

# Risk Aversion and Incentive Effects

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## Abstract

A menu of paired lottery choices is structured so that the crossover point to the high-risk lottery can be used to infer the degree of risk aversion. With "normal" laboratory payoffs of several dollars, most subjects are risk averse and few are risk loving. An increase in payoffs by a factor of twenty makes no significant difference when the high payoffs are hypothetical. In contrast, subjects become considerably more risk averse when the high payoffs are actually paid in cash.

Keywords: lottery choice, risk aversion, incentive effects.

Although risk aversion is a fundamental element in standard theories of lottery choice, asset valuation, contracts, and insurance (e.g. Daniel Bernoulli, 1738; John Pratt, 1964; Kenneth Arrow, 1965), experimental research has provided little guidance as to how risk aversion should be modeled. In fact, risk aversion effects are controversial and are often ignored in the analysis of laboratory data.<sup>1</sup> This general approach does not ring alarm bells with referees; most theorists are used to bypassing risk aversion issues by assuming that the "payoffs" for a game are already measured as utilities.

The nature of risk aversion is ultimately an empirical issue, and laboratory experiments should produce useful evidence that can complement field observations by providing careful controls of probabilities and payoffs. While many economists admit that risk aversion may be

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<sup>1</sup> To an experimentalist, the possibility of risk aversion effects is often considered to be an irritation, since it can complicate theoretical predictions and there is no widely accepted way of inducing risk neutrality. If it is not induced, risk aversion would have to be estimated or controlled for in costly sorting pretests. In its first two and a half years of publication, the journal *Experimental Economics* contains only one paper that incorporates risk aversion into the analysis.

important, it is commonly asserted that decision makers should be approximately risk neutral for the low-payoff decisions involving several dollars that are typically encountered in the laboratory. One way to assess this point of view is to provide subjects with high-payoff lottery choices, since most experimentalists are skeptical of the alternative of using high hypothetical payoffs. This paper reports the results of an experiment involving three conditions: low money payoffs, high hypothetical payoffs, and high money payoffs. The procedures are explained in Section I, and the effects of incentives on risk attitudes are analyzed in Section II.

## I. Procedures

The low-payoff treatment is based on ten choices between the paired lotteries in Table 1. Notice that the payoffs for Option A, \$2.00 or \$1.60, are less variable than the potential payoffs of \$3.85 or \$0.10 in the "risky" option B. In the first decision, the probability of the high payoff for both options is 1/10, so only an extreme risk seeker would choose Option B. As can be seen in the far right column of the table, the expected payoff incentive to choose Option A is \$1.17.<sup>2</sup> When the probability of the high payoff increases enough (moving down the table), a person should cross over to Option B. For example, a risk neutral person would choose A four times before switching to B. Even the most risk averse person should switch over by the bottom row, since option B yields a sure payoff of \$3.85 in that case.

Constant relative risk aversion is commonly assumed in the literature on auctions, for computational convenience and its implications for bid function linearity with uniformly distributed private values. With constant relative risk aversion for money  $x$ , the utility function is  $u(x) = x^{1-r}/(1-r)$  for  $x > 0$ , where the division by  $(1-r)$  is necessary for increasing utility when  $r > 1$ . This specification implies risk preference for  $r < 0$ , risk neutrality for  $r = 0$ , and risk aversion for  $r > 0$ . (When  $r = 1$ , the natural logarithm is used.) The payoffs for the lottery choices in the experiment were selected so that the crossover point would provide an interval estimate of a subject's coefficient of constant relative risk aversion. The payoff numbers for the

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<sup>2</sup> Expected payoffs were not provided in the instructions to subjects, which are provided in the Appendix. The probabilities were explained in terms of throws of a ten-sided die. In addition, we have a computerized version that is freely available on request, but we did not use it in this experiment in view of the large payoff consequences of a single die throw in the high-payoff treatment.

