PROBABILITY WEIGHTING BY CHILDREN AND ADULTS

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Abstract:

Experimental and real world evidence show that many aspects of risk-taking behavior can be explained by assuming that people weight outcomes by a subjective rather than objective probability. In this paper we explore how these probability weights change with age by looking at risk-taking behavior in participants from age 5 to 64. Our participants make choices between certain payoffs and simple gambles for which the probability of winning and losing varies. We find strong evidence for probability weighting in children. Children underweight low-probability events and overweight high-probability ones. Probability weighting tends to diminish with age, and on average adults use the objective probability when evaluating gambles over gains.

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1 Introduction.

In this paper we examine decisions under risk in a sample of people ranging in age from 5 to 64. Our objective is to determine whether risk preferences change with age. Since previous experimental investigations of risk generally examine the risk preferences of a particular age group, most frequently college students, they provide little help in determining whether behavior changes with age.

While there are many reasons why economists are interested in the risk attitudes of mature adults, one might question why we should be concerned about the development of risk preferences with age, or the risk attitudes of children and adolescents. There are two reasons. First, risk-taking of children is intrinsically important. Many decisions made by children and teenagers have uncertain outcomes and some of those decisions have significant long-term consequences. Second, by studying the development of risk-taking behavior we hope to learn something about why adults behave as they do.

We are particularly interested in determining the extent to which age affects an individual's tendency to behave in a manner consistent with expected utility theory (EUT).[1] Economic models typically assume that agents are expected utility maximizers. However, a large number of studies have shown that EUT fails in predicting the behavior of young adults.[2] Or as stated by Starmer (2000), "…put bluntly, the standard theory did not fit the facts." For example, Allais (1953) found that people tend to increase their relative preference for the more risky of two projects when the probability of winning is reduced by an equal proportion.[3] This so-called common-ratio effect presented one of the first real challenges to EUT as a theory of behavior.[4]

One approach to these sorts of violations is to argue that they are mistakes, with the presumption that experience with risk may correct the mistake and lead to behavior more consistent

[1] See Schoemaker (1982) for a review of the expected utility model. and Starmer (2000) for a discussion of the alternatives.
[2] See for example Schoemaker (1982), Machina (1987).
[3] This result has been confirmed by studies by Morrison (1967), Raiffa (1968) and Slovic and Tversky (1974).

with EUT.[5] Relative to adults, children presumably have had far less experience taking risks and bearing their consequences. Hence, if a lack of experience is what causes EUT violations, then these violations should decrease with age. Alternatively it may be that the preferences that create the violations are innate, in which case age should have no effect on the tendency to violate EUT.[6] Yet another possibility is that the violations are actually learned behavior, perhaps representing some sort of rule of thumb that is on average accurate. This would suggest that people might start out obeying EUT, but gradually adopt behaviors that violate it.

Many descriptive models have been proposed to explain EUT violations, however recent work has concentrated on variations of what Edwards (1955) originally called subjective expected value, but which is also known as subjective expected utility or SEU. SEU type models propose that, when forming the value of a prospect that involves risk, people weight the outcomes by decision weights that are functions of probabilities, rather than by the objective probabilities.

One well-known modification of SEU theory is Tversky and Kahneman's (1992) cumulative prospect theory.[7] Tversky and Kahneman identify a four-fold pattern of behavior, as follows:

1. Risk-seeking over small-probability gains,
2. Risk-aversion over high-probability gains,
3. Risk-seeking over high-probability losses, and
4. Risk-aversion over small-probability losses.

They fit a probability weighting function to their data, which consists of reported certainty equivalents for a variety of hypothetical gambles over losses and gains by 25 Berkeley and Stanford graduate students, and show that it overweights low-probability events and under-weights high-probability ones. That is, as a function of the objective probability, the estimated probability weighting function is regressive. Tversky

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[4] Machina (1987) and Weber and Camerer (1987).
[5] Camerer and Kunreuther (1989). Similarly Starmer (2000) states that "the more relevant question is whether agents who lack, say, expected utility preferences might evolve behavior more consistent with them through market experience (p.372)."
[6] Certainly there is evidence that violations of EU is not limited to humans. Battalio et al (1985) and Kagel et al (1990) find standard Allais-type violations of expected utility theory in rats as well as humans.
[7] Other examples of SEU are Edwards (1955), Ramsey (1931), Savage (1954), and Quiggin (1982).

and Fox (1995) and Wu and Gonzalez (1998) have identified similar regressive patterns. Camerer and Ho (1994) examine data from 11 experiments and find that a regressive probability weighting function best describes the data in all but two experiments.

Assuming a concave utility function, a regressive probability weighting function will generate the four-fold pattern observed by Tversky and Kahneman. Finally, Prelec (1998) shows that based on axioms involving the common-ratio effect one can derive a regressive weighting function defined by only one parameter, and this weighting function is consistent with other violations of EUT.[8]

It is clear from this previous work that the probability weighting function is an important organizing principle for describing behavior under risk. The primary objective of this paper is to examine a sample of people with widely differing risk experience to determine how the shape of the probability weighting function changes with age. This allows us to determine the extent to which departures from EUT may be caused by a lack of experience making decisions that involve risks. If EUT violations are truly mistakes, then we should find that children are more likely to use probability weights than adults. If subjective weighting actually increases with age and experience, then it would be very difficult to argue that EUT is the appropriate model of risk preferences.

Of course one may worry that children simply are incapable of conceptualizing a probabilistic event. Developmental psychologists have done considerable work examining exactly this question and have found that children are capable of understanding probabilities.[9] For example, Schlottmann and Anderson (1994) employ the same sort of spinner mechanisms that we use to represent probabilities for simple gambles. They show that children as young as five consider both the probability and the size of a prize in assessing the desirability of various gambles. In contrast to this literature our approach is more economic than psychological. We investigate *choices* under risk, not the age at which an understanding of probability develops.

Our paper differs from existing work on risk-taking behavior in three significant ways. First, participants in our experiment face the simplest possible decision involving risk. They simply need to choose between taking a certain outcome or a simple prospect, where one outcome involves no

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[8] Over-weighting of low-probability events and under-weighting of high ones would produce the common ratio effect.

[9] Reyna and Brainerd (1995) provide a review of this literature.

change.[10] This is in contrast to much of the previous literature, which either asks people to reveal their willingness to pay for a gamble, or asks them to choose between two gambles, each of which might involve different outcomes with different probabilities. Second, rather than the hypothetical questions that are commonly asked of children (and often of adults), we use real and salient payoffs, and we make it very clear that actual choices, and chance, will determine these payoffs. Average payoffs were about $5 with a range of about $1 to $9, and about $50 for adults, with variation from about $10 to $90. Last, since we use very similar protocols on both children and adults, we are able to describe how risk-taking behavior varies across a wide range of ages.

2 Testing the characteristics of the probability weighting function.

Most existing work on probability weighting measures willingness to pay (WTP) for gambles of various types, and then derives probability weights by comparing the expected value of the gamble with the reported WTP. In many cases the payoffs in these experiments are hypothetical, so WTP can be elicited without strategic concerns. If the payoffs are real, a truth-telling mechanism, generally the Becker-DeGroot-Marschak mechanism (BDM), is used to ensure that participants have incentives to report WTP accurately.

We felt that both of these approaches were inappropriate for this study. First, our prior experience running economic experiments on children has convinced us that real and readily apparent payoffs are essential for ensuring that children pay attention to the instructions and for maintaining their interest during the experiment. Their eyes wander at first, but once they realize there is something real at stake they are quite attentive. Second, the BDM procedure is quite complicated, even for adults. We tried to use it with 10 year olds, and only about half appeared to understand that telling the truth was the optimal strategy. Third, there is evidence that risk preferences differ across various truth-telling mechanisms, for example in Isaac and James, (2000).

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[10] Our experiments involve gambles over both gains and losses with a range of different probabilities.

Therefore we use real incentives and a simple choice procedure in our protocol.[11] In each experiment the participant evaluates a series of fourteen choices between a simple gamble and a certain outcome. Ten of these choices are between an all-or-nothing gamble, g, where there is a probability p_g of getting a stake s_g, and probability $1- p_g$ of getting nothing. The alternative to the gamble is to choose the gamble's expected value, $p_g s_g$. The remaining four choices serve as a test of the rationality of the participants. We will discuss these choices in greater detail in Section 3.

