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Noussair, C.N.; Wu, P.C.

Published in:
Managerial and Decision Economics

Publication date:
2006

Citation for published version (APA):
Noussair, C. N., & Wu, P. C. (2006). Risk aversion in the present and the future: An experimental study. *Managerial and Decision Economics*, *27*(6), 401-412.

Risk Tolerance in the Present and the Future: An Experimental Study*

Charles Noussair

Department of Economics, Emory University,

1602 Fishburne Dr., Atlanta, GA 30322-2240

Telephone: 404-712-8617; Fax: 404-727-4639

E-mail: cnoussa@emory.edu

Ping Wu

Information and Decision Sciences, Carlson School of Management

University of Minnesota, 321 19th Avenue S., Minneapolis, MN 55455

Telephone: 612-626-3668; Fax: 612-626-1316

E-mail: pwu1@csom.umn.edu

* We thank Glenn Harrison and one anonymous referee for helpful comments on an earlier version of this paper.

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Abstract

We design an experiment to study the consistency of risk preferences between lotteries that are resolved and paid in the present versus in the future. The results show that a substantial fraction of subjects (38.6%) exhibits a greater level of risk aversion for lotteries resolved and paid in the present than in the future. Additional treatments suggest that the effect is not specific to gambles that are realized immediately, nor is due to steep discounting of future payoffs. Our experiment suggests that risk tolerance increases the farther in the future the gamble is realized.

1. Introduction

The nature of the tradeoffs that agents make between present and future payoffs has been a subject of considerable discussion among economists (see Camerer, 1995, or Frederick et al., 2002, for a review). Empirical work in behavioral economics has presented challenges to the traditional assumption of positive exponential discounting on several grounds. In this paper we provide evidence of an additional phenomenon in intertemporal choice behavior that is inconsistent with classical economic theory. We describe the results of an experiment establishing that many agents' decision patterns reflect more risk aversion for gambles that are resolved and paid in the present than in the future. In our experiment, which is based on the protocol of Holt and Laury (2002), individual subjects are asked to make several choices between a relatively safe and a relatively risky lottery. Subjects' decisions imply a range of risk aversion. Unlike some previous studies of intertemporal choice behavior, in which decisions were over hypothetical payments, the choices in this study are for real cash incentives.

In our experiment, the outcomes of the lotteries are realized at various times, present and future, which are known to subjects in advance. The times of realization and payment of the gambles range from the present to three months into the future. Our baseline treatment, in which agents choose between relatively safe and risky gambles realized in the present as well as three months into the future, demonstrates that agents are more risk tolerant when gambles are realized in the future than in the present. Data from an additional treatment, with a front-end delay, suggest that the differences are not specific to the case of the immediate realization of gambles, but rather the level of risk aversion also appears to be greater for gambles realized in the near future compared to those realized in the more distant future. Moreover, the pattern does not appear to be due to heavy discounting of future payoffs, as we also obtain some evidence that risk aversion is greater over small gambles paid in the present than over much larger ones to be paid in the future.

The previous research that is most closely related to ours consists of several experiments that have studied intertemporal choice patterns with respect to risky lotteries. Research that has explored whether or not departures from exponential discounting generalize to the case of uncertain lotteries has yielded weak support at best. Stevenson (1992) observes that risky lotteries are discounted more heavily over the near term than the long term. This result constitutes a generalization of earlier findings concerning riskless future payoffs. On the other hand, Shelley (1994) finds differences in discount rates for risky lotteries, depending on whether the payoffs are in terms of gains or losses, with lotteries consisting exclusively of losses discounted more heavily. This suggests that the observation, obtained in the case of riskless payoffs, that gains are discounted more heavily than losses (see for example Thaler, 1981), does not generalize to risky lotteries. Ahlbrecht and Weber (1993), in a study focused directly on the difference in discounting behavior between fixed payments and risky lotteries (in the domain of gains), observe heavier discounting for fixed payments. Anderhub et al. (2001) find that there is a correlation between risk attitudes and discount factors, with risk-averse agents discounting the future more heavily.

If the phenomenon of greater risk tolerance for lotteries realized in the future than in the present is general, which further study of decisions in other contexts would establish, it has potential implications for economic modeling. This is particularly true for areas that involve dynamic optimization in the presence of random variables. These include stochastic growth theory, asset pricing, and dynamic game theory under incomplete information. It would also suggest that empirical estimates of risk aversion parameters might be sensitive to the time horizon of the decisions that are used in the calculation of the estimates. The next section describes the design of the experiment, section three reports the results, and section four is a brief conclusion.