**Table 1.** The Ten Paired Lottery-Choice Decisions with Low Payoffs

Option A	Option B	Expected Payoff Difference
1/10 of \$2.00, 9/10 of \$1.60	1/10 of \$3.85, 9/10 of \$0.10	\$1.17
2/10 of \$2.00, 8/10 of \$1.60	2/10 of \$3.85, 8/10 of \$0.10	\$0.83
3/10 of \$2.00, 7/10 of \$1.60	3/10 of \$3.85, 7/10 of \$0.10	\$0.50
4/10 of \$2.00, 6/10 of \$1.60	4/10 of \$3.85, 6/10 of \$0.10	\$0.16
5/10 of \$2.00, 5/10 of \$1.60	5/10 of \$3.85, 5/10 of \$0.10	-\$0.18
6/10 of \$2.00, 4/10 of \$1.60	6/10 of \$3.85, 4/10 of \$0.10	-\$0.51
7/10 of \$2.00, 3/10 of \$1.60	7/10 of \$3.85, 3/10 of \$0.10	-\$0.85
8/10 of \$2.00, 2/10 of \$1.60	8/10 of \$3.85, 2/10 of \$0.10	-\$1.18
9/10 of \$2.00, 1/10 of \$1.60	9/10 of \$3.85, 1/10 of \$0.10	-\$1.52
10/10 of \$2.00, 0/10 of \$1.60	10/10 of \$3.85, 0/10 of \$0.10	-\$1.85

lotteries were determined to make the risk neutral choice pattern (AAAA/BBBBBB) optimal for constant relative risk aversion in the interval (-0.15, 0.15). The payoff numbers were also selected to make the choice pattern (AAAAAA/BBBB) optimal for an interval (0.41, 0.68), which is essentially symmetric around a coefficient of 0.5 (square root utility) that has been reported in econometric analysis of auction data cited below.

Each of the 175 subjects began by indicating a preference, Option A or Option B, for the ten paired lottery choices in Table 1, with the understanding that only one of these choices would be selected at random *ex post* and played to determine the earnings for the option selected. The second decision task involved the same ten decisions, but with hypothetical payoffs at 20 times the levels shown in Table 1 (\$40 or \$32 for Option A, and \$77 or \$2 for Option B). The third task was also a high-payoff task, but the payoffs were in cash. The final task was a "return to baseline" treatment with the low money payoffs shown in Table 1. The outcome of each task was determined before the next decision was to be made. In theory, incentives are diluted by the random selection of a single decision for each of the treatments, which is one motivation for running the high-payoff condition. Subjects did seem to take the low-payoff condition seriously, often beginning with the easier choices at the top and bottom of the table, with choices near their switch point more likely to be crossed out and changed.

To control for wealth effects between the high and low real-payoff treatments, subjects were required to give up what they had earned in the first low-payoff task in order to participate

in the high-payoff decision. They were required to initial a statement accepting this condition, with the warning:

Even though the earnings from this next choice may be very large, they may also be small, and differences between people may be large, due to choice and chance. Thus we realize that some people may prefer not to participate, and if so, just indicate this at the top of the sheet. It's up to you. If you decide to have this next round count, your earnings will be added to those of all previous parts up to now, except for the Option A/B part just finished, and the total will be paid to you in cash tonight. Since the throw of the die is so important in this next round, we will use a cup to shake it, and the throw only counts if it stays on your table. If you decide to participate, please initial the top line of the decision sheet and cross out the earnings you just received in the previous Option A/B exercise just completed. Let me reiterate, even though some of the payoffs are quite large, there is no catch or chance that you will lose any money that you happen to earn in this part. We are prepared to pay you what you earn. Are there any questions?

This procedure certainly caught their attention, and the tension in the room was noticeable. Nobody declined to participate, so there is no selection bias. For comparability, subjects in the high-hypothetical treatment were required to initial a statement acknowledging that earnings for that decision would not be paid. The hypothetical choice does not alter wealth, but the high real payoffs altered the wealth positions a lot for most subjects, and the final low-payoff task was used to determine whether risk attitudes are affected by large changes in accumulated earnings.