The children were paid tokens that they could use immediately after the experiment to buy toys from a selection of popular items that we showed to them in advance. Teenagers, college students and older adults were paid in cash. While this procedure does not provide WTP estimates, it has the advantage of transparency. The incentive to make the most preferred choice is quite obvious. In this section we explain how we use this choice data to make inferences about the shape of the probability weighting function.

An attractive feature of this design is that it provides a simple test of the models of subjective probability weights. In particular we are able to determine whether our participants use subjective weights, and how these weights might change with the probability of getting the stake s_g. While many functional forms have been proposed for the probability weighting function $w(p)$, all of them have the common characteristic that there is a reflection point p^* such that $w(p)> p$ for $0<p<p^*$ and $w(p)<p$ for $p^*<p<1$.

We will test this hypothesis both directly and indirectly. If people use subjective weights in the manner just described, then it is clear that an estimated probability weighting function $w(p)$ is regressive and must cut the diagonal $w(p)=p$ from above. Needless to say the empirical results obtained will be sensitive to the functional form assumptions one makes on the participant's weighting and value function.

Fortunately our experimental design also allows us to use an indirect approach, which is not sensitive to the particular functional form. If participants have a concave value function and have weighting functions with a reflection point as described above, then we can show that the proportion of participants choosing the gamble increases as the probability of winning decreases, and as the probability of losing increases.

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[11] The experiments are described in greater detail in Section 3, and the instructions are provided in the appendix.

Let $U_i(t)$ denote person i's value function and assume for simplicity that the value of getting a zero payoff equals zero, i.e. $U_i(0)=0 \ \forall i$. Person i chooses the gamble over the expected value if $w_i(p_g)U_i(s_g) > U_i(p_g s_g)$. Consider first the case where the gain is positive, i.e. $s_g > 0$. If the probability weighting function has the characteristic described above then for a $p_g > p_i*$ the subjective probability is less than the objective probability, which implies that $w_i(p_g)U_i(s_g) < p_g U_i(s_g)$. By concavity we know that $p_g U_i(s_g) \leq U_i(p_g s_g)$, hence for $p_g > p_i*$ the expected value is preferred to the gamble, i.e. $w_i(p_g)U_i(s_g) < p_g U_i(s_g) \leq U_i(p_g s_g)$.

The subjective weighting models therefore have a strong prediction in our experiment. For a given distribution of p_i*, an increase in the probability of winning increases the proportion of people choosing the expected value over the gamble.

The opposite argument can be made over losses. In this case the concavity of the value function implies that $p_g U_i(s_g) \geq U_i(p_g s_g)$, hence for $p_g < p_i*$, the gamble is the preferred outcome, $w_i(p_g)U_i(s_g) > p_g U_i(s_g) \geq U_i(p_g s_g)$. The proportion of participants choosing the expected value decreases as the probability of losing increases.

3 Description of the experiments:

We report results from three experimental studies. The first was run on 78 children; the second on 51 children; six 14 to 20 year olds, and 47 adults, and the third on 52 college undergraduates, for a total of 234 participants. The protocols for each of these experiments were nearly identical.

In this section we describe the first protocol and then the modifications used in the second and third. The sets of choices available in each experiment are described in Appendix 3. Each choice set is designed to determine the characteristics of the participant's weighting function.

3.1 First protocol.

Children were recruited from after-school programs conducted by the City of Albuquerque, New Mexico. The experiments were conducted at the program sites. Each participating child was first given 50 tokens. The tokens were counted out and placed in five stacks of ten on the table at which the child was seated. The participants were told that the tokens were now theirs and that there was a chance that they might lose them, or win some more, during the experiment. We then showed the children our “store” which consists of a variety of art supplies, toys, and games and we explained that, when the experiment was over, they would be able to use the tokens to buy things from the store.[12]

Each child was seated separately with an experimenter. A partition separated the child’s table area from the experimenter so that the child could record decisions without being observed by the experimenter or any other children. The experimenter read the instructions to the child (see Appendix 1 for instruction script). The children were told that they would make 14 different choices, but that only one of the choices would really count, and that we would decide which choice counts by picking a number out of an envelope after they have made all of their choices. We explained that since any choice might count, the best thing for them to do is to make *each* choice as if it is the one that counts. The heightened anticipation with which the children faced the drawing of the “card that counts” indicated that they understood the ramifications of this aspect of the protocol. Each of the fourteen choices was between a certain change in their tokens and a risky change.

We presented the choices graphically and numerically. Each choice was presented on a separate plastic card. The probabilities for the gamble were depicted in a circle with the two outcomes shown in red and green, and with the relative sizes of the colored areas corresponding to the probabilities of each outcome. Probabilities were also given numerically as “chance of two out of ten” and so on. At the center of the circle was a hole that matched a rivet on the back of a clear plastic spinner. The spinners were snapped onto each card, creating a device similar to those found in many children’s games. The numbers of tokens at stake where given as numbers and using pictures of tokens in stacks of 10.[13] To ensure that they understood the choice representation, we worked through several examples with the children and then gave them a brief test. For the examples, we showed them two choice cards, one for losses and one for gains, and talked through the task of choosing the sure thing or the spinner. We explained that if they picked the sure thing, they would gain or lose that amount with certainty, while if they picked the spinner there was a chance of either of the outcomes shown occurring,

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[12] We did not reveal the exact prices of the goods, but we did tell them that each token was worth about ten cents, and that the things in the store cost about as much as in a regular store. It was very clear from the children's behavior after seeing the store that they knew that their decisions would have real consequences for them.

[13] An example of a choice card is shown in Appendix 2.

depending on where the spinner arrow stopped. For all possible outcomes we also showed them how many tokens they have left. We also described and pointed out the information regarding the relative likelihood of each outcome. For the quiz, we showed them 4 different choice cards along with response slips marked with choices for an imaginary participant. We spun the spinner wheel and asked them what change if any would be made to this person's tokens and how many they would have left. The choice pairs for all the protocols are shown in Appendix 3 (with those used in this protocol indicated in the second column).

For most decisions the certain choice is simply the expected value of the risky choice, except that in each sample there are two sets of three choices designed to check rationality. Within each of these sets the gambles are the same, while the gain or loss associated with the certain option is less than, equal to, or greater than the expected value of the gamble. For the gains, if a participant picks the certain gain from any one of these pairs, then it would be irrational of him to choose the gamble when the certain gain is higher. Similarly for losses, a participant who picks a given certain loss is acting irrationally if he also takes the gamble from a pair that includes a smaller certain loss.

There are arguments for inclusion of data from participants who failed this test and arguments for exclusion. We could argue that the participants with violations have shown a tendency for irrational or random choices, and since we are interested in purposeful choice, we should exclude them from the analysis. Alternatively, we could say that while the violations indicate that those participants are choosing irrationally at least some of the time, this does not mean that all their choices are random. For that matter, we cannot be sure that the participants who pass these tests would pass a different rationality test, or the same test if offered a second time. Therefore, it might be best to accept that irrational choices are a possibility with all participants, and that it is best to simply treat the observed violations as random errors. However, we did find that participants who made errors in the rationality test tended to choose the certain outcome more often than did participants who had no rationality violations. Given the systematic difference in the level of risk taking between the participants passing and not passing the test, we present our results for both the entire sample and for the participants with no violations, whom we label "rational."[14]

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[14] Systematic differences between "rational" participants and those who we label as "irrational" are discussed in Section 5 below.

To allow us to check for order effects, we presented these choices in 4 different orders, and we also kept track of the experimenter who was paired with each participant to allow us to look for experimenter effects. Tests for order and experimenter effects are reported in section 5.

3.2 Second protocol.

We recruited participants for the second set of experiments from the families of children attending summer programs operated by the City of Albuquerque. Notes were sent home asking parents to call us if the entire family would be willing to participate in a study of economic decision-making. We conducted the experiments at the University of New Mexico. The parents and any available siblings simultaneously participated in the experiments, but in different rooms.

We modified the probabilities and payoffs from those in the first protocol, and these probabilities and payoffs are shown in Appendix 3. Before conducting the choice experiments, we conducted one continuous choice experiment. Participants were not told the outcome of this experiment until after they made decisions for the choice pairs, and only the dichotomous choice data are analyzed in this paper.