2. Experimental Design

2.1. General Framework

Our experimental protocol builds on the design of Holt and Laury (2002). The instructions for our experiment are given here in Appendix A. In the baseline treatment, each subject is required to make ten decisions between two lotteries in each of two separate rounds. The lotteries are called Option *A* and Option *B*. If a participant chooses Option *A*, he receives either $10 US or $8, depending on the realization of an exogenous random variable with a known probability distribution. If he chooses Option *B*, he earns either $19.25 or $0.5, depending on the realization of the same variable.[1] The difference between the high and the low payoff under Option *A* is relatively small, while the difference is larger under Option *B*. Thus, Option *B* can be viewed as the "risky option" while Option *A* can be considered the "safe option". In each round, each subject

[1] The payoffs for the two lotteries in our baseline treatment are multiples of 5 of the payoffs in the baseline treatment of Holt and Laury (2002).

makes ten decisions between Option *A* and Option *B* by completing the sheet entitled "Decision Sheet: Round 1", shown in Appendix A. To enter the decision, the subject fills in an *A* or a *B* in each row of the rightmost column of the table.

The ten decisions differ from each other only in the probability that the outcome equals the higher of the two payoffs of each option, as can be seen from the decision sheet. For the first decision, the probability of receiving the high payoff is 10% and the probability of obtaining the low payoff is 90% under each option. For the second decision, the probability of receiving the high payoff is 20% and that of earning the low payoff is 80% under each option. If the 10^{th} decision is selected, the subject receives a certain payoff of $10 if he has chosen Option *A*, or a certain payoff of $19.25 if he has chosen *B*.

For the first decision appearing in the sheet illustrated in appendix A, where there is a ten percent probability of receiving the high payoff under each option, the expected payoff of Option *A* is $5.83 more than that of Option *B*. Thus, only extreme risk-lovers would prefer Option *B*. Notice that while the probability of receiving the high payoff under each option is identical for a given decision, and the high payoff under Option *B* exceeds that of *A*, the low payoff under *A* is greater than that of *B*. Thus it is clear that an expected utility maximizer would never choose Option *A* at any higher probability of receiving the high payoff than a probability at which he selects Option *B*. In other words, a consistent expected utility maximizer would not choose a *B* on any row of the decision sheet that precedes a row containing an *A*. He would have at most one point at which his decision would shift from Option *A* to Option *B*. The row at which the shift from *A* to *B* occurs can be used as a measure of risk tolerance because it implies a range of risk preferences consistent with an individual's decision profile. A risk neutral agent would always choose the option with the greater expected payoff, that is, Option *A* for the first four choices, which correspond to a chance of receiving the high payoff from 10% to 40%, and Option *B* for the reminder of choices (from 50% to 100%). A sufficiently risk averse agent chooses option *A* more often than a risk neutral one.

After completing the form entitled "Decision Sheet: Round One", specifying his choice between the two lotteries for each of the ten pairs of lotteries, the participant rolls a ten-sided die twice to determine his payoff for the current round. The first roll determines which one of the ten decisions is selected to count toward his earnings. The second roll determines the payoff to the subject as a function of the choice he has previously made. For example: suppose the first roll of the die indicates that the third decision (in the row labeled 3 on the decision sheet) is selected to count toward the subject's earnings and that he has previously specified a choice of option *A* for the third decision. Then, if the second roll yields a number from 1 to 3 inclusive (corresponding to a .3 probability), the subject receives the high payoff under Option *A,* which is equal to $10. If the die shows 4-10 on the second roll, he receives the low payoff under Option *A,* which equals $8. Had he chosen Option *B* instead of *A*, he would have received $19.25 if the second roll of the die resulted in 1-3, and $.50 if the roll yielded 4-10.

2.2. The Sessions and Treatments

A session consisted of two or more rounds, and each round consisted of an opportunity to make each of the ten decisions described above. The six sessions comprising the *Baseline Treatment* were made up of two rounds. In the first round, subjects were informed that the earnings for the round would be paid in cash at the end of the current experimental session. After all of the subjects had recorded their decisions for the first round and turned them in to the experimenter, the instructions and the decision sheet for round two were distributed. Round two was identical to the first round, except that the realization of the random variables determining the outcome and the payment to the participants would not occur until a specified future date,[2] exactly three months after the current session. Subjects made their decisions for round two before the payoffs for the first round were determined. Each individual determined his own earnings by rolling a ten-sided die twice as described in the previous subsection. Earnings determination for round 1 occurred at the end of the session, while for round 2 it took place at a later date. Thus the realizations of the random variables that influenced the determination of different subjects' earnings were independent between subjects and between rounds. Subjects were always paid privately and were not informed of the decisions or the earnings of other participants.