All together, we conducted the experiment using groups of 9-16 participants per session at three universities (two at Georgia State University, four at the University of Miami, and six at the University of Central Florida). About half of the students were undergraduates, one third were M.B.A. students, and 17 percent were business school faculty. The results, by session, are summarized in Table 2. Note that the low payoff tasks were always done, but the high payoff condition was for real money in some sessions, for hypothetical payoffs in others, and in half of the sessions we did both in order to obtain a within-subjects comparison. Doing high hypothetical before high real allows us to hold wealth constant and to evaluate the effect of any extra thought induced by real incentives. For our purposes, it would not have made sense to do

**Table 2.** Average Numbers of Safe Lottery Choices by Treatment  
(with Standard Deviations for Treatment Averages in Parentheses)

Session	Number of Subjects	Low Real Payoffs (First)	High Hypothetical Payoffs	High Real Payoffs	Low Real Payoffs (Second)
A	16	5.7	-	6.5	5.9
B	16	5.1	5.2	-	5.0
C	16	5.8	-	6.5	5.6
D	16	5.2	-	6.3	5.0
E	16	5.4	5.8	6.4	5.7
F	16	4.8	4.6	5.4	5.2
G	16	5.1	4.5	6.1	5.4
H	13	4.5	3.5	5.5	4.4
I	16	5.4	4.9	5.6	5.2
J	16	4.9	5.3	5.7	5.2
K	9	4.8	-	5.8	5.0
L	9	5.4	5.3	-	5.7
combined sessions E-J	175	5.2 (1.4)	4.9 (1.8)	6.0 (1.7)	5.3 (1.4)
	93	5.0 (1.4)	4.8 (1.8)	5.8 (1.7)	5.2 (1.3)

the high real treatment first, since the careful thinking would bias the high hypothetical decisions.<sup>3</sup> Earnings averaged about \$80 for the sessions with high real payments, and about \$50 for the other sessions.<sup>4</sup> The Appendix contains all individual lottery choice decisions and

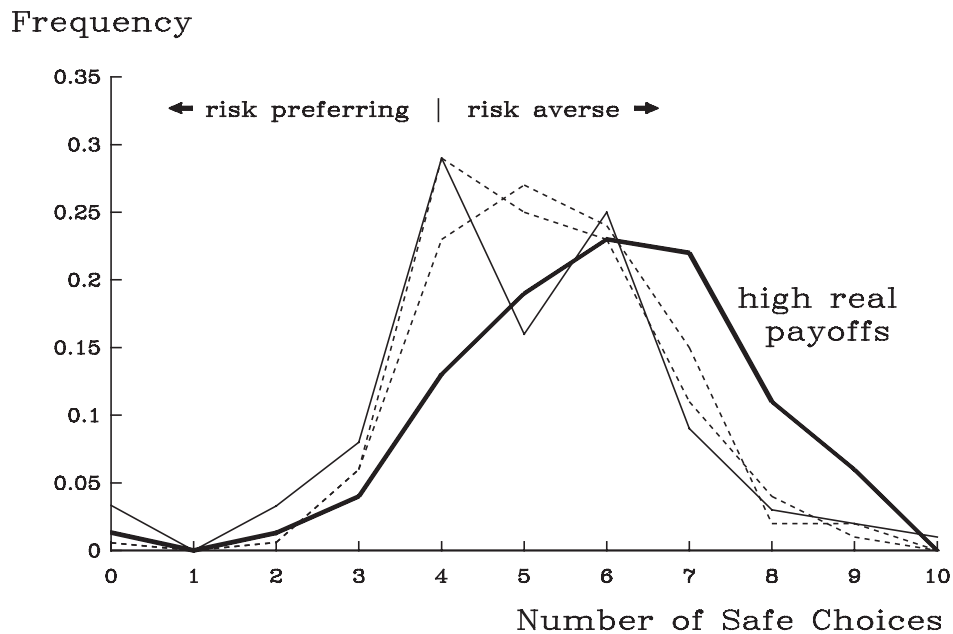
<sup>3</sup> Of course, the order that we did use could bias the high real decision toward what is chosen under hypothetical conditions, but a comparison with sessions using one high-payoff treatment or the other indicates no such bias.