We used the same protocol for the teenaged siblings and parents in these experiments, with the probabilities and payoffs represented with the same kinds of spinners. Payoffs, however, were in cash and were presented in dollars rather than tokens. Teenagers started with $10 and all gambles included a possible gain or loss of $8, while parents started with $50 and all gambles included a possible gain or loss of $40.

3.3 Third protocol

Participants in the third protocol were undergraduate students enrolled in introductory economics courses at the University of New Mexico. Virtually all of these participants were traditional students aged 18 to 20. This protocol was like the first in that there was no continuous gamble, but we used the same choice pairs as in the second protocol. Undergraduates were given an endowment of $30, and each choice included a possible gain or loss of $25.

3.4 Age categories

For descriptive purposes we find it useful to group the participants into four age categories. Table 1 gives the age ranges and some descriptive statistics for these categories.

Table 1: Selected descriptive statistics by age category.

	Age category				
	Age 5-8	Age 9-13	Age 14-20	Age 21-64	All Ages
Average age	7.4	10.1	19.6	37.8	17.3
Proportion male	0.516	0.338	0.534	0.426	0.453
Proportion tested with second protocol gambles	0.391	0.400	1.00	1.00	0.667
Number in group	64	65	58	47	234

4 Results.

In this section we determine the characteristics of the probability weighting functions that best explain our data, concentrating on how these functions change with age. We start with a descriptive analysis. This analysis allows us to determine whether our participants use the objective probability or a subjective probability. If the latter appears to be the case, then we can determine whether the proportion of participants choosing the gamble increases as the probability of winning decreases, and as the probability of losing increases. That is, we can determine whether the participant's probability weighting function is regressive and has a reflection point similar to that described in the literature. We then use regressions to fit weighting functions. We are interested in determining how the weighting functions change with age, and the extent to which age affects the functions distance from the diagonal $w(p)=p$. This is followed by a within-subjects analysis to classify individual behavior to determine whether it is consistent with the predictions of a regressive weighting function.

4.1 A descriptive analysis of choice over gambles with gains and losses.

Table 2 gives overall summary results and results by age category. The first line shows that on average our participants pick the gamble 56% of the time, and that they are more likely to gamble over losses than over gains. While we do observe differences across age groups, at this aggregate level no clear age-related pattern emerges.

Table 2: Proportion of gambles chosen, by age category.

	Age 5-8	Age 9-13	Age 14-20	Age 21-64	All ages
All gambles	0.591	0.612	0.544	0.475	0.562
Gambles over gains	0.531	0.569	0.544	0.496	0.538
Gambles over losses.	0.652	0.655	0.544	0.456	0.587

Next we disaggregate the gambles by probability. Table 3 shows the proportion of all participants choosing the gamble over its expected value by the probability of getting the stake and whether the gamble is over a gain or a loss. The table includes only those fair gambles that were played by all participants. There is an obvious pattern. For gains, the proportion choosing the gamble increases with the probability of winning, and for losses the proportion choosing the gamble decreases with the probability of losing. These results are not consistent with a regressive weighting function. Rather than risk seeking over small-probability gains and risk aversion over small-probability losses, we find the opposite. Rather than risk aversion over high-probability gains and risk seeking over high-probability losses, again we find the opposite.

Table 3: Proportion choosing the gamble over the certain outcome.

	Proportion choosing gamble	
Probability of winning or losing	over a certain gain	over a certain loss
0.02	0.444	0.667
0.1	0.504	0.671
0.8	0.615	0.474
0.98	0.645	0.483

As a whole, our data do not support a regressive weighting function. However, our data does over-sample children, and it is possible that their behavior drives this result. Figure 1 shows the proportion of participants by age category choosing the gamble over the certainty equivalent. The probability of winning is on the horizontal axis. We also show least squares fitted lines for descriptive purposes.[15] Figure 2 shows the same for losses.

[15] We report detailed regression results in the next subsection.

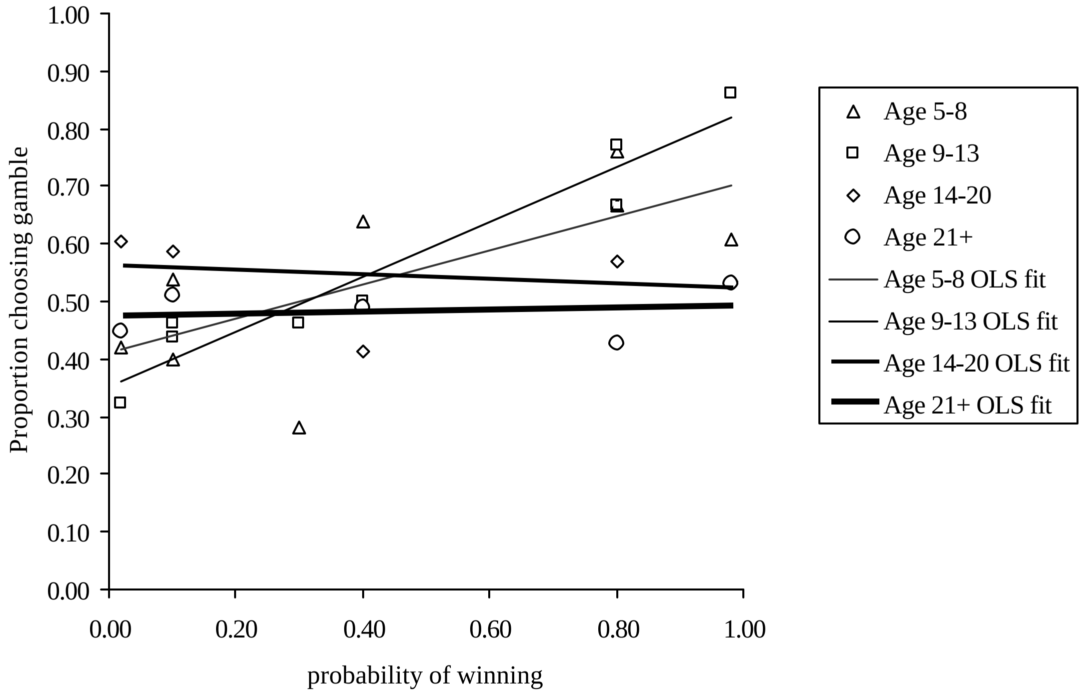

Figure 1: For gains, proportion of all participants choosing the gamble.

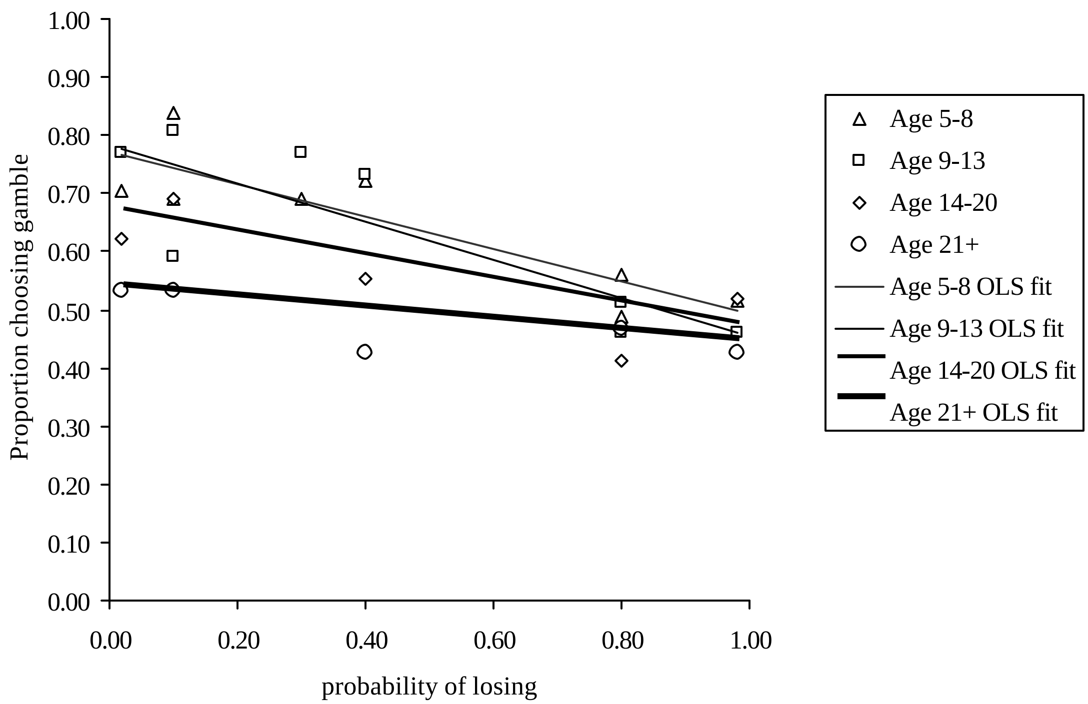

Figure 2: For losses, proportion of all participants choosing the gamble.