Two other treatments were conducted to investigate the robustness of our results, which are detailed in section three. The first treatment, which we call the "Both Delayed" treatment, was motivated by the possibility that the greater risk tolerance for future than for current gambles observed in the baseline treatment constituted a special case. A decision on a bet realized in the present might differ from all bets realized at any time in the future, even though all future bets are viewed in a similar manner to each other.[3] An alternative possibility is that more generally, risk tolerance for gambles realized in the future increases as the time of realization extends farther into the future. For the purpose of discriminating between these two possibilities, we conducted

[2] There is strong evidence that the differences we observe between rounds 1 and 2 are not due to the sequencing of the two decision rounds. Harrison et al. (2003) find that with the system of risk measurement that we use here, agents' decisions tend to reflect more risk aversion when they are preceded by another decision. The fact that we observe less risk aversion in round 2 than in round 1, as described in section three, means that the difference in risk attitude between the present and the future is so strong that it overwhelms the effect of the decision sequence.

[3] There is previous work suggesting that this is a possibility. Coller et al. (2003) report results indicating that discount rates are higher when the tradeoff between payments in the present and in the future are measured, than when the tradeoff between payments in two different dates in the future are elicited. However, discount rates are fairly constant when there is a "Front End Delay", regardless of the length of the delay. This suggests that the high discount rates observed in many previous studies may be specific to the tradeoff between present and future, or that traditional experimental methodology leads to inaccurate measurement of this particular tradeoff. This could occur, for example, if the promises of the experimenter to make future payments are not credible. Thus, we view the "Both Delayed" treatment as a check on methodology as well as a robustness check of our main result. Consistency between the Baseline and the Both Delayed treatments would indicate robustness of our results to a case where both gambles are realized in the future, as well as provide evidence supporting the credibility of our future commitment to pay participants' earnings.

sessions where all earnings were revealed and paid on future dates. Under the Both Delayed treatment, outcomes were determined and earnings were paid for the first round on the day after subjects made their decisions. Outcomes were determined and earnings were paid for the second round two months plus one day after the choices were made. Thus the time difference between the two rounds is two months and the payment for both rounds is determined in the future. In the Both Delayed treatment, where no earnings were determined and no lottery proceeds were paid the day of the session itself, each subject received a participation fee of three dollars that was awarded at the session.

Another treatment was included to consider the possibility that heavy discounting of the future might account for the presence of greater risk tolerance in the future than in the present. As the value of the future gamble declines, risk neutrality might become a better approximation of a concave utility function. This would cause a risk-averse agent to behave in a more risk-tolerant manner when valuing a lottery to be paid in the future. To study the effect of discounting, we introduced the "Double-Pay" treatment, in which we doubled all payoffs in round two relative to round one. The Double-Pay treatment was identical to the baseline treatment except that payment for round two was made two months into the future rather than three months, and the payoff vectors were increased to ($20, $16) for Option *A* and ($38.50, $1) for Option *B* in round two. Doubling the payoff of the future round is presumably an increase of large enough magnitude to offset the effect of heavy discounting, since the annual discount rate that would equalize the stakes in the two rounds is 6,300%.[4]

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[4] Thaler (1981) estimated the annual discount rate for the average participant receiving positive payments at between 62 and 345 percent over a horizon of three months. Harrison et al. (2002) estimated the average discount rate for participants in their study of discounting at 28 percent. Hausman (1979) computed the implied discount rate for six income classes and the highest rate that he observed among the groups was 94 percent.

Results obtained by Holt and Laury (2002) indicate that the level of risk aversion of the average individual increases in the magnitude of payment, suggesting a risk aversion level that increases in income, at least for the monetary amounts paid in the laboratory. Thus, the observation of less risk aversion in the future

Eight laboratory sessions were conducted for this study between November 2002 and May 2003[5] with a total of 63 subjects participating in the study. Because the experiment consists of an individual decision making task, the 63 observations are independent. The subjects were undergraduate student volunteers recruited from Principles of Microeconomics, Principles of Macroeconomics, and Intermediate Microeconomics classes at Emory University. Table 1 indicates the number of participants and the timing and magnitude of payments applicable to each session.[6] Our baseline treatment was in effect for the first six sessions. In session 8, the Both Delayed treatment was in effect. There were two decision rounds, both paid in the future, the first on the day after the session and the second two-months plus one-day after the session, using the baseline payoffs. In session 7, there were four decision rounds and the Both Delayed and the Double Pay treatments were in effect. The first round in session 7 was resolved and paid in the current session with payoffs of ($10, $8) and ($19.25, $0.5) for the two options, as in round one of the baseline treatment. The second round was paid two months after the session, with payoffs ($20, $16) and ($38.50, $1) for the two options. These are equal to twice the baseline payoffs. The third round was paid on the day following the session, and the fourth round two months and one day after the session. The third and fourth rounds used the baseline payoffs of ($10, $8) and ($19.25, $0.5).[7] To claim any delayed payments for any session, subjects returned to the experimental laboratory on the appropriate day to roll the die to determine their earnings, which were paid in cash at that time.