<sup>4</sup> The lottery choice decisions for sessions A-J at the Universities of Miami and Central Florida were sandwiched in between two parts of an experiment conducted (and funded) by a colleague. The first part contained a repeated individual decision (tax compliance) task, for which earnings averaged \$17.31. The lottery choices for these sessions were followed by a double auction. Earnings for all parts combined averaged about \$70.00 per person. We flew into Miami with over \$10,000 in small bills, divided between two people to avoid problems with the "RICO law" that allows detention of individuals carrying at least \$10,000 in cash as suspected drug dealers. The four lottery choices for sessions K and L were conducted at Georgia State, and followed a series of individual choice tasks for which earnings averaged \$26.49. We consider wealth effects in the next section, but the difference in the prior experience is probably not relevant; the inclusion of the Georgia State data does not alter the means, medians, or modes of the numbers of safe choices in any of the treatments by more than 0.05.

responses to fifteen demographic questions.

## II. Incentive Effects

The majority of subjects chose the safe option when the probability of the higher payoff is small, and then crossed over to option B without ever going back to option A. Even for those who switched back and forth, there is typically a clear division point between a clusters of A and B choices, with few "errors" on each side.<sup>5</sup> Therefore, the total number of A choices will be used as an indicator of risk preference. Figure 1 shows the frequencies of each possible number of safe choices, for the first and second low-payoff decisions (dashed lines), the high hypothetical payoff decision (thin line), and the high payoff decision (thick line).



**Figure 1.** Choice Frequencies for Low Payoffs (Dashed Lines), High Real Payoffs (Dark Line), and High Hypothetical Payoffs (Light Line)

Even for the low payoff levels there is considerable risk aversion, with about two thirds of subjects choosing more than the four safe choices that would be predicted by risk neutrality.

<sup>5</sup> Only 22 of the 175 subjects switched back from B to A in the first low-payoff decision, and only 11 switched back in the final low-payoff choice. Very few subjects switched back from B to A more than once.

**Table 3.** Risk Aversion Classifications Based on Lottery Choices

Number of Safe Choices	Range of Relative Risk Aversion for $U(x) = x^{1-r}/(1-r)$	Risk Preference Classification	Proportion of Choices		
			Low Real <sup>a</sup>	high real	high hypothetical
0-1	$r < -0.95$	highly risk loving	.01	.01	.03
2	$-0.95 < r < -0.49$	very risk loving	.01	.01	.04
3	$-0.49 < r < -0.15$	risk loving	.06	.04	.08
4	$-0.15 < r < 0.15$	risk neutral	.26	.13	.29
5	$0.15 < r < 0.41$	slightly risk averse	.26	.19	.16
6	$0.41 < r < 0.68$	risk averse	.23	.23	.25
7	$0.68 < r < 0.97$	very risk averse	.13	.22	.09
8	$0.97 < r < 1.37$	highly risk averse	.03	.11	.03
9-10	$1.37 < r$	stay in bed	.01	.06	.03

<sup>a</sup> Average over first and second decisions.

The increase in payoffs by a factor of 20 shifts the choice frequency to the right in the figure, with more than 80 percent of choices in the risk averse category. Of the 150 subjects who faced the high-payoff choice, 84 showed an increase in risk aversion, with only 20 showing a decrease (the others show no change). This difference is highly significant using a binomial test of the null hypothesis that changes in each direction are equally likely.<sup>6</sup> The actual frequencies, along with the implied risk aversion intervals, are shown in Table 3. These risk aversion categories were used to design the menu of lottery choices, but the clear increase in risk aversion as all payoffs are scaled up is inconsistent with constant relative risk aversion. One notable feature of the frequencies in Table 3 is that 40 percent of the choice patterns in the high-payoff condition involve 7 or more safe choices, which indicates a very high level of risk aversion for those

<sup>6</sup> Observations with no change were not used. In addition, a one-tailed Kolmogorov-Smirnov test applied to the aggregate cumulative frequencies, based on all observations, allows rejection of the null hypothesis that the high-payoff condition has no effect at  $p < 0.001$ .

