportunity to change any decisions with which they were dissatisfied. Thus, we were able to compare subjects' *first* risk aversion decisions when choices were encountered in a sequential, unordered manner, with their *final* decisions in which probability ordering and simultaneity were present. Of course, we could also then examine what types of changes were made and what types were not. We used this research procedure for 60 subjects. The next section of the paper reviews the results for our subjects.

V. Experimental Outcome

Subjects' decisions differed between their *first* and *final* choices in terms of their level of risk aversion. Using the HL criteria of number of safe choices as the indicator of risk aversion, we found that the mean number of safe choices was 6.72 when decisions were *first* made sequentially and in random order. This differed from the 6.92 *final* safe choice mean when outcomes were displayed simultaneously and in probability order (Table 3, p = 0.05). Using another measure, there were 30 of the 60 subjects who changed their number of safe choices between the *first* and *final* stages. Of these, 21 opted to reduce their level of risk while only 9 increased their level of risk taking (Table 4, p = 0.03). This finding, of a tendency to change toward more safe choices, and therefore toward more risk aversion, implies that subjects making risky decisions that are confronted "one by one" may exhibit less risk aversion than when the same decisions are made in the face of an ordered array of alternatives. It also suggests that prior studies of risk may overstate the level of risk aversion evidenced by people when they confront choices in what is arguably a more common circumstance – sequentially and unordered.

Table III
Differences Between *First* and *Final* Choices

	LL *First*	LL *Final*	p-value
Mean # of safe choices	6.72	6.92	.05
Subjects with inconsistent choices	41.7%	8.3%	.00

Subjects' decisions differed between their *first* and *final* choices in terms of consistency as well as in degree of risk aversion. The changes made from the *first* to *final* choices reduced the number of inconsistent responses. The inconsistency rate for the *final* choices was relatively small (8.3%) and similar to the mean for the HL studies (8.5%). The inconsistency rate for the *first* choices, however, was 41.7%, significantly higher than the *final* inconsistency rate (Table 3, p = 0.00). No subject made a *first* selection that was consistent but then, when given the opportunity, changed it to an inconsistent selection in his/her *final* choice (Table 4). As in the earlier finding, regarding the level of risk aversion, the *first* to *final* consistency reduction data indicates that risky decisions made sequentially exhibit less consistency in risk aversion than those same decisions made when confronting an ordered array of alternatives. Thus, this part of our study suggests that policies relying on consistency in people's assessments of risk should be approached more cautiously than previously thought.

TABLE IV
Subjects' Changes Between *First* and *Final* Choices

# of Subjects who changed:	Increased	Decreased	p-value
Level of Risk	9[12]	21[13]	.03
Consistency	20[14]	0	.00

In considering both types of changes, i. e., those undertaken to alter the number of safe choices and those undertaken to improve consistency, 32 of the 60 subjects (53%) changed their minds in some way between their *first* and *final* decisions. Twelve of the 32 were consistent in their *first* choices and altered their decisions solely for the purpose of changing their number of safe choices. Two of the 32 left their number of safe choices alone but altered their patterns from inconsistent to become consistent. The other 18 of the 32 altered both their number of safe choices and their decision consistency (Table 4). Taken together, these findings suggest that decision makers confronting risky decisions that are posed sequentially and in random probability order exhibit behavior that is considerably different than when they confront probability ordered arrays of choices. In our study over half of the experimental subjects changed their minds when the choice format was altered. Information from studies using probability ordered arrays may be valuable for making inferences about "real world" behaviors when decision makers confront such arrays. But these studies may well mislead when making inferences about decision makers confronting individual, unordered decisions. It may be appropriate to entertain *multiple* conceptions and measurements of the risk aversion that people generally experience, depending upon not only the specific content of the decision problem, but also relatively subtle aspects of the problem presentation format.

A simple example may add clarity. Suppose a potential car buyer was to choose between nine brands of cars, each with a different and known repair cost history. Further suppose that all brands offer a warranty, but for a fee. The rational buyer confronted <u>with all nine brands at once</u> would prefer the warranty on the less reliable brands but decline on the most reliable brands. Existing research suggests that for most buyers their decisions would be consistent and reflect moderate risk aversion. Our research agrees, but *only* if all brands and warranties are considered side by side. However, if the buyer does his/her analysis sequentially rather than simultaneously, the result would be higher levels of risk taking and more inconsistent decisions. The additional inconsistency and risk taking would hold for financial decisions as well such as mortgage selection, decisions about investments, and decisions about alternative financing arrangements.

VI. Conclusion

We report above on an experimental study that reprised the well known Holt-Laury risk aversion experiments of 2002 and 2005. Our experiments were conducted by having participants play a modified version of an adventure-type video game. The participants' in-game decisions were made while confronting choice sets and payments that were the same as those in the HL

12 3 subjects changed only their risk level; 6 changed both their risk level and their consistency.
13 9 subjects changed only their risk level; 12 changed both their risk level and their consistency.
14 2 changed only their consistency, 18 changed both their risk level and their consistency.

20x experiments. Our participants were paid $2.00 to $77.00 in accordance with the random round method used in HL and several other prior risk aversion studies. Our experiment produced some outcomes very similar to or identical to the HL results, thus validating our novel experimental technique. Other results evidenced distinct differences from the HL study and allowed us to examine important aspects of framing in more detail than has previously been accomplished.

Our game software included a Sequel data base that recorded participants' individual decisions as they occurred in the game, both when the decisions were encountered one-by-one in the early part of the game, and later, when participants arranged their choices in a probability-ordered array reminiscent of the HL paper-based experiment. It was discovered that subjects made riskier decisions and less consistent decisions initially, then altered them so that less risky and more consistent choices were evident in their *final* probability-ordered array format. This suggests that studies such as those of HL that rely upon probability-ordered arrays may provide relatively reliable information about probability-ordered and arrayed "real world" decisions, but less reliable information about decisions that are not probability-ordered and that are made sequentially or individually.

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