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gambles than for the current gambles in our Double-Pay treatment would further strengthen our result that risk tolerance increases in the future. The pure effect of higher stakes would point in the opposite direction. Smith and Walker (1993) report auction market data that are also consistent with the hypothesis that there is more risk aversion at higher monetary stakes.

[5] The timing of the sessions and the use of student populations ensured the credibility of our promise to pay participants the earnings of future rounds. All future rounds were scheduled so that their dates fell within the same academic year. This meant the subjects were unlikely to believe that they would be unable to claim their earnings.

[6] Session 1 was a pilot session with one participant who was recruited from our subject pool. The purpose of the pilot session was to check our procedures for adequate comprehension. Since no problems were indicated, similar procedures were used in the subsequent sessions, and the data from the subject in the pilot were included in the study.

[7] Subjects were unaware beforehand that rounds 3 and 4 would be following round 2, so that there is no danger that the anticipation of further rounds might have distorted decisions in round 2.

[Table 1: About Here]

3. Results

The complete data for all sessions is given in appendix B. Table 2 contains a summary by session. The number of choices of Option *A* is interpreted as an indicator of risk attitude.[8] The values in the tables in Appendix B indicate the number of decisions for which each subject chooses *A* in each round. In table 2, the (+) symbol on the column heading indicates that the individual made strictly more choices of *A* in the first than in the second round, while (-) denotes strictly fewer, and (=) indicates the same number. Thus, in the baseline treatment, (+) indicates more risk tolerance when the payment of the lottery occurs in the future than in the present, (-) denotes the reverse, and (=) signifies that no difference between present and future was detected. The values in the cells of the table are the numbers of subjects falling into each category for the session.[9] The values in parentheses denote the number of subjects in the treatment that made at least one inconsistent decision, where an individual decision was classified as inconsistent if the subject submitted a decision of *A* on a lower row, that is, at a higher probability of receiving the relatively high payoff, than a row at which a *B* was submitted, thus violating expected utility maximization.[10]

[8] The use of the first "crossover point", that is the first decision of *B* observed on the decision sheet, as a measure of risk aversion yields highly similar results. This measure is very highly correlated with the measure used in the data analysis, the number of *A*'s chosen.

[9] The average number of *A*'s that subjects in Round 1 of the baseline treatment chose was 5.43. This figure is highly consistent with Holt and Laury (2002) who report an average of 5.17 for decisions with payments of one-fifth the magnitude of ours, and an average of 5.95 for decisions with payments equal to four times ours. Our average decision as well as our payment magnitude lies between their two treatments. This suggests that there is no feature of our procedures that induces a departure from the results of other researchers.

[10] In the table, the values in parentheses are a subset of the preceding values so that, for example, an entry of 4(1), indicates that one of the four subjects receiving the particular classification indicated in the cell exhibited an inconsistent set of choices within one of the rounds being compared. All but eight subjects chose the safe option *A* when the probability of the higher payoff was small, and then crossed over from Option *A* to Option *B* without ever going back to Option *A*. One individual made an inconsistent choice in more than one round. For all but one of the subjects who switched back and forth from *A* to *B*, there is exactly one row containing an inconsistent choice.

Seventeen of the 44 (15 of 39 if inconsistent subjects are removed from the data set) subjects in the baseline treatment chose Option *A* strictly more frequently in the first round, which was paid at the current session, than in the second round, which was paid three months in the future. That is, 38.6 percent of participants (38.5 percent if inconsistent decision makers are excluded) behaved as if more risk tolerant when the lottery outcomes were revealed and disbursed in the future. In contrast, 9.1 percent (7.7 excluding inconsistent agents) of individuals in the baseline treatment made more choices of *A* in round two than in round one, showing more risk aversion in the future than in the present. These observations are the basis of the first result of our study.

[Table 2: About Here]

Result 1: Individuals are significantly more likely to exhibit greater, rather than less, risk tolerance for payoffs realized and paid in the future compared to the present.