individuals.<sup>7</sup> The overall message from the real payoff treatments is that there is a lot of risk aversion, centered around the 0.3-0.5 range, which is roughly consistent with estimates implied by behavior in games, auctions, and other decision tasks.<sup>8</sup> To summarize:

*Conclusion 1. A clear majority of subjects are risk averse even for relatively low payoffs, and risk aversion is much more prevalent when earnings are scaled up by a factor of twenty.*

The next comparison is between hypothetical and real payoffs at the high level. The clear treatment effect suggested by Figure 1 is supported by the within-subjects analysis. Of the 93 people who made both decisions, 44 showed more risk aversion in the real-payoff condition, 42 showed no change, and 7 showed less risk aversion. The positive effect of real payoffs on the number of safe choices is significant using either a binomial test or a Kolmogorov-Smirnov test ( $p < 0.001$ ). There seems to be more risk seeking (15 percent) in the hypothetical-payoff condition than is the case in the other treatments (6-8 percent). Behavior appears a little more erratic with hypothetical payoffs; one person who chose option A in all ten decisions, including the sure hypothetical \$40 over the hypothetical \$77 in decision 10. The only other case of option A being selected in decision 10 also occurred in the hypothetical treatment.

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<sup>7</sup> Similarly, Hal Arkes, Lisa Herren, and Alice Isen (1988) find increased risk aversion as the *hypothetical* payoffs for a lottery increase. Hans Binswanger (1980) ran a lottery-choice experiment with real cash prizes that were quite large for a group of low-income farmers in Bangladesh; he reports that virtually all subjects were risk averse at high payoff levels. Similarly, Antoni Bosch-Domenech and Joaquim Silvestre (1999) report that willingness to purchase actuarially fair insurance against losses is increasing in the scale of the loss.

<sup>8</sup> In a classic study, Binswanger (1980) finds moderate to high levels of constant relative risk aversion (above 0.32), especially for high stakes gambles. Some recent estimates for constant relative risk aversion are:  $r = 0.67$ , 0.52 and 0.48 for private-value auctions (James Cox and Ronald Oaxaca, 1996; Jacob Goeree, Charles Holt, and Thomas Palfrey, 1999; and Kay-Yut Chen and Charles Plott, 1998, respectively),  $r = 0.44$  for several asymmetric matching pennies games (Goeree, Holt, and Palfrey, 2000),  $r = 0.45$  for 27 one-shot matrix games (Goeree and Holt, 2000). Sandra Campo, Isabelle Perrigne, and Quang Vuong (2000) estimate  $r = 0.56$  for field data from timber auctions. One thing to note is that risk aversion estimates can be quite unstable when inferred from willingness-to-pay prices as compared with much higher willingness-to-accept prices that subjects place on the same lottery (Steven Kachelmeier and Mohamed Shehata, 1992, R. Mark Isaac and Duncan James, 1999). The low willingness-to-pay prices imply risk aversion, whereas the high willingness-to-accept prices imply risk neutrality or risk seeking. One important implication of this measurement effect is that the same instrument should be used in making a comparison, as is the case for the comparison of risk attitudes of individuals and groups reported in Robert Shupp and Arlington Williams (2000).



*Conclusion 2. The use of cash payoffs raises measures of inferred risk aversion above those for high hypothetical payoffs.*<sup>9</sup>

The roughly comparable choice frequencies for the "before" and "after" low-payoff conditions, shown by the dashed lines in Figure 1, suggests that the level of risk aversion is not affected by the high earnings in the intermediate high-payoff condition that most subjects experienced. This invariance is supported by a simple regression in which the change in the number of safe choices between the first and last low-payoff decisions is regressed on earnings in the high real payoff condition that were obtained in between. The coefficient on earnings is near zero and insignificant. If we just consider the subset who won the \$77 prize, 26 people did not change their number of safe choices, 11 increased, and 14 decreased. It seems to be the case that high unanticipated earnings have little or no effect on risk preferences in this context. This observation would be consistent with constant absolute risk aversion,  $-u''(x)/u'(x)$ , which would also be consistent with the increasing relative risk aversion,  $-u''(x)x/u'(x)$ , implied by the payoff scale treatment. Alternatively, the lack of a strong correlation between earnings in the high-payoff lottery and subsequent lottery choices could be due to an "isolation effect" or tendency to focus on the *status quo* and consider risks of payoff changes. In fact, there is no experimental evidence that we know of which supports the "asset integration" hypothesis that wealth affects risk attitudes.