The results shown in these figures are striking.[16] First, for children, the overall pattern of behavior is exactly the opposite of the fourfold pattern predicted by a regressive weighting function. In figure 1 we see that for gains, instead of the expected decrease in the proportion taking the gamble as the probability of a gain increases, we find an increase. Figure 2 shows that as the probability of losing increases we see a decrease in the proportion gambling rather than the predicted increase. For the college students and adults, on the other hand, behavior appears to be close to risk neutrality.

If we recast these behaviors in terms of probability weights, we can explain younger participants' behavior over both losses and gains as the result of a tendency to underweight low-probability events and overweight high-probability ones. That is, they use probability weights, but they do not have the type of reflection point as that described in Section 2. Adult behavior, on the other hand, appears to be consistent with weighting probabilities by their objective values.

4.2 Estimating the probability weighting function.

Next we fit regressions to ask whether the descriptive analysis above is statistically robust. An individual’s choice between two risky outcomes will depend on both the individual's value or utility function, and his or her probability weighting function. In this section we make the simplifying assumption that the value function is linear. We justify this linearity assumption using the argument in Rabin (2000). Rabin shows that the degree of diminishing marginal utility that is needed to explain risk aversion over small or even medium-sized stakes is so large that it leads to “absurd” levels of risk aversion over large stakes.

Given linearity in the value function, we can express the difference between the values of the gamble g and the certain option as

$$w(p_g)s_g - c_g,$$

where once again $w(.)$ is the probability weighting function, p_g is the probability of winning (or losing) the amount s_g at stake in the gamble, and c_g is the positive or negative change in wealth

[16] Our first reaction to them was to go back to the data collection forms to make sure we had not reversed the codes for the choices.

associated with the certain option. Our goal is to estimate how the function *w(.)* changes with age and other observable characteristics. To estimate this function we use our data on choices between the gamble and the certain option, over a variety of values of p_g. We assume that people chose the gamble g if $w(p_g)s_g - c_g > e$, where e is distributed normal $(0,s)$, and we estimate the parameters of $w(p)$ using maximum-likelihood.

To estimate this function we use our data on choices between the gamble and the certain option for different people over a variety of values of p_g. We estimate the functional form used in Prelec (1998),

$$w(p) = \exp(-b(-\ln p)^{a}).$$

For positive values of a and $ß$ this functional form is monotonic in p and has the desirable properties of bounding $w(p)$ between 0 and 1 and requiring that $w(0)=0$ and $w(1)=1$, but it is otherwise very flexible. If $a=ß=1$, then $w(p)=p$ and people use objective probabilities and $w(p)$ will be a straight line from the origin with slope 1. Loosely speaking, the parameter a shows whether small probabilities are under or overweighted, with higher values implying that the higher probabilities get more weight. $ß$ can be interpreted as a measure of the general tendency to under or overweight probabilities, with higher values associated with underweighting.

Since the object of this paper is to examine how probability weighting changes with age, we allow a and $ß$ to vary with the observable characteristics of the participants. Specifically, we use maximum likelihood to estimate

$$w(p) = \exp(-b_i(-\ln p)^{a_i}),$$

where the parameters a and $ß$ are linear functions of the participant's characteristics X_i, that is $a_i=X_i q_a$ and $ß_i=X_i q_ß$, where q is the vector of coefficients. Results from six different regressions are shown in table 4.

Table 4: Weighting function estimation results.

		Reg. 1	Reg. 2	Reg. 3	Reg. 4	Reg. 5	Reg. 6
α:	Age	-0.0784* (0.0457)	-0.0524** (0.0257)	0.0304** (0.0136)	0.0374** (0.0171)	-0.0180*** (0.00557)	-0.0145*** (0.00374)
	Age squared	0.000957 (0.000654)	0.000654 (0.000426)	-0.000674*** (0.000229)	-0.000751** (0.000318)		
	Constant	2.47 (0.776)	1.91 (0.345)	0.986 (0.148)	0.846 (0.157)	1.65 (0.196)	1.48 (0.121)
ß:	Age	0.0263 (0.0177)	0.0163 (0.015)	-0.0599*** (0.0218)	-0.0565*** (0.0206)		
	Age squared	-0.000450 (0.000295)	-0.000309 (0.000283)	0.000675** (0.000326)	0.000651* (0.000343)		
	Constant	0.720 (0.181)	0.807 (0.142)	2.19 (0.335)	2.11 (0.281)	0.984 (0.0524)	0.959 (0.0355)
Log likelihood		-1106	-665	-1069	-625	-1110	-668
Standard Error		16.1	8.63	12.3	8.14	14.9	8.49
Prob. > chi²		0.126	0.0054	0.0011	0.0482	0.0013	0.0001
Participants		All	Rational	All	Rational	All	Rational
Choices		Gains	Gains	Losses	Losses	Gains	Gains
Participants x choices = n		234 x 7 = 1638	145 x 7 = 1015	234 x 7 = 1638	145 x 7 = 1015	234 x 7 = 1638	145 x 7 = 1015

Note: Dependent variable: indicator for choosing the gamble.
Standard errors are in parentheses.
For the age and age squared variables, * indicates significantly different from 0 at the 10% level, ** at the 5% level, *** at the 1% level.

We run these regressions separately over gains and losses. We begin by allowing *a* and *ß* to be functions of age and age squared. Regressions 1 and 2 are over gains, with regression 1 including all participants and regression 2 only including those who pass the rationality tests. Regressions 3 and 4 are the same specifications over losses. Tests of significance for the coefficients in regressions 1 and 2 show that, for gains, *a* appears to be a function of age but not age squared, while *ß* is constant across ages. Therefore we rerun the gains regressions using that specification, shown as regressions 5 and 6. For losses, on the other hand, regressions 3 and 4 show that both age and age squared are significant determinants of both a and ß.

We also estimated the regressions using gender variables, both directly and interacted with age. These coefficients were always insignificant and switched signs with different specifications. So, while many other researchers have reported finding that men are less risk averse than women, for example Jianakopolos and Bernasek (1998), with this protocol we find no evidence to support gender differences in risk behavior, either in children or in adults.[17]

To make it easier to interpret the regression results, in figure 3 we show plots of fitted probability weighting functions from regressions 3, 4, 5, and 6. The left hand plots are for choices over gains and the right are over losses, while the top are estimated on all participants and the bottom over just those passing the rationality tests. For each estimated function we fit the predicted probability weighting function for an 8, 20, and 32 year old. The dotted lines show objective weighting, while the solid lines show the fitted functions, with the thickness increasing with age.

[17] This result is confirmed by simple tests of means across ages and gender. The differences are small and insignificant.

Insert figure 3 here.

These estimated weighting functions correspond to the choices shown in figures 1 and 2. The pattern is for children to underweight low-probability events rather than overweight them: their weighting functions cross the diagonal from below. That older participants tend towards objective weighting is shown by the close correspondence between their estimated weighting functions and the diagonal. Formally, we can test the hypothesis that people use objective probabilities by jointly testing the hypotheses that $a_i=X_iq_a=1$ and $ß_i=X_iq_ß=1$. We find that, for gains and using the estimates for all participants, we can reject the hypothesis at the 5% confidence level at ages below 25, but not above. On the other hand, for losses and using estimates for all participants, we can reject the hypothesis of objective weighting at the 1% level for all ages in our sample. Among participants who passed the rationality tests we find very similar results, for losses we always reject the hypothesis that participants use objective probabilities, for gains we can reject the hypothesis for ages below 26.