Support for result 1: We conduct a two-tailed sign-test, using an individual's choices in a round of the baseline treatment as the unit of observation. The individual's decisions in the two rounds are considered as paired observations, so that the comparison of the data from the two rounds is conducted within subjects. Including only data from those agents who made consistent decisions, we reject the hypothesis that the agents are equally likely to be more and less risk averse in round two than in round one at the 1% level (p = .0075). If subjects who made inconsistent decisions are included, the hypothesis is also rejected at p = .0072. The test supports the alternative hypothesis that the probability of a subject being more risk tolerant for the delayed payment is different from the probability of his being more risk averse. □

The data can be used to derive a conservative lower bound for the percentage of subjects in our population that exhibit greater risk tolerance for the future lottery. We can calculate a 95% confidence interval for the percentage of the population that exhibits the bias and use the lower limit of the interval as the lower bound. Because our protocol only detects changes in risk attitude that are large enough to change an individual's decision profile, the lower bound is very conservative, and the true percentage of the population exhibiting the bias is very likely to be considerably higher. Furthermore, our study considers only a horizon up to three months in the future and it may well be the case that gambles resolved in the more distant future yield greater risk tolerance.

Result 2: 38.6 percent of our subjects exhibit more risk tolerance for the future gamble than for the present gamble. A conservative lower bound for the percentage of agents that are more risk tolerant for the future than for the current gamble is 24.3 percent of the population.

Support for Result 2: The lower and upper bounds L and U of a confidence interval of the percentage of the population who exhibits greater risk tolerance for the future lottery can be calculated. These bounds are given by $L = \frac{T}{n} - Z_{1-\alpha/2}\sqrt{T(n-T)/n^3}$ and $U = \frac{T}{n} + Z_{1-\alpha/2}\sqrt{T(n-T)/n^3}$ respectively. T equals the number of observations where greater risk tolerance is observed, and n is the total number of observations (both T and n include observations on inconsistent subjects). For the data from the baseline treatment, the 95% confidence interval is [0.2425, 0.5302]. □

In a similar manner, a 95 percent confidence interval can be calculated for the percentage of the population we have sampled that behaves as if more risk averse in the future than in the present. The lower and upper bounds of the interval are .006 and .176, respectively. The lower bound barely exceeds zero, and there is no intersection between the 95% confidence intervals for the percentage of agents who are more risk tolerant for the future gamble, and the percentage that are more risk averse for the future gamble.[11] Thus it is clear that the difference between the two rounds in the direction of greater risk tolerance for the future lottery is systematic rather than random.

In addition to the results of our study, we offer two conjectures. The first is that the results are not specific to present versus future gambles. Rather, in paired future gambles that occur on different dates, more risk tolerance exists for the gamble to be realized and paid farther into the future. One possible interpretation for the results from the baseline treatment is that an immediate gamble constitutes a special case. An immediate gamble may be evaluated differently from all future gambles, while future gambles are all viewed identically. The existence of systematic differences in choice behavior when individuals are faced with present versus future gambles is an important result, because obviously many economic decisions yield payoffs in the present. However, such a pattern does not necessarily imply that there is a general tendency toward greater risk tolerance for gambles farther into the future. Sessions 7 and 8 offer an opportunity to study this issue. Comparison of rounds three and four in session 7 enable a contrast of decisions made over gambles of identical magnitude played one day in the future versus two months plus one day into the future. The two rounds in session 8 yield a similar comparison. Our interpretation of the data is stated as conjecture one.

[11] These confidence intervals are calculated using all of the data from the baseline treatment, including those decisions that were inconsistent. If the inconsistent individuals' decisions are excluded, the 95 % confidence intervals are [.2319, .5373] and [-.0067, .1606] for the percentages that are more and that are less risk tolerant in the future than the present, respectively.

Conjecture 1: Risk tolerance is greater for lotteries resolved and paid in the distant than in the near future.

The data in table two, in the rows labeled 7 (Round 3 vs. Round 4) and 8, indicate that 5 out of 19 (4 of 18 if data from an inconsistent subject is removed) individuals' choice patterns show more risk tolerance for the lottery that is revealed farther in the future. None show more risk aversion for the lottery revealed farther in the future. A sign test of the hypothesis that individuals are equally likely to be less and more risk averse for the gamble paid farther into the future yields a *p*-value of .063. The statement in Conjecture 1 is advanced as a conjecture rather than a definitive result because of the fact that all of our comparisons involve only one pair of future dates, so that we have not adequately sampled the space of possible future gambles to be confident in stating a general result on this point. Further research would be required to explore the level of generality of the conjecture.

The second conjecture concerns a possible alternative explanation for our results. The propensity toward greater risk tolerance with regard to future payments in our baseline treatment may exist because agents discount future payments so heavily that the stakes for the future lottery are much smaller than for the one realized in the present. The smaller stakes that heavy discounting induces could mean that risk neutrality is a better approximation for participants' concave utility functions for the heavily discounted future payoffs, thus accounting for the pattern observed in the baseline treatment. To evaluate this possibility, we created the "Double Pay" treatment, in which there existed a difference in payment between the current lottery and the future lottery. All payoffs for round two, paid two months into the future, were doubled. The Double Pay treatment was in effect in session seven. The Double Pay data leads to Conjecture 2.