We also distributed a post-experiment questionnaire to collect information about demographics and academic background. While the study was not designed to address demographic effects on risk aversion, the subject pool shows a wide variation in income and education, and some interesting patterns do appear in our data. Using the any of the real-payoff

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<sup>9</sup> This result raises the issue of whether a hypothetical bias is also present in low-payoff conditions. We did not include a low-payoff hypothetical treatment in our experiment because we anticipated that there would not be much difference when payoffs are low. This issue did arise in subsequent discussions, and therefore we added low hypothetical and low real lottery choices to the end of two sessions being run for a different (sequential search) experiment. In all, 27 subjects made low hypothetical choices, followed by low real and a final low hypothetical set of decisions. The average number of safe choices was 4.6 for the first low-hypothetical condition, as compared with 5.0 for the low real condition with the same group of subjects (3 decreased, 9 increased, and 15 showed no change). A more interesting comparison *between* subject groups indicates that the magnitude of the low-to-high payoff change is twice as great for real incentives (5.0\* to 6.0 for real payoffs, versus 4.6\* to 4.9 for hypothetical, where the \* indicates the treatment average for the second sample of 27 subjects).

decisions to measure risk aversion, income seems to have a mildly negative effect on risk aversion ( $p < 0.06$ ). Other variables (major, MBA, faculty, age, etc.) were not significant. Using the low-payoff decisions only, we find that men are slightly less risk averse ( $p < 0.05$ ), with the number of safe choices going down by about 0.5 for them, which is consistent with findings reported by Eckel, Grossman, Lutz, and Pachmanabhan (1998). The surprising result for our data is that this gender effect disappears in the high-payoff condition (both real *and* hypothetical). Finally, although the white/non-white variable is not significant, the Hispanic variable is, and this effect becomes stronger at high-payoff levels. This Hispanic effect may be due to the narrow geographic basis of the sample; most of the Hispanic subjects were students at the University of Miami where they are likely to be descended from Cuban immigrants, who by selection may be less risk averse than non-immigrants. We plan to investigate this possibility in the future by comparing comparable groups of Cuban students in Miami and Havana.

### **III. Conclusion**

Perhaps the most commonly held belief about payoff-scale effects is that decisions are more variable with low or hypothetical payoffs, but that the average decision may not change. Another commonly heard position is that risk aversion ought to be minimal for the low payoffs typically associated with each individual decision in economics experiments. Each of these two points of view is only partly supported by our results. Although behavior is slightly more erratic under the high hypothetical treatment, the primary incentive effect is in levels, i.e. between the proportions of safe lottery choices in the two conditions. Subjects are significantly more risk averse with real payoffs. And while there is more risk aversion when payoffs are scaled up by a factor of 20, about two-thirds of the subjects exhibit risk aversion at the lower payoff levels that are typical for economics experiments.

It would, however, be unfortunate if this study and related papers are cited as an argument for considering risk aversion in all experimental work. Many decisions involve comparable levels of risk, and therefore the inclusion of risk aversion will not improve theoretical predictions. In common value auctions, for example, risk aversion has two counter-acting effects: aversion to a prize of unknown value which causes lower bids, and aversion to the risk of loss, which causes higher bids. Another caveat is that risk aversion will never explain all deviations from theoretical

predictions, and to assume so may yield contradictory inferences about risk aversion. For example, implied levels of risk aversion would not be stable across private value auctions with differing numbers of bidders if there are other effects that interact with numbers, e.g. tacit collusion or a tendency for "errors" to push bids away from boundaries. Finally, our conclusions about risk aversion may not extend to other domains, e.g. losses or large increases in wealth.

**Data and Instructions Appendix: <http://www.people.virginia.edu/~cah2k>**

(Click on <Research> and then on <Instructions and Data>.)

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