Another age related trend is the decrease in the difference between weighting functions for gains and losses. For 8 and 20 year olds the probability weighting functions for gains is quite different from that for losses, particularly in the intercept. For the 32-year-olds the weighting functions for gains and losses are quite similar.

While the general trend is for older people to have objective probability weighting, there are also consistent patterns in the weighting functions for the younger ages. Weights for losses are substantially lower than those for gains, as indicated by the results shown in figures 1 and 2.

4.3 Individual differences and probability weighting.

We have shown that, in aggregate, children act as if they underweight low-probability events and overweight high-probability ones, while adults act as if they use weights that are much closer to the objective probabilities. Since we have observations of behavior over different choices by the same participants, we can also do a within-subjects analysis.

Prelec (1998) summarizes the current knowledge of the probability weighting function, and in addition to the regressive shape of the function, he also points out that the function generally is asymmetric with a fixed point at about 1/3. That is the reflection point p*=1/3. This implies that at an objective probability of 0.1 and 0.8 the weighting function is furthest away from the objective probability. Hence if the characteristics of the weighting function carry over to our experiment, then the predictions are strongest at these two probabilities. In particular one would predict that our participants would gamble over low-probability gains and high-probability losses and choose the certain outcome where the probability of gain is high and the probability of loss is low. In this section we look only at this subset of gambles where the predictions are strongest. We count the number of participants that follow each possible pattern for those gambles, and see how the proportions change with age. Table 5 shows the percentages of all participants whose choices fall into each of sixteen possible patterns.

Table 5: Percentage of all participants with given choice patterns.

Pattern of gambles (Low p. gain, high p. gain, low p. loss, high p. loss)	Age 5-8	Age 9-13	Age 14-20	Age 21-64	All
(g,g,g,g)	**20.3**	10.8	6.9	4.3	11.1
(g,g,g,c)	10.9	9.2	**15.5**	8.5	11.1
(g,g,c,g)	4.7	4.6	5.2	0.0	3.9
(g,g,c,c)	4.7	3.1	1.7	2.1	3.0
(g,c,g,g)	1.6	3.1	6.9	6.4	4.3
(g,c,g,c)	1.6	1.5	8.6	4.3	3.9
(g,c,c,g)*	3.1	7.7	6.9	**21.3**	9.0
(g,c,c,c)	1.6	4.6	6.9	4.3	4.3
(c,g,g,g)	10.9	15.4	10.3	6.4	11.1
(c,g,g,c)+	17.2	**20.0**	13.8	12.8	16.2
(c,g,c,g)	0.0	1.5	1.7	4.3	1.7
(c,g,c,c)	1.6	6.2	1.7	4.3	3.4
(c,c,g,g)	7.8	4.6	1.7	0.0	3.9
(c,c,g,c)	4.7	3.1	5.2	10.6	5.6
(c,c,c,g)	3.1	1.5	1.7	4.3	2.6
(c,c,c,c)	6.3	3.1	5.2	6.4	5.1
Number of participants	64	65	58	47	234

***** indicates the choice pattern consistent with a reflection point at 1/3 and a regressive weighting function; + indicates the choice pattern least consistent with a reflection point at 1/3 and a regressive weighting function. **Bold** indicates the modal pattern for each age group.

The aggregate data indicate that age is associated with a decline in the percentage of gambles chosen. This effect is particularly strong for gambles over losses. Looking at the individual data we can see that most of this decline comes from large changes in the proportion of people who follow a relatively small number of patterns.[18] For example, the percentage of participants gambling over all of these four choices decreases from more than 20% in the youngest to less than 5% in the oldest. Similarly, the (c,c,g,g) pattern, choosing the certain outcome for gains but gambling over losses, falls from about 8% of the youngest to none of the oldest.

There is strong evidence that as people get older they are more likely to behave in a manner consistent with a regressive weighting function with a reflection point at 1/3. The pattern consistent with such a weighting function is (g,c,c,g). The percentage picking this increases from 3% among the youngest to 21% among the oldest. In fact, this is the most popular pattern among the adults. The pattern most at odds with the standard characteristics of the weighting function is (c,g,g,c). This is either the modal choice or the second most popular choice in every age group, although the percentage displaying this pattern decreases with age. We find very similar patterns if we just look at the rational participants.

5 Order and experimenter effects and rationality checks.

In this section we examine the robustness of our data. We first determine whether the order in which choices were presented affects responses, and whether there are systematic differences across experimenters. We find no significant effects. Second we identify rationality violations and test for differences in these violations across age, gender and protocol. We also examine if the behavior of the participants whose choices pass the rationality test differ systematically from those whose choices fail.

5.1 Order and experimenter effects.

There are two reasons to test for order effects. First, determining why certain choices are made is complicated if choices are dependent on the order in which the pairs are presented. Second, significant order effects indicate that choices are influenced by factors that we would like to believe should be unimportant. For example, if it turns out that children's choices in this experiment vary

[18] Note, however, that counts for some of these cells are very small.

dramatically according to whether they are first presented with the small or the large-probability gambles, any theory would have to somehow deal with that fact if it is to have reasonable predictive value.

To test whether the order in which the pairs are presented to the participants affects individual choices, we look to see if the order causes significant differences in the mean numbers of participants choosing each of the gambles. We used four different orders, two starting with gains and two with losses, and then either beginning with the high-probability or the low-probability gambles. Choices that tested rationality were never presented consecutively. With four orders there are six possible comparisons between orders, and with 24 gambles this means 144 comparisons in total. Under the null that order has no effect, we should expect 7.2 significant differences at the 5% confidence level. We actually find seven significant differences at the 5% level, which suggests that order has no important effect on choice behavior.

We use a similar procedure to look for experimenter effects. Since we were particularly concerned that young children's decisions might be influenced by the experimenter, for the first protocol we used six different experimenters, leading to 15 crosswise comparisons. There were 14 different choices for this protocol, leading to 210 comparisons altogether. Under the null that the experimenter has no effect, we should expect 10.5 significant differences at the 5% confidence level. We actually find 11 significant differences at the 5% level, which suggests that there is no important experimenter bias.

5.2 Rationality.

In this sub-section we look at the characteristics of those violating our rationality test and whether the choices of those making violations differ systematically from those not making violations. For each of the two tests of rationality - one over gains, the other over losses - described in the protocol section above there are eight possible patterns of responses. Four of these are irrational, meaning that they involve a participant choosing the certain option on one choice and choosing the gamble when presented with another choice between an identical gamble but a higher certain option. If participants were randomly choosing between the gamble and the certainty equivalent, we would expect 25% to have no violations, 50% one violation, and 25% two violations. Of our participants 62% have no violations, 32% have one violation, and 6% have two violations. The average number of violations is 0.45. The average number of violations is 0.53 among children aged 5 to 8, 0.45 among pre-teens, 0.36 among teenagers, and 0.40 among adults. To simultaneously examine the effect of age and other covariates, we ran an ordered probit regression with the number of violations as the dependent variable and age, gender, and participating in Protocol 2 or 3 as independent variables. The results, in table 6, confirm that violations decrease with age, and that they are higher among boys, though these effects are not statistically significant.

The rationality tests differed between protocols. For the first protocol the certain outcomes were 11, 12 and 13 tokens, while for the second and third they were 35, 40, and 45.[19] The larger differences in the second and third protocols (in both absolute and relative terms) might be expected to reduce rationality violations for two reasons. First, errors are more costly, and second, the differences between the certain outcome and the expected value of the gamble are more apparent. In fact, we do find that after controlling for age and gender, protocols 2 and 3 are associated with a decrease in violations of about 25%, though again the effect is not significant.

[19] Dollar amounts varied according to the participants age, as explained in section 3. In addition, the probability of the win (or loss) outcome was 0.3 in the first sample, and 0.8 in the second. We see no reason this should have an effect on mistakes.

Table 6: Rationality violations, ordered probit regression.

Variable	Coefficient
Age	-0.00490
	(0.00794)
Male	0.0952
	(0.160)
Protocol 2 or 3	-0.197
(higher costs of irrationality)	(0.195)
n = 234, pseudo r-squared = 0.0077	

Notes: Dependent variable is the number of violations.
Standard errors in parentheses.

For the first sample, we included a test of comprehension in the protocol. This involved showing the participants four versions of the spinner cards used in the experiment, and asking how much their tokens would change if they made various choices and the spinner stopped in various places. Only 10 of 92 participants made any errors in this test. Those making errors were on average slightly younger than those making no errors, though the difference was not significant. The participants making errors on the test were more likely to make rationality violations, but this correlation was also insignificant. This supports the idea that the rationality violations do not result from a lack of understanding of the protocol, but rather from making choices that do not necessarily derive from consistent preferences.

While the number of violations seems large, most of our participants are choosing purposively. Rather surprisingly, children are at most only slightly more prone to violations than adults. The fact that violations respond in a reasonable way to changes in the cost of being irrational is a mixed blessing, in several different ways. On the one hand it suggests that our participants are not only (on average) rational, but also that they are rational in deciding how hard to work at being rational. Perhaps more significantly, the result that violations decline with increases in their cost shows that payoffs do affect behavior. This suggests that our use of real rewards is an effective way of reducing the noise in children's behavior. It raises the possibility, however, that behavior in more realistic situations, say with still higher payoffs, might systematically differ from that in our experiment.

As a simple test of whether participants with rationality violations make different choices than others, we run a regression with an indicator for choosing the gamble as the dependent variable, using a panel data probit model with random effects. Results are shown in table 7. Controlling for age, age squared, and gender, we found that the participants with rationality violations are substantially less likely to gamble than those with no violations – at the means, about 10% less likely.

Table 7: Rationality violations and risk aversion (panel probit regression).

Variable	Coefficient
Any rationality violations	-0.165** (0.07405)
Age	-0.0280** (0.0116)
Age squared	0.000318 (0.000223)
Male	0.0113 (0.0721)
n=234	

Notes: Dependent variable is an indicator for choosing the gamble.
Standard errors in parentheses.
* indicates different from zero at the 10% level, ** at 5%, *** at 1%.

6 Conclusion and Discussion

Previous research has shown that adults tend to use subjective probabilities to evaluate risky outcomes. Our primary objective in this paper was to examine how probability weighting functions change with age. We examined choices between a simple gamble and a certain outcome for children and adults and we found large age-related differences in choices. In virtually identical experimental protocols, about 70% of the youngest children chose a fair gamble when the chance of the gain was 0.8, while only 43% of the oldest adults did. Over losses, about 75% of these children took a fair gamble when the chance of the loss was 0.1, compared to 53% of the adults. These differences are even more dramatic if we limit the sample to those who pass the rationality tests.

This is strong evidence that children use probability weights. However the weighting functions that we estimate for children are very different from those that others have reported for adults. Most experimental work on adults finds that they tend to over-weight low-probability outcomes and under-weight high-probability ones, a pattern of behavior that can be explained by a regressive probability weighting function. We find the opposite of regressive weighting: on average children underweight low-probability events and overweight high-probability ones. This result is statistically significant and it is large.

We find that on average adults use objective probabilities when evaluating a gamble over a gain, however when evaluating a gamble over a loss they use subjective weights. Over losses their weighting function also underweights low probability events and overweights high ones, though to a lesser extent than children do. This lack of support for regressive probability weights in adults is an unexpected result, at odds with previous work.

We suspect that the primary explanation for this is that we asked people to choose between a certain outcome and a gamble. Almost all prior experimental work on this subject has either asked participants to report their willingness to pay for a gamble, or asked them to choose between two gambles. This divergence in results raises questions about the sensitivity of estimates of the weighting function to protocol variations, an issue we plan to investigate further in future work. Our feeling is that our result is closely related to the literature on preference reversal, discussed in Holt (1986) and Tversky et al. (1990).

On the other hand, our within-subjects analysis reveals that the proportion of participants with a regressive weighting function increases with age. In fact the pattern most consistent with over-weighting low probabilities and under-weighting high ones is the most commonly observed pattern of behavior among the oldest adults, while the proportion choosing the pattern which is most at odds with a regressive weighting function falls with age.

We believe that our most important finding is that children use large subjective probability weights and that these weights decrease with age. We argue that the most reasonable explanation for this result is that the accumulated experience evaluating risks, making decisions, and bearing the consequences of those decisions that accompanies age somehow moves peoples' risk preferences towards objective probability weighting and EUT. Despite this result, we do not argue that subjective weighting is likely to completely disappear with experience, since a substantial number of our older participants do exhibit robust evidence of subjective weighting.

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Appendix 1

Child Probability Weighting Experiment Script
One child is seated with each experimenter. Each pair is separated from the others by space and a partition.

We are going to play a game. It will take about 20 minutes. You will get some tokens while playing the game, and at the end of the game you will be able to use the tokens just like money to buy stuff from our store. Each token is worth about a dime, and the stuff at the store costs about what it would cost at a regular store.

Let child look at the inventory, no further descriptions or explicit prices are mentioned.

The number of tokens you will have at the end to buy things from the store will depend on your choices. Pay attention, because the better you understand things, the better your chance to get the things that you want. In a few minutes we will play the game for real, but right now we are just explaining things and practicing. We will tell you when we get to the part that counts for real.

I am giving you 50 tokens to start. I am going to put them in piles of ten.

Count tokens and stack in tens.
So now you have 10, 20, 30, 40, 50 tokens. These are yours.

Now look at this spinner wheel.

Show them Demo 1. (Probability of loss: 30%)

I'm going to spin the spinner and see what happens.

Spin it, and mark how it comes up, say either:

This means I don't take away any tokens. *OR*
This means I take away 40 tokens. See how they're crossed out? Crossed out tokens means that I take them away. (*If this is the one, actually take away 4 stacks of tokens, count by tens)*

Then spin it again and stop it with your hand on the other side.

What if the spinner had stopped here? Then ________*(alternative outcome*)
This is the kind of spinner that if you spun it ten times, it would land on red about **seven** times and would land on green about three times. That's what these numbers here mean.

Point to the numbers on the spinner.

Now let's try it with a different spinner wheel. On this one, instead of losing any tokens, you might get more.

Show Demo 2. (Probability of gain, 30%)

I'm going to spin the spinner and see what happens.

Spin it, and mark how it comes up. Say either:

This means you don't get any new tokens. *OR*
This means I give you 40 more tokens. (*If this is the one, count out 40 additional tokens)*
These extra tokens *(point to picture*) mean you get more if the spinner lands here.

Then spin it again and stop it with your hand on the other side.

What if the spinner had stopped here? Then *(say alternative outcome)*. This is the kind of spinner that when you spin it ten times about three times it will point to green and about seven times it will point to red. That's what these numbers here mean.

Let's try again.

Repeat process with Demo 3 (2% probability of loss of all 50)

I'm going to spin the spinner and see what happens.

Spin it, and mark how it comes up. say:

This means we don't take away any tokens. *OR*
This means I take away 50 tokens. See how all fifty are crossed out?

If this is the one, actually take away all the tokens. Count by tens.
Then spin it again and stop it with your hand on the other side.

What if the spinner had stopped here? *(alternative outcome)* This is the kind of spinner that, if you spun it fifty times, it would probably land on green once and on red every other time. That's what these number's here mean.

Let's try one more.

Show them Demo 4 (2% probability of gain of 50).

I'm going to spin and see what happens.

Spin it, and mark how it comes up. Say:

This means I don't give you any new tokens. *OR*
This means I give you 50 new tokens. (*If this is the one, actually give them five stacks of ten each, count by tens)*

Then spin it again and stop it with your hand on the other side.

What if the spinner had stopped here? *(describe alternate outcome)*
With this kind of spinner, if you spun it fifty times, it would probably land on green once and on red every other time. That's what these number's here mean.

Now let's try something a little different. This time there's a choice. This is the kind of choice that you make in the real game, but for now it's still just for practice. Look at this card.

Show them the first card that has a gain on it.

On this side is a spinner like the ones we just used. See how the pictures show how many tokens you can win if the spinner points here? On the other side, the card just shows you that you can win this many tokens, for sure. In the real game, you have to choose one side or the other. You choose by putting a sticker on a card like this.

Show them the slip of paper used for recording and demonstrate putting one of their stickers on the slip.

Pointing to appropriate sides of slip and spinner: If you choose the sure thing side, then you get those tokens for sure. If you choose the spinner side, at the end of the game I will spin the spinner and the number of tokens you get depends on where the spinner stops. If this were a real game, you would put a sticker on a piece of paper like this one either in the blank side *(point to it)* if you didn't want me to spin, or on the picture of the spinner *(point to it)* if you wanted me to spin.

Here's a different kind of choice, where you can lose tokens instead of win them.

Show the first card with a possible loss.

See how the pictures show how many tokens you might lose if you land on (green or red, depending on card)?

Point to crossed out tokens.

Or if the spinner arrow pointed here, you wouldn't lose any.

On the other side, the card just shows you that if you decided to put your sticker on this side, I would take away this many tokens, for sure. *Point to crossed out tokens*.

In the real game, you have to choose one side or the other. You choose the same way, by putting a sticker on a card.

Ok, let's try a practice game.

Using the gains frame of the ones you just showed.

What if you put your sticker here? *(Put dot on plain side)*
How many tokens would you have?

(Check correct if correct, otherwise repeat instructions and then ask again).

What if you put your sticker here? *(Put dot on spinner side, make sure response is along the lines of "you would spin it to find out")*
Right. I would spin at the end of the game to see how many you would have. *(Spin).* How many tokens would you have?
(If correct check correct, otherwise repeat and ask again).

Repeat with the loss spinner. Check correct if right on the first time, otherwise repeat.

There is one more thing about the game that you need to know. You are going to make 14 different choices like these ones. But only one of the choices will really count. After you've made all your choices, we will mix up your slips and then pick one out without looking. That one will be the choice that will really count.

Remember, in the end we just pick one choice. But since you don't know which one we will pick, the best thing is for you to choose carefully, since it might be that one. Do you have any questions about this game?

Simple questions are answered using sentences from above, more complicated ones by repeating the appropriate part of the protocol above.

Now it's time to play the game. You have as much time as you want to make up your mind, but we would like you to take at least 15 seconds. That's because we want you to think very carefully about your choices. We will tell you when 15 seconds are up, and then hand you another spinner if you are ready.

Let's see the first one:
(Hand child top card from stack that is ordered according to one of four orderings)

Remember, this turn might come true, but it might not come true. At the end of the game we'll find out.

(Attach first spinner back, write pair number on response slip and hand it to the child).

Ok, now think: If this game comes true will you want me to spin the spinner or will you want the sure thing? If you would want me to spin, put a sticker on the picture of the spinner. If you want the sure thing, then put the sticker on the other side. Don't show me what you decide, you can just put the sticker on and then put the paper in this envelope.

Hand child envelope with ID marked on it. Help with the first one if he needs it by reminding him of directions, but allow privacy for decision. While the participant chooses, the experimenter sits on the other side of the partition, occupied with other tasks.

OK, let's make another decision.

(Put next card on the spinner, write pair number on response slip, and hand both to child. If child appears to be rushing, hand spinner, wait 5 seconds or so, then hand response slip).

Now decide if you would want to spin on this one, or not spin. *(Wait if necessary)*
Put a sticker on this paper to show which one.

Repeat 12 more times. MINIMAL instruction unless they absolutely need it. They might need to be told that they must make a decision for every choice.

After the 14th choice is made,

Ok that's all the turns at this game. In just a minute we'll see what choice will come true.
I want to ask you just a few questions, ok?

First do short survey, then draw card and determine payoffs. Adult does the spinning if the child chose to spin.

Teenager Probability Weighting Experiment Script

After collecting consents and marking envelopes and response sheets with ID for each participant:

Thank you for coming and participating in this research. We are going to ask you to make several choices tonight. For each choice we will ask you to pick one of several options. There is no right or wrong answer, we just want you to make the choice you like best.

We will not tell anyone, including the other members of your family, what you decide. At the end of the experiment we will give you any money that you earn in a sealed envelope.
During the experiment, we are also going to ask you not to discuss any of your decisions with anyone, or to talk. If you do, we may have to stop the experiment and ask you to leave.

We are going to ask the adults to stay in this room and take a seat behind these partitions. Everyone else will be doing the study in the room next door.

Experiment assistant shows participant to another room. Participant is seated behind a partition. Give participant a numbered envelope and a pencil.

In the experiment you will be making decisions over money provided by us. You will not need any of your own money to participate in this experiment.

Now I am going to ask you to make a series of decisions, fourteen in all. In this part of the study, we will ask you to fill out a slip of paper indicating your decision for each of the fourteen cases. We will not pay you for every single one of these decisions. Instead, at the end of the study we will pick one decision, at random, and pay you for it. Since we could pick any one of the cases, the best thing for you to do is to treat each case as if it is the one that will be picked, and make the decision that you like.

We will choose which of the 14 decisions will count by picking a numbered ball from this bingo cage. The cage contains balls numbered 1 through 14, and each ball has an equal chance of being chosen. After we have drawn a ball, we will look at the slip of paper that has that number on it, and that will be the decision which is carried out.

For these decisions, the odds of winning and losing will vary. You will always have a choice between a certain result and playing a game that has two possible results.

You will be starting out each choice with $10. Remember that only one of the choices that you make will be actually paid, so each decision is separate. None of the money you win or lose in any decision will affect the next decision.

There are 14 different choices to make. I am going to hand you each one separately along with a slip of paper on which you mark your choice.

Sometimes you will have a choice between getting more money for sure and spinning a spinner for the chance to win $8. *Show example of a spinner with a chance of a gain.* Sometimes you will have a choice between losing part of your $10 for sure and spinning a spinner with a chance of losing $8. *Show example of a spinner with a chance of loss.* For example, you may be asked to choose between adding $1to the $10 you are starting with and taking a 50/50 chance of getting $8 more.

If you want to take the sure thing, mark an X next to that choice. *Show a response slip and indicate how choices are made.* If you would want to spin the spinner at the end of the experiments and take whatever the arrow points to, mark an X next to the symbol of the spinner. After you have marked your choice, put the slip into your envelope and I will hand you your next one.

Remember that only one game will count for payment, but that any one of them might.

Do you have any questions about this part of the study?

Here is your first choice.

Hand participant the first spinner card and a response slip. When the slip has been deposited in his envelope, hand the next card and slip.

After all choices have been made, spin the bingo cage and determine payment. The participant can complete the survey while experimenter computes payment.

Adult Probability Weighting Experiment Script

After collecting consents and marking envelopes and response sheets with ID for each participant:

Thank you for coming and participating in this research. We are going to ask you to make several choices tonight. For each choice we will ask you to pick one of several options. There is no right or wrong answer, we just want you to make the choice you like best.

We will not tell anyone, including the other members of your family, what you decide. At the end of the experiment we will give you any money that you earn in a sealed envelope.
During the experiment, we are also going to ask you not to discuss any of your decisions with anyone, or to talk. If you do, we may have to stop the experiment and ask you to leave.

We are going to ask the adults to stay in this room and take a seat behind these partitions. Everyone else will be doing the study in the room next door.

Introduce experimenters that will be doing the kids.

Show parents and youngest kids that the rooms are right next to each other, etc. Kids go with experimenter.

Adult is seated behind a partition, an experimenter sits on the other side. Hand participant an empty envelope with ID marked.

In the experiment you will be making decisions over money provided by us. You will not need any of your own money to participate in this experiment.

Now I am going to ask you to make a series of decisions, fourteen in all. In this part of the study, we will ask you to fill out a slip of paper indicating your decision for each of the fourteen cases. We will not pay you for every single one of these decisions. Instead, at the end of the study we will pick one decision, at random, and pay you for it. Since we could pick any one of the cases, the best thing for you to do is to treat each case as if it is the one that will be picked, and make the decision that you like.

We will choose which of the 14 decisions will count by picking a numbered ball from this bingo cage. The cage contains balls numbered 1 through 14, and each ball has an equal chance of being chosen. After we have drawn a ball, we will look at the slip of paper that has that number on it, and that will be the decision which is carried out.

For these decisions, the odds of winning and losing will vary. You will always have a choice between a certain result and playing a game that has two possible results. The odds of winning and losing will vary. You will always have a choice between a certain result and playing a game that has two possible results.

You will be starting out each choice with $50. Remember that only one of the choices that you make will be actually paid, so each decision is separate. None of the money you win or lose in any decision will affect the next decision.

There are 14 different choices to make. I am going to hand you each one separately along with a slip of paper on which you mark your choice.

Sometimes you will have a choice between getting more money for sure and spinning a spinner for the chance to win $40. Sometimes you will have a choice between losing part of your $50 for sure and spinning a spinner with a chance of losing $40. For example, you may be asked to choose between adding $10 to the $50 you are starting with and taking a 50/50 chance of getting $40 more.

If you want to take the sure thing, mark an X next to that choice. If you would want to spin the spinner at the end of the experiments and take whatever the arrow points to, mark an X next to the spinner symbol. After you have marked your choice, put the slip into your envelope and I will hand you your next one.

Remember that only one decision will count for payment, but that any one of them might.

Hand participant the first card and a response slip. Indicate how choices can be marked on the slip.

Do you have any questions about this part of the study?

Here is your first choice.

Hand cards and slips in order, one at a time. When they have completed all 14, spin the bingo cage to determine payment. They can complete the survey while payment is being computed.

Undergraduate Probability Weighting Experiment Script

After collecting consents and marking envelopes and response sheets with ID for each participant, direct each participant to one partition. The participant sits behind the partition, an experimenter sits on the other side. Hand participant an empty envelope with ID marked.

Thank you for coming and participating in this research. We are going to ask you to make several choices. For each choice we will ask you to pick one of several options. There is no right or wrong answer, we just want you to make the choice you like best.

We will not tell anyone what you decide. At the end of the experiment we will give you any money that you earn in a sealed envelope. During the experiment, we are also going to ask you not to discuss any of your decisions with anyone, or to talk. If you do, we may have to stop the experiment and ask you to leave.

In the experiment you will be making decisions over money provided by us. You will not need any of your own money to participate in this experiment.

Now I am going to ask you to make a series of decisions, fourteen in all. We will ask you to fill out a slip of paper indicating your decision for each of the fourteen cases. We will not pay you for every single one of these decisions. Instead, at the end of the study we will pick one decision, at random, and pay you for it. Since we could pick any one of the cases, the best thing for you to do is to treat each case as if it is the one that will be picked, and make the decision that you like.

We will choose which of the 14 decisions will count by picking a numbered ball from this bingo cage. The cage contains balls numbered 1 through 14, and each ball has an equal chance of being chosen. After we have drawn a ball, we will look at the slip of paper that has that number on it, and that will be the decision which is carried out.

For these decisions, the odds of winning and losing will vary. You will always have a choice between a certain result and playing a game that has two possible results. The odds of winning and losing will vary. You will always have a choice between a certain result and playing a game that has two possible results.

You will be starting out each choice with $30. Remember that only one of the choices that you make will be actually paid, so each decision is separate. None of the money you win or lose in any decision will affect the next decision.

There are 14 different choices to make. I am going to hand you each one separately along with a slip of paper on which you mark your choice.

Sometimes you will have a choice between getting more money for sure and spinning a spinner for the chance to win $25. Sometimes you will have a choice between losing part of your $30 for sure and spinning a spinner with a chance of losing $25. For example, you may be asked to choose between adding $10 to the $30 you are starting with and taking a 50/50 chance of getting $25 more.

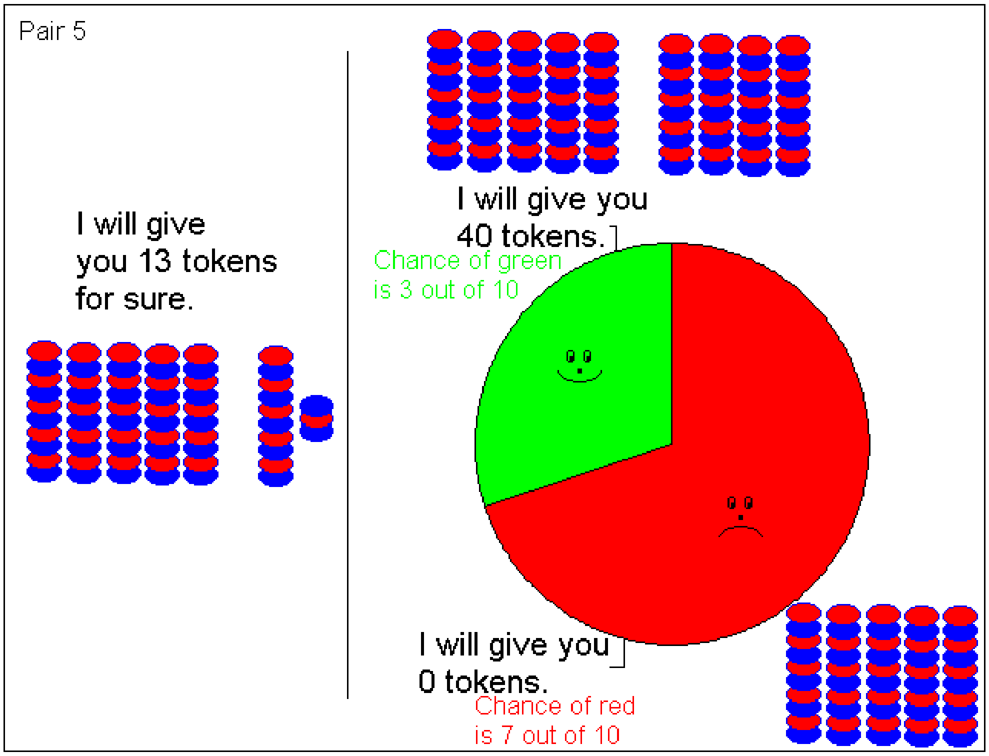
If you want to take the sure thing, mark an X next to that choice. If you would want to spin the spinner at the end of the experiments and take whatever the arrow points to, mark an X next to the spinner symbol. After you have marked your choice, put the slip into your envelope and I will hand you your next one.

Remember that only one decision will count for payment, but that any one of them might.

Hand participant the first card and a response slip. Indicate how choices can be marked on the slip.

Do you have any questions about this part of the study?
Here is your first choice.
Hand cards and slips in order, one at a time. When they have completed all 14, spin the bingo cage to determine payment.

Appendix 2:


Pair 5
I will give you 13 tokens for sure.
I will give you 40 tokens.
Chance of green is 3 out of 10
I will give you 0 tokens.
Chance of red is 7 out of 10

Appendix 3:

Table A1: Choice pairs.

Choice pair	Protocol 1	Protocol 2,3	Certain choice: Changes in Payoff + children (Tokens)	Certain choice: Changes in Payoff + parents (Dollars)	Gamble choice: Probability	Gamble choice: Changes in Payoff + Tokens	Gamble choice: Changes in Payoff + Dollars
1	x	x	1	.80	0.02	50	40
2	x		4		0.1	40	
3		x	5	4	0.1	50	40
4*	x		11**		0.3	40	
5*	x		12		0.3	40	
6*	x		13**		0.3	40	
7		x	20	16	0.4	50	40
8	x		32		0.8	40	
9*		x	35**	28**	0.8	50	40
10*		x	40	32	0.8	50	40
11*		x	45**	36**	0.8	50	40
12	x	x	49	39.20	0.98	50	40
13	x	x	-1	-.80	0.02	-50	-40
14	x		-4		0.1	-40	
15		x	-5	-4	0.1	-50	-40
16*	x		-11**		0.3	-40	
17*	x		-12		0.3	-40	
18*	x		-13**		0.3	-40	
19		x	-20	-16	0.4	-50	-40
20	x		-32		0.8	-40	
21*		x	-35**	-28**	0.8	-50	-40
22*		x	-40	-32	0.8	-50	-40
23*		x	-45**	-36**	0.8	-50	-40
24	x	x	-49	-39.20	0.98	-50	-40

* indicates choice pairs used in the rationality checks.

** indicates certain options that are not equal to the Expected Value of the gamble.

\+ Children were paid in tokens, each worth about $0.10 each. The dollar amounts are those paid to the parent participants. The dollar amounts for teenagers were scaled to equal 1/5 of the parent dollar amounts, while undergraduate dollar amounts (protocol 3 only) were 5/8 of the parent amounts.