Conjecture 2: Discounting cannot account for the tendency toward greater risk tolerance when payments are delayed.

The data are shown in the row labeled "7 (rounds 1 and 2)" in table 2. Three of the ten participants in the session made decisions that indicated more risk tolerance for the future payment, with only one (inconsistent) agent choosing in the other direction. This pattern reinforces Result 1 and provides evidence that heavy discounting is not the cause of the anomalous behavior we have detected. The statement is left as a conjecture, because we did not elicit the discount rates for participants in the experiment, so we do not know for certain which bet was viewed as the most valuable (although as mentioned previously, an annual discount rate of more than 6,300% would be required for the delayed lottery to be considered more valuable).

4. Conclusion

More than 38 percent of the subjects in our study display strictly more risk tolerance for outcomes that are realized in the future than in the present. Additional robustness checks suggest that the pattern is not specific to present versus future decisions, but also manifests itself over different horizons in the future, with agents more risk tolerant over outcomes in the more distant than in the more proximate future. Furthermore, the effect does not appear to be due to discounting, as agents also demonstrate more risk aversion for gambles realized in the present than those for twice the stakes two months into the future.

The 38.6 percent fraction of the subject population that exhibits the bias we have identified is a conservative estimate of the overall fraction of the population that would have some degree of greater risk tolerance over some future time horizon. The reason is that our protocol fails to detect any change in the level of risk aversion that is not sufficiently large to change the decision profile of an individual. We believe that a protocol with lotteries at finer probability increments would likely detect a considerably higher percentage of agents who exhibit more risk tolerance for future payoffs. Furthermore, extending the horizon of the future gamble would appear likely to increase the proportion of agents who display greater risk tolerance for the future decision. In the limit, as the time horizon becomes very long, it may be the case that the typical agent is risk neutral or that many agents become risk seeking in the domain of positive payoffs.

References

Ahlbrecht M., and M. Weber. 1997. An Empirical Study of Decision Making Under Risk. *Management Science* 43: 813-826.

Anderhub, V., W. Güth, U. Gneezy, and D. Sonsino. 2001. On the Interaction of Risk and Time Preferences: An Experimental Study. German Economic Review, 2 (3), 239-253.

Camerer, C. 1995. Individual Decision Making. *The Handbook of Experimental Economics*, J. Kagel and A. Roth eds., Princeton University Press: Princeton, NJ, USA: 587-703.

Coller M., G. Harrison, and E. Rutstrom. 2003. Dynamic Consistency in the Laboratory. Working Paper, University of South Carolina.

Frederick S., G. Lowenstein, and T. O'Donoghue. 2001. Time Discounting and Time Preference: A Critical Review. *Journal of Economic Literature* 40(2): 351-401.

Harrison G., M. Lau M, and M Williams. 2002. Estimating Individual Discount Rates in Denmark: A Field Experiment. *American Economic Review* 92(5): 1606-1617.

Harrison G., E. Johnson, M. McInnes, and E. Rutstrom. 2003. Risk Aversion and Incentive Effects.Working Paper, University of South Carolina.

Holt, C. and S. Laury (2002), "Risk aversion and Incentive Effects," *American Economic Review* 92(5): 1644-1655.

Shelley M. 1993. Outcome Signs, Questions Frames and Discount Rates. *Management Science* 37: 770-786.

Shelley M. 1994. Gain/Loss Asymmetry in Risky Intertemporal Choice. *Organizational Behavior and Human Decision Processes* 59: 124-159.

Stevenson M. 1992. The Impact of Temporal Context and Risk on the Judged Value of Future Outcomes. *Organizational Behavior and Human Decision Processes* 52: 455-491.

Table 1: Number of Subjects and Timing and Magnitude of Lotteries, All Sessions*

Session	**Number of Subjects**	**Option**	**Timing and Magnitude of Gamble (in $)**				
			At the session	***One day after session***	***Two months after session***	***Two months and one day after session***	***Three months after session***
1-6	44	Option A	(10,8)				(10,8)
		Option B	(19.25,0.5)				(19.25,0.5)
7	10	Option A	(10,8)	(10,8)	(20,16)	(10,8)	
		Option B	(19.25,0.5)	(19.25,0.5)	(38.5,1)	(19.25,0.5)	
8	9	Option A		(10,8)		(10,8)	
		Option B		(19.25,0.5)		(19.25,0.5)	

* The number in parentheses represents the higher and lower payoffs possible under the option indicted in the "Option" column.

