THE FOURFOLD PATTERN OF RISK ATTITUDES IN CHOICE AND PRICING TASKS

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Abstract: Using simple gambles with real payoffs we examine the robustness of the fourfold pattern of risk attitudes under two different elicitation procedures. That is, we determine if on average individuals are (1) risk-seeking over low-probability gains, (2) risk-averse over high-probability gains, (3) risk-averse over low-probability losses, and (4) risk-seeking over high-probability losses. We find that participants' risk attitudes are consistent with the fourfold pattern when using the Becker-DeGroot-Marschak procedure to elicit prices for the gambles. However, when instead relying on a simple choice-based elicitation where participants choose between the gamble and its expected value, individual decisions are not distinguishable from random choice. This sensitivity to the elicitation procedure holds both between- and within-participants, and it remains even when participants review their price and choice decisions simultaneously and are allowed to change them. Given the greater complexity of the price elicitation procedure this finding may be further evidence that an increase in cognitive load exacerbates behavioral anomalies.

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1. Introduction

Individual decisions over risky outcomes often deviate from that predicted by expected utility theory, and alternative models have been proposed to better explain behavior.[1] Perhaps the most accepted alternative is cumulative prospect theory (CPT) by Tversky and Kahneman (1992).[2] Two central assumptions in CPT are that individuals are risk averse over gains and risk seeking over losses, and that they tend to overweight low probability events while underweighting the likelihood of high probability ones. Combined these two assumptions may result in a unique pattern of risk attitudes. As stated by Tversky and Kahneman (1992) "The most distinctive implication of prospect theory is the fourfold pattern of risk attitudes."[3] Specifically, it is predicted that when faced with a risky prospect people will be:

(1) risk-seeking over low-probability gains,

(2) risk-averse over high-probability gains,

(3) risk-averse over low-probability losses, and

(4) risk-seeking over high-probability losses.

The objective of this paper is to examine the robustness of the fourfold pattern using two different elicitation procedures. We asked 128 people to evaluate a small set of simple gambles with low and high probabilities of cash gains and losses. In one price-based procedure we use the Becker-DeGroot-Marschak (BDM) procedure to elicit participants' willingness to pay for the lotteries, and in the other choice-based procedure we ask them to choose between the gamble and its expected value. This allows us to observe whether individuals make decisions that are consistent with each of the four elements of the fourfold pattern, and whether those decisions are affected by the elicitation procedure.

We find that the fourfold pattern is a very good predictor of risk attitudes – but only when people are asked to report their willingness to pay for a risky prospect. When they are instead asked to choose between the gamble and its expected value, we find that their decisions are not distinguishable from random choice. This result holds both between- and within-

[1] For reviews of the literature see for example, Schoemaker (1982), Machina (1987), and Starmer (2000). For examples of comparisons between the alternative models, see e.g., Harless and Camerer (1994), Hey and Orme (1994).

[2] Cumulative prospect theory is a generalization of prospect theory, Kahneman and Tversky (1979). Camerer (1998) argues that cumulative prospect theory is supported by the preponderance of evidence, and he suggests that it is time to abandon expected utility theory in its favor. Camerer (2000) makes a similar recommendation

[3] Tversky and Kahneman (1992), p. 306.

participants and does not depend on the ordering of tasks. We also show that the change in elicited preferences between the two methods remains even after participants review their price and choice responses simultaneously and are allowed to change them.

There are several potential explanations for the sensitivity to the elicitation procedure. One such explanation may be found in the literature on dual selves.[4] The dual-self models argue that cognitive load may decrease an individual's ability to exert willpower over the more impulsive self. Thus an increase in cognitive load may result in more substantial behavioral anomalies. Interestingly a recent experimental study by Benjamin, Brown, and Shapiro (2006) shows that cognitive load increases both small-stakes risk aversion and short-run discounting. To the extent that the cognitive load of the BDM price procedure is greater than in the choice based procedure our finding may be seen as further evidence that cognitive load exacerbates behavioral anomalies.

In Section 2 of the paper we review the literature that motivates our study. Section 3 presents our experimental design. Section 4 and 5 show how the results support the conclusion that the fourfold pattern is present in pricing tasks, but not in choice tasks. Section 6 discusses various explanations for the sensitivity to elicitation procedure and concludes the paper.

2. Motivation

As mentioned in the introduction, CPT's assumptions on the value- and probability weighting functions give rise to the fourfold pattern of risk attitudes. First, CPT assumes that preferences can be described by a reference-dependent value function $v(x)$, where x denotes the change in the payoff from a person's initial wealth position. As shown in Figure 1, Panel a, the value function is kinked at the endowment point with a steeper slope for losses than gains, thus capturing the loss aversion finding that losses loom larger than gains Furthermore, based on evidence that people are risk-averse over gains and risk-seeking over losses, the value function is assumed to be concave for gains and convex for losses. Second, rather than responding to the objective probability p, it is assumed that individuals weight these by a non-linear probability weighting function $w(p)$, as illustrated in Panel b of Figure 1. Impossible events are discarded such that

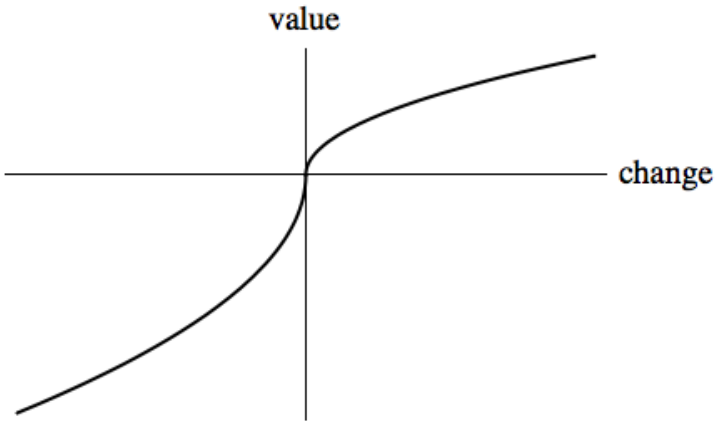
[4] See e.g., Bernheim and Rangel (2004), Loewenstein and O'Donoghue (2005), Brocas and Carillo (2005), Fudenberg and Levine (2006), and Ozdenoren, Salant, and Silverman (2006).

w(0)=0 and the scale is normalized such that *w(1)=1*.[5] To capture the finding that individuals are insensitive to changes in the probability, the weighting function is assumed to be "regressive," and as shown in Panel b of Figure 1 to cut the diagonal from above. Thus people are assumed to overweight low probability events and underweight high probability ones. Kahneman and Tversky's predicted fourfold pattern results when the magnitude of *w(p)* is large relative to *v(x).* That is, the overweighting of low probabilities needs to be large enough that people are risk-seeking for lotteries with low probability gains and risk-averse for low probability losses. Note however that probability weighting alone will give rise to the fourfold pattern when individuals are risk neutral.

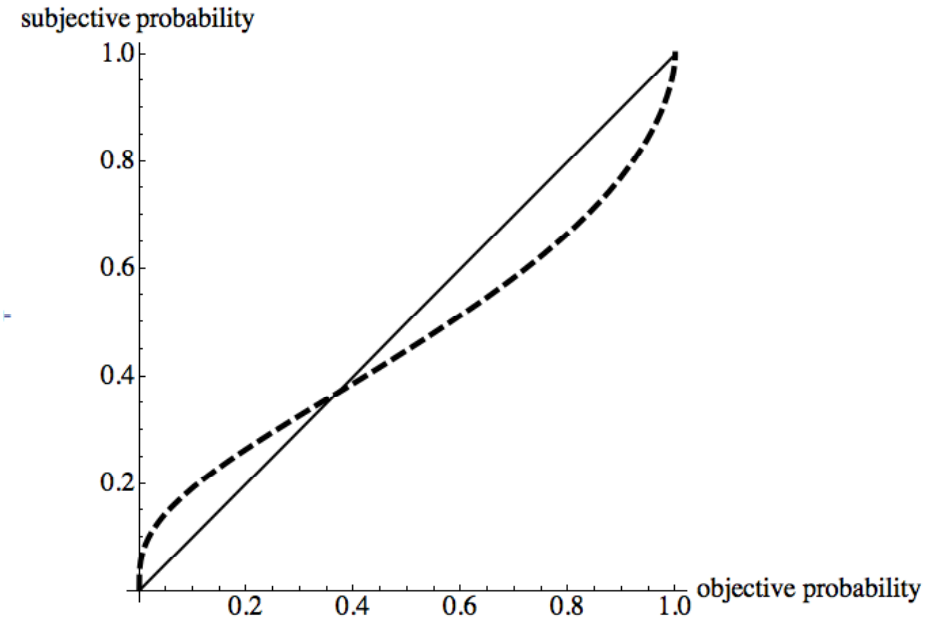
[5] Kahneman and Tversky (1979) present a probability weighting function that is discontinuous at the bounds to demonstrate that the function is not well-behaved on the boundary. Subsequent presentations, including those of Tversky and Kahnrman (1992), are nonetheless of a continuous probability weighting function. We too illustrate a continuous probability function to demonstrate the characteristics of the continuous functions estimated by Camerer and Ho (1994), Gonzalez and Wu (1999), Prelec (1998), Tversky and Kahneman (1992), Tversky and Fox (1995), Wu and Gonzalez (1996).

Figure 1: The prospect theory value and weighting functions

Panel a: The value function



Panel b: The subjective probability weighting function



While there is a large experimental literature on decision-making under risk very few studies directly test the fourfold pattern of risk attitudes. The focus of much of the literature is on testing CPT against alternative models by relying on choices over a large set of relatively complex gambles. For example, Hey and Orme (1994) show people 100 pairs of (mostly) three-outcome lotteries and have them choose one of each pair, or report indifference. The lotteries are fairly complicated – for example, individuals chose between a lottery with 0.375 chance of £10, 0.125 chance of £20, and 0.5 chance of £30, and one with a 0.125 chance of £10, 0.750 chance of £20, and 0.125 chance of £30.[6] Other studies focus on estimating the shape of the value function, the weighting function, or both. Gonzalez and Wu (1999) use an iterative procedure to elicit certainty equivalents for 300 two-outcome gambles, all over gains, with varying probabilities and payoffs. Participants are paid $50 for completing the four-hour-long task, and in addition at least one participant is paid for at least one decision. The data helps them estimate both the probability weighting and the value functions, and they report that results from ten of the eleven participants, who were psychology graduate students, are consistent with the CPT predictions about the shape of these functions over gains.

[6] The odds are shown with pie charts on a computer, and one randomly chosen decision is played for real money. Hey and Orne (1994) report that neither of several varieties of probability weighting models provide better explanations of the data than does expected utility theory. They repeat the experiment a week later, and find many differences in choices, suggesting that decision errors are an important aspect of decision-making in these experiments. See also, Harless and Camerer (1994) for analysis of 23 datasets consisting of choices over similarly complex gambles.

Direct tests of the fourfold pattern using real and simple gambles are scarce. The data for Kahneman and Tversky's 1979 paper came from survey questions about choices between an array of lotteries with large hypothetical gains and losses. Tversky and Kahneman (1992) presented 25 graduate students with a series of simple lotteries over smaller, but still hypothetical, losses and gains. They used an iterative procedure to obtain close bounds on the certainty equivalents for the lotteries, and found strong support for the fourfold pattern.[7] However behavior elicited from survey-type data need not mirror that over real cash lotteries (see e.g., Harless and Camerer, 1994, Camerer and Hogarth, 1999, and Battalio, Kagel, and Jiranyakul, 1990). More recently Holt and Laury (2002) conduct a direct comparison of decisions for hypothetical and real lotteries over gains, and find that people appear more risk-seeking when faced with hypothetical rather than real gambles. Laury and Holt (2007) present the same hypothetical/real comparison for decisions over gains and over losses, and find that while the hypothetical decisions are risk-averse over gains and risk-seeking over losses, with real gambles they are risk-averse for gains but risk-neutral for losses. As the Holt-Laury procedure relies on choices between pairs of lotteries with different probabilities and expected values, it does not enable a comparison of behavior between low- and high-probability lotteries, and as a result their papers do not shed light on the full fourfold pattern.

Others have allowed for high- and low-probability gambles, but focus solely on the gain domain. For example, Kachelmeier and Shehata (1992) presented Chinese, Canadian, and American participants with a sequence of 25 simple real lotteries over gains, and asked what price they would be willing to accept in return for their lottery ticket. They used the demand revealing Becker-DeGroot-Marschak procedure to elicit prices. The results show substantial risk-seeking for low-probability prospects, but do not show risk-aversion for high-probability prospects. In a follow-up experiment on a limited set of gambles they find evidence that the lack of risk-aversion is due to the willingness-to-accept format of their elicitation. Reported willingness to pay for a prospect is much lower than the reported willingness to accept.

Harbaugh, et al. (2002) is to our knowledge unique in using real and simple gambles to directly test the full fourfold pattern. They examine decisions over a small set of simple lotteries with cash payoffs, over gains and losses and with a range of probabilities. The participants range

[7] Thus the elicitation method used by Tversky and Kahneman (1992) effectively asks participants to determine their willingness to pay for a hypothetical gamble.

in age from five to 64. To make the protocol transparent for the youngest participants they use a very simple choice-based elicitation procedure, asking people to choose between a risky prospect with one non-zero outcome, and its expected value. They find that children's risk attitudes diverge from the fourfold pattern, and while the divergence diminishes with age they do not find adults behaving in a manner consistent with the fourfold pattern. Our objective in this paper is to determine why Harbaugh et al. (2002) in contrast to previous studies do not find evidence of the fourfold pattern. As previous evidence for the fourfold pattern has been observed by eliciting prices of a gamble, it may be that failure to observe the fourfold pattern is due to their choice-based elicitation procedure. Another possible explanation is that the unusual subject pool caused the results to diverge from the fourfold pattern. To address both of these explanations we determine if the fourfold pattern is robust to the elicitation procedure when using a standard subject pool.

3. Experimental Design

We design an experiment to test the fourfold pattern of risk attitudes using simple lotteries for cash gains and losses over a range of probabilities. Risk attitudes are elicited using both choice- and price-based procedures. The choice procedure simply asks individuals to choose between a lottery and its expected value. The price procedure asks participants to report the most they are willing to pay to play a lottery over gains, or the most they are willing to pay to avoid playing a lottery over losses.[8] The BDM procedure is used to determine whether participants will pay a randomly determined price to play the lottery (gain), or to avoid the lottery (loss). We explain the BDM procedure separately for losses and for gains. Each explanation includes an example, a test of understanding, and then a further discussion.

[8] With this procedure the willingness-to-pay and the choice decisions are slightly different over gains. Because people must pay to play the gambles, their payoff is reduced by the random price drawn. We address this issue in Section 5. Note that the willingness-to-accept format presents a similar difference over losses where participants accept a payment in return for the gamble. We use the willingness-to-pay format to limit the "overbidding" that is frequently found with willingness-to-accept questions. When eliciting the monetary equivalent of a gamble one must elicit either a willingness-to-accept or willingness-to-pay measure. Schmidt, Starmer and Sugden (2005) develop a reference-dependent model that they call third-generation prospect theory. This model predicts preference reversals between choice and willingness-to-accept (WTA) evaluation tasks because loss aversion causes a decision-maker to require greater compensation to forego a potential gain. This perceived loss is not present in the choice task. As a result, a WTA preference elicitation mechanism will lead to higher valuations of a lottery than a choice task.

Participants in the experiment were asked to evaluate the six prospects shown in Table 1. Prior estimates of the probability weighting function report, and Panel b of Figure 1 illustrates, that the absolute difference between the weighted probability and the objective probability is largest when the objective probability is 0.1 and 0.8, and that the functions cross at approximately 0.4.[9] Therefore we are particularly interested in determining risk attitudes for prospects 1, 3, 4, and 6, as we expect strong support for the fourfold pattern at these prospects.

Table 1: The Six Prospects

Prospect Number	Probability	Payoff	Expected Value	Predicted FFP of Risk Attitude
1	.1	+$20	$2	Seeking
2	.4	+$20	$8	Neutral
3	.8	+$20	$16	Averse
4	.1	-$20	-$2	Averse
5	.4	-$20	-$8	Neutral
6	.8	-$20	-$16	Seeking

The participants were college students from a variety of majors at the University of New Mexico. To allow for both between- and within-participants analyses, everyone evaluated the prospects using both procedures. Sixty-four students used the choice method first and thirty-two used the price method first. We selected to have a larger subject pool for the choice method since this version is less common when examining the fourfold pattern. After the first elicitation procedure each group then evaluated the gambles using the other method.[10] We refer to participants who first complete the choice method as "choice-participants" and those who first complete the price method as "price-participants."

Each experimental session lasted about 30 minutes and only one participant at a time was present. Upon arriving at the lab the student was directed to a partition, where he or she could make decisions without being observed by the experimenter. Participants were randomly assigned to be either a price- or a choice-participant. After reading the instructions for the initial

[9] See for example Camerer and Ho (1994), Gonzalez and Wu (1999), Prelec (1998), Tversky and Kahneman (1992), Tversky and Fox (1995), Wu and Gonzalez (1996).

elicitation method, participants were shown a sample prospect and a spinner card of the sort used in board games.[11] They were told they would be asked to make six decisions, and that one decision would be picked randomly to count for their payoff.[12] We then counted out $22 in single dollar bills, put it on the table in front of them, and asked them to evaluate the six prospects, one at a time.[13] The odds for the gambles were shown both numerically and using spinner cards, and these same spinners were used by the experimenter to determine outcomes.[14] We refer to the initial decision as the first-round decision. At the time the first-round decision was made the participant had no reason to believe that it was not his or her final decision. After completing the initial evaluation of one set of six decisions, the participants were then asked to lay all their decisions out on a table so that they could see them simultaneously. At this point they were given an opportunity to change any of their responses.[15] We refer to decisions at this point as the second-round decisions.

We used a restart procedure to obtain decisions for the second elicitation procedure. After completing the second-round decisions of the first task, participants were asked to participate in another experiment, before their earnings from the first task were determined. Using a self-contained set of instructions, they were presented with the second elicitation method. They were given another $22, completed the six evaluations, and were again asked to review the six decisions simultaneously and make any changes they wished. Once both elicitation methods were completed, participants reviewed all twelve decisions simultaneously, and were given a third and final opportunity to change their answers. After completing the third-round decisions,

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[10] Note that the participants were unaware that they would be asked to evaluate the prospects more than once.
[11] Instructions for the experiment are posted at http://www.pitt.edu/~vester/FFPInstructions.pdf
[12] A similar procedure is also used by Tversky and Kahneman (1986), Starmer, Sugden, and Cubitt (1998), and Camerer (1989). When offering participants to change their decision once it has been randomly selected, Camerer (1989) finds that they don't use that option. Laury (2002) shows that the procedure of randomly choosing one of several gambles elicits roughly the same preferences as when participants are paid for all of the decisions they make.
[13] Prospect theory will not predict the fourfold pattern unless people view this $22 as "theirs." This might not be the case if people see this $22 as a windfall gain, rather than as compensation for the time involved in participating in the experiment. In section 2 we show that, in the pricing task, people exhibit the fourfold pattern as well as loss aversion. We take this as evidence that they do treat this payment as part of their endowment. Note also that this is the procedure that has previously been used to elicit risk attitudes over losses, see for example, Camerer (1989), and Battalio, Kagel, and Jiranyakul (1990).
[14] Hertwig, Barron, Weber, and Erev (2003) find that individuals overweight low-probability events in decisions from description, while they underweight such events in decisions from experience. While Hertwig et al. classify decisions in our experiment as being from description it is possible that prior experience with spinners lead individuals to underweight low-probability events.
[15] We thank Dale Stahl for suggesting this revision procedure.

we picked one prospect from each elicitation method, played any gambles, and paid the participants their net earnings in cash, which averaged $44 and ranged between $4 and $84.

People did not know they would participate in the second task, nor that they would be allowed to re-evaluate their choices, so the first-round decisions allow for a clean between-participants comparison of price and choice behavior. The opportunity for the revisions was included to reduce errors, but our general results are the same regardless of the round.

For each elicitation method we presented the prospects according to one of four different orders. An equal proportion of participants was given each order. Two orderings presented the prospects in increasing order of probability (from 10 percent to 80 percent), with one ordering presenting gains first and then losses, and the other ordering presenting losses first and then gains. Two other orderings presented the prospects in decreasing order of probability (from 80 percent to 10 percent), once again one ordering first presented gains, and the other first presented losses. Participants received the prospects in the same order for both the choice and pricing methods, and the order in which a person was shown the choices was determined randomly. We find that decisions do not differ significantly across these orders.

4. Risk Attitudes from Price Elicitations

We start by examining the risk attitudes that result when using the price elicitations. We first present the results for the price-participants who were asked to first evaluate the prospects using the price elicitation. Table 2 reports their first-round average and median prices. A participant is classified as risk-neutral if the reported price equals the expected value of the gamble. If the participant is willing to pay more than the expected value to play the gamble over gains then she is classified as risk-seeking. Similarly, she is classified as risk-seeking if the amount she is willing to pay to avoid playing a gamble involving a loss is less than the expected value.

Table 2: Price-participants in the Price Task

Prospect			Mean Reported Price			Median Reported Price		
Description		Expected Value	Price	p-value, Wilcoxon Test	Mean Risk Attitude	Price	p-value, Sign Test	Median Risk Attitude
Gain +$20	1. p=0.1	$2	$4.9	0.007	Seeking	$2.0	0.078	Neutral
	2. p=0.4	$8	$8.1	0.500	Neutral	$7.0	0.170	Averse
	3. p=0.8	$16	$12.2	0.000	Averse	$12.0	0.000	Averse
Loss -$20	4. p=0.1	-$2	-$5.7	0.000	Averse	-$4.5	0.000	Averse
	5. p=0.4	-$8	-$9.6	0.021	Averse	-$9.0	0.064	Averse
	6. p=0.8	-$16	-$12.6	0.000	Seeking	-$13.0	0.000	Seeking

Notes: 32 participants, first-round decisions. The Wilcoxon test assumes the price distribution is symmetric and tests the hypothesis that the mean and median of the distribution equal the expected value of the gamble. The sign test does not assume symmetry and tests the hypothesis that the median of the distribution equals the expected value of the gamble.

We first note that the prices reported for the low and high probability prospects differ substantially from the associated expected values.[16] Second, consistent with CPT's assumption of loss aversion we see that losses loom larger than similar sized gains. Both the mean and median prices for a positive prospect are smaller than the absolute value of the prices reported for the corresponding negative prospect.[17] Third, the mean reported prices imply risk attitudes that are consistent with the fourfold pattern. When presented with a prospect involving a gain participants are risk-seeking at low-probability gains and risk-averse at high-probability ones. Over losses, risk attitudes reflect and we see the opposite pattern. In all four cases the risk attitude implied by mean prices is significantly different from risk-neutrality. This pattern is also supported by the median prices. The only exception is prospect 1, where the median price equals the expected value of the gamble. Thus, across participants the price elicitation results in risk attitudes that are very much in line with the fourfold pattern.

A similar result holds within-participants, where we directly can assess the individual reflections in risk attitudes when moving from low to high probabilities of winning, or when

[16] The prices found by Tversky and Kahneman (1992) also differ substantially from the expected value. For example they find a median reported price of $9 for a 10 percent chance of winning $50.

moving from the gain to the loss domain. Conditional on the stake of the prospect being a loss or a gain, the first panel of Figure 2 shows the proportion of participants whose reported prices suggest that they are risk averse versus risk seeking for the high- and low-probability prospects (High P and Low P, respectively). The second panel shows the proportion with each combination of risk attitudes when conditioning on the likelihood of the stake and recording risk attitudes for prospects with a similar sized loss and gain. The highlighted cells are the outcomes predicted by prospect theory.

The within-participant support for the fourfold pattern of risk attitudes is striking. The modal cell in the price task is always consistent with the predicted reflection of risk attitudes, and in two of the four cases more than half the participants are in the predicted cell. Risk attitudes reflect in two dimensions: conditional on a gain or a loss, attitudes reflect when moving from a high- to a low-probability prospect; conditional on a low- or a high-probability prospect, attitudes reflect between a gain and a loss.

We determine statistically whether the proportion with the predicted risk attitudes exceeds the proportion that would be expected if participants were equally likely to have any combination of risk attitudes. With three different risk attitudes and hence 9 possible combinations we use an exact binomial test of proportions to test the null that at most $1/9^{th}$ are in the cell predicted by the fourfold pattern of risk attitudes.[18] In all four comparisons we can reject the null in favor of the alternative that more people are in the predicted cell, with p-values less than 0.001. The same conclusion is reached when we exclude those who are risk-neutral and test the hypothesis that at most 25 percent of the remaining participants reflect in the predicted manner.[19] Thus using the price elicitation there is substantial support for the fourfold pattern, whether we focus on reflection of risk attitudes between gains and losses, or between low- and high-probability prospects.

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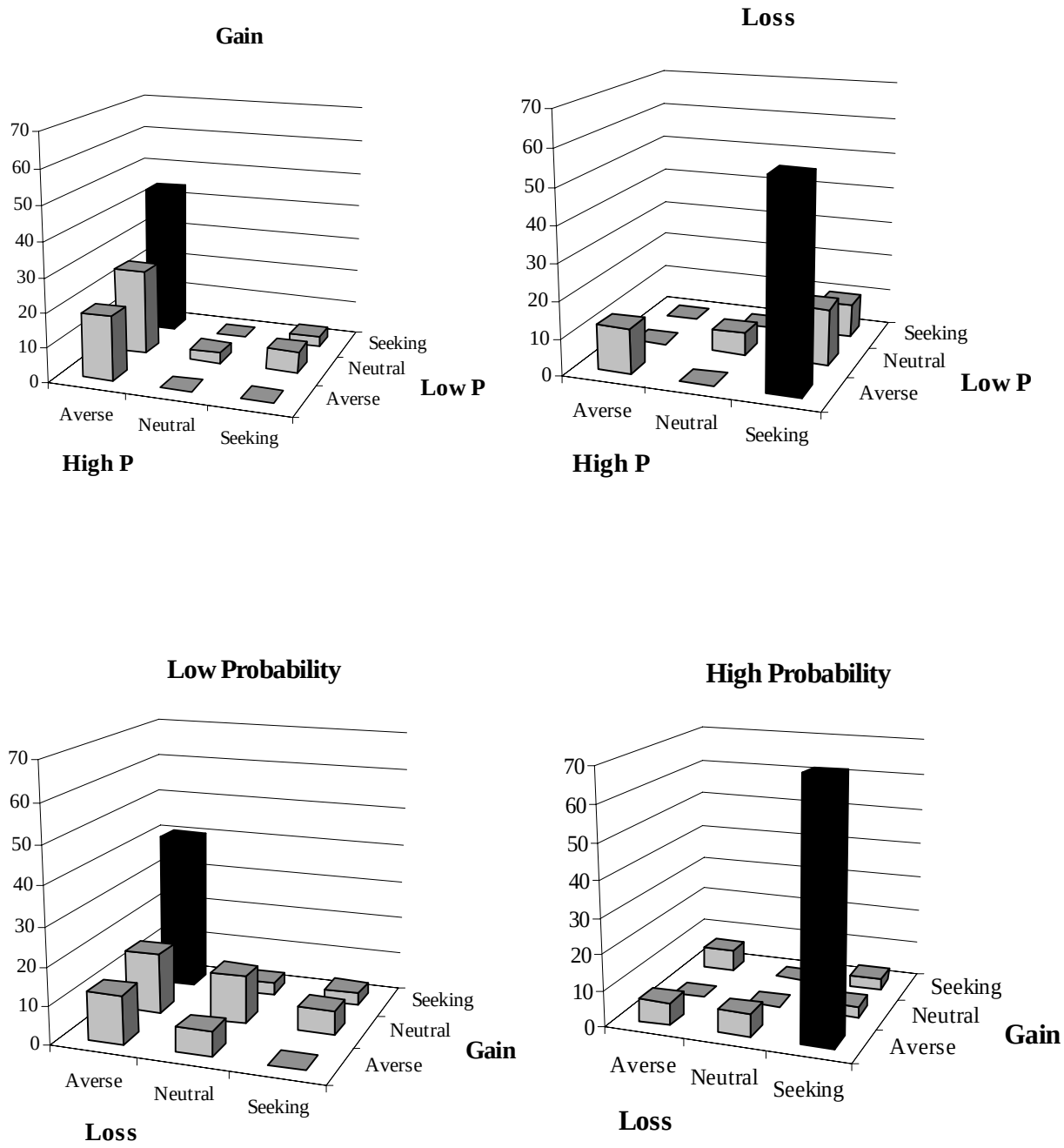
[17] Note however that only in the comparison of prospect 2 and 5 can we reject the hypothesis that the absolute price reported for a loss equals that of the similar sized gain (p-value of the Wilcoxon test equals 0.03).

[18] Given the size of the gambles it may be argued that the majority of participants should be risk-neutral, thus the null distribution is not obvious. We therefore consider outcomes when including and excluding risk-neutral participants.

[19] p-values are at 0.002 or lower. A stronger test of the fourfold pattern is whether the majority of participants reflect as predicted or whether all participants have the predicted reflection. Throughout the paper we focus on the weaker test.

Figure 2: Risk Attitudes of Price-participants in the Price Task



Note: 32 participants, first-round decisions, percentages on vertical axis. The proportion with the predicted reflection between high- and low-probability prospects is 44% for gains and 56% for losses. For low-probability prospects 41% reflect as predicted between losses and gains, and for high-probability prospects 56% exhibit the reflection.

While Figure 2 allows us to look at the two-way reflection it is also of interest to determine whether the fraction of those who exhibit the entire fourfold pattern over the four prospects exceeds the fraction expected if people were equally likely to have any combination of risk attitudes. Looking only at first-round prices, we find that 10 of 32 price-participants, or 34 percent, report prices that are fully consistent with the fourfold pattern. At most 4 participants choose any of the other combinations of risk attitudes. Since there are 3 possible risk attitudes for 4 prospects, there are 81 possible combinations. Ignoring individuals with risk-neutral decisions there are 16 possible combinations. With p-values of less than 0.001 we reject the null that the proportion of all participants choosing the fourfold pattern at most equals 1/81, as well as the hypothesis that at most 1/16 of the participants who are never risk-neutral exhibit the fourfold pattern.

As a control for error, participants were given two opportunities to review and change their decisions. Most people chose to revise their decisions. Of 96 participants only 19 never changed any of their decisions between the first and third round. Recall that second-round decisions are made after all six prospects in a task are reviewed, and the third-round decision is made after the participant has completed both tasks and reviewed the decisions of all 12 prospects. The elicited risk attitudes over the three rounds are reported for the price-participants in Table 3a. The attitudes predicted by the fourfold pattern are highlighted. Although revisions slightly diminish the support for the fourfold pattern it remains across the three rounds. For every round we can reject the null that 1/3 or fewer of the price-participants choose prices consistent with the fourfold pattern. For the low-probability loss and for the two high-probability prospects we reject the null with p-values less than 0.01, for the low-probability gain prospect the p-value is instead 0.08 in the first round and less than 0.05 in the second and third round. Thus the fourfold pattern remains despite revisions.

To further study the robustness of the fourfold pattern under the price elicitation we also examine the prices that result when participants first have used the choice task and then evaluate the same prospects using the price task. Interestingly for these choice-participants the mean prices are also consistent with the fourfold pattern.[20] When we characterize each individual's

[20] For the gain prospects with 10%, 40% and 80% chance of winning the reported mean prices are $3.1, $6.9, and $12.0. For the three loss prospects the mean prices are -$4.5, -$7.8, and -12.4, respectively. When replicating Figure 2 for the choice-participants the modal choice continues to be that predicted.

risk attitude according to their reported price, the distribution of individuals is consistent with the fourfold pattern for all but the low-probability gain. While the p-value for the null is 0.2 for the low-probability gain it is less than 0.01 for the three other prospects. Thus independent of order we find that risk attitudes elicited with the price task are consistent with the fourfold pattern.

Table 3a: Price-participants in Price Task, Risk Attitudes by Prospect and Round

	Low Probability (p=0.1)						High Probability (p=0.8)					
	Gain (+$20)			Loss (-$20)			Gain (+$20)			Loss (-$20)		
	Round			Round			Round			Round		
Risk attitude:	1	2	3	1	2	3	1	2	3	1	2	3
Averse	19	16	16	69	66	63	88	78	75	13	22	22
Neutral	34	34	34	22	25	25	3	6	9	6	6	6
Seeking	47	50	50	9	9	13	9	16	16	81	72	72

Note: 32 participants, percentages in cells. Highlighted cells show the fourfold pattern predictions.

Table 3b: Choice-participants in Price Task, Risk Attitudes by Prospect and Round

	Low Probability (p=0.1)						High Probability (p=0.8)					
	Gain (+$20)			Loss (-$20)			Gain (+$20)			Loss (-$20)		
	Round			Round			Round			Round		
Risk attitude:	1	2	3	1	2	3	1	2	3	1	2	3
Averse	27	25	25	56	52	52	77	75	75	11	9	9
Neutral	34	36	36	22	23	25	8	11	11	11	11	11
Seeking	39	39	39	22	25	23	16	14	14	78	80	80

Note: 64 participants, percentages in cells. Highlighted cells show the fourfold pattern predictions.

5. Risk Attitudes from Choice Elicitations

While participants in the price task were asked to report a monetary equivalent for each of the six prospects, in the choice task participants only needed to decide whether they preferred the prospect or its expected value. Despite the prospects being the same across the two elicitations,

we do find very different results. We start by examining the initial choices by participants who only had been presented with the choice task. Table 4 shows the proportion of choice-participants choosing the gamble over its expected value, and the implied median risk attitude for the first round choices. Assuming that indifference causes individuals to randomize, the implied risk attitudes tend to be statistically indistinguishable from risk-neutrality, and if anything they are opposite of that predicted by the fourfold pattern.