Table 2: Number of Subjects More, Less, and Equally Risk Tolerant for Lottery Realized Farther in the Future: All Sessions

Session	Number of Subjects	Number of "+"	Number of "-"	Number of "="
1	1	1	0	0
2	10	5	0	5
3	7	1	2	4
4	7	2	0	5
5	7	4	1	2
6	12	4	1	7
Pooled Data: Sessions 1-6	44	17 (2)	4 (1)	23 (2)
7(Round 1 vs. Round 2)	10	3	1 (1)	6 (1)
7(Round 1 vs. Round 3)	10	2 (1)	2 (1)	6
7(Round 1 vs. Round 4)	10	2 (1)	2 (1)	6
7 (Round 3 vs Round 4)	10	1	0	9
7(Round 1 vs. Round 3 and Round 4)	10	2 (1)	2 (1)	6
8	9	4 (1)	0	5

"+": fewer choices of Option A in round realized at later date.
"0": equal number of choices of Option A in both rounds.
"-": more choices of Option A in round realized at later date.
"( )": indicates the number of "inconsistent" subjects.

Appendix A

This appendix contains the instructions used in the baseline treatment of our experiment. The instructions for the other treatments contained only minimal changes from those shown here. At the beginning of each session, sections 1 and 2 were distributed and read aloud to subjects. After subjects submitted their decision sheets for round 1, section 3, containing the instructions for round 2, was distributed and read aloud. The decision sheet accompanying round 2 (not shown here because of space considerations) was identical to that of round 1 except for an indication of the date on which the earnings would be paid. Also, in the "Double Pay' treatment only, the round two decision sheet contained payoff amounts that were twice those of round 1. In session seven, where there were more than two rounds, the only difference between rounds three and four and round one was an indication of the date on which the earnings for the round would be awarded to participants.

Instructions

1.General Instructions

This experiment deals with the economics of decision making under uncertainty. Various agencies have provided funds for the experiment. The instructions are simple and if you follow them carefully, you might earn a significant amount of money, which you will receive in cash privately. But we don't guarantee that everyone will receive a large amount of money.

You are to act as a potential buyer of lotteries in this experiment. There are two rounds of decisions in this experiment. For each round, you will make ten choices and record these in the final column in the decision sheet.

2. Instructions for Round 1

Your decision sheet for Round 1 shows ten decisions listed on the left. Each decision is a paired choice between "Option A" and "Option B". You will make ten decisions and record these in the final column, but only one of them will be used in the end to determine your earnings. Before you start making your ten decisions, please let me explain how they will affect your earnings for this part of the experiment.

Here is a ten-sided die that will be used to determine payoffs; the faces are numbered from 1-10 (the "0" face of the die will serve as 10.) After you have made all of your choices, we will ask each of you to throw this die twice, once to select one of the ten decisions to be used, and a second time to determine what your payoff is for the option you chose, A or B, for the particular decision selected. Even though you will make ten decisions, only one of these will affect your earnings, but you will not know in advance which one. Note that each decision has an equal chance of being used in the end.

Suppose decision 1 is selected and your choice is Option A, then you will get \$10 if the number turns out to be 1 when you throw the die for the second time and \$8 otherwise. On the other hand, if your choice is Option B, then you will get \$19.25 if the number is 1 and \$0.5 otherwise.

Now suppose decision 2 is selected and your choice is Option A. In this case, you will get $10 if the throw of the ten-sided die is 1 or 2, and $8 otherwise. If you choose Option B, you will get $19.25 if the number on the die is 1 or 2 and $0.5 otherwise. The outcomes of the other decisions are similar, except that as you move down the table, the chance of getting a higher payoff for each option increases. In fact, if Decision 10 is selected, you will get a sure payoff of either $10 or $19.25, depending on whether Option A or B is chosen.

Table [A1] shows how the second throw of the die decides whether you receive the high payoff or the low payoff for each decision. For example, if the first throw of die is 6, your choice of the 6th decision, either Option A or B, will decide your payoff. Then you throw the die for the second time. If the number appears from 1-6, you will get the high payoff. If the number is from 7-10, you will get the low payoff.

Table [A1]

Decision	High Pay	Low Pay
1	1	2~10
2	1~2	3~10
3	1~3	4~10
4	1~4	5~10
5	1~5	6~10
6	1~6	7~10
7	1~7	8~10
8	1~8	9~10
9	1~9	10
10	1~10	/

To summarize, you will make ten choices: for each decision row you will have to choose between Option A and Option B. You may choose A for some decision rows and B for other rows, and you may change your decisions and make them in any order**. At the end of the whole experiment**, that is, after you make the decisions of both rounds, we will ask you to wait outside until we call the call number you hold. When a participant is called, he will come into this room and throw the ten-sided die twice, once to determine which of the ten decisions will be used, and the second to determine his payoff based on his choice of either Option A or B. Earnings for this choice will be paid in cash when we finish.

So now please look at the empty boxes on the right side of the record sheet. You will have to write a decision, A or B, in each of these boxes.

Decision Sheet: Round 1

You may begin making your choices. Please write down your name, call number social security number and e-mail address below. While we are doing this, please do not talk with anyone. Raise your hand if you have a question.

Participant Name: ______________________
Call Number: ___________________________
Social Security: ________________________
E-mail: _________________________________

	Option A	Option B	Decision (A or B)
1	1/10 of $10, 9/10 of $8	1/10 of $19.25, 9/10 of $0.5	
2	2/10 of $10, 8/10 of $8	2/10 of $19.25,8/10 of $0.5	
3	3/10 of $10, 7/10 of $8	3/10 of $19.25, 7/10 of $0.5	
4	4/10 of $10, 6/10 of $8	4/10 of $19.25, 6/10 of $0.5	
5	5/10 of $10, 5/10 of $8	5/10 of $19.25, 5/10 of $0.5	
6	6/10 of $10, 4/10 of $8	6/10 of $19.25, 4/10 of $0.5	
7	7/10 of $10, 3/10 of $8	7/10 of $19.25,3/10 of $0.5	
8	8/10 of $10, 2/10 of $8	8/10 of $19.25, 2/10 of $0.5	
9	9/10 of $10,1/10 of $8	9/10 of $19.25, 1/10 of $0.5	
10	10/10 of $10, 0/10 of $8	10/10 of $19.25, 0/10 of $0.5	

3. Instructions for Round 2

Now we will provide you with the chance to make another choice, with same potential payoffs, as you can see from the sheet we are passing around. The difference between this part and all other decisions you have made is that all payoffs from this round will **not** be decided today. You will come to […information removed to preserve author anonymity…], Room 301 on …… any time from ……to …... At that time, you will also need to throw the ten-sided die twice to get your payoff and receive your earnings in cash on that day. If you have any questions or cannot come on the above days, please contact […name and e-mail address removed to preserve author anonymity…].

If you don't have any questions, you may begin making your choices for this round. Please do not talk with anyone while we are doing this: raise your hand if you have a question.

Appendix B

This appendix contains the complete data for our experiment. The data reported in the tables below are the number of A's an individual chooses out of his ten possible choices in each round. Each row corresponds to one individual. The time of resolution and payment of the lottery is given in the parentheses.

Baseline Treatment

Session	Subject Number	Round 1 Decision (Present)	Round 2 Decision (Three Months in the future)	"+"/"="/"-"
1	1	4	2	+
2	1	8	7	+
	2	4	4	=
	3	4	1	+
	4	4	4	=
	5	4	4	=
	6	6	5	+
	7	6	6	=
	8	6	5	+
	9	6	5	+
	10	6	6	=
3	1	5	5	=
	2	6	6	=
	3	4	4	=
	4	5	7	-
	5	2	4	-
	6	5	5	=
	7	5	4	+
4	1	6	6	=
	2	6	6	=
	3	5	5	=
	4	6	6	=
	5	7	5	+
	6	4	4	=
	7	7	6	+
5	1	3	9	-
	2	4	2	+
	3	7	6	+
	4	7	6	+
	5	5	4	+
	6	6	6	=
	7	6	6	=
6	1	6	6	=
	2	8	8	=
	3	6	6	=
	4	5	7	-
	5	8	7	+
	6	7	6	+
	7	6	6	=
	8	4	4	=
	9	4	4	=
	10	5	5	=
	11	6	5	+
	12	5	4	+

Session 7 (Double Pay and Delayed Payment)

Session 7	Subject Number	Round 1 Decision (Present)	Round 2 Decision (Two Months in the Future, Stakes Doubled)	Round 3 Decision (Next Day)	Round 4 Decision (Two Months and One Day in the future)
	1	7	6	7	7
	2	6	5	6	6
	3	6	6	5	5
	4	8	7	7	7
	5	6	6	6	6
	6	6	6	6	6
	7	6	6	6	6
	8	6	6	6	6
	9	3	3	5	4
	10	4	6	6	6

Session 8 (Delayed Payment)

Session	Subject Number	Round 1 Decision (Next Day)	Round 2 Decision (Two Months and One Day in the future)	"+"/"="/"-"
8	1	4	4	=
	2	6	6	=
	3	7	5	+
	4	6	6	=
	5	7	5	+
	6	5	5	=
	7	6	5	+
	8	7	5	+
	9	6	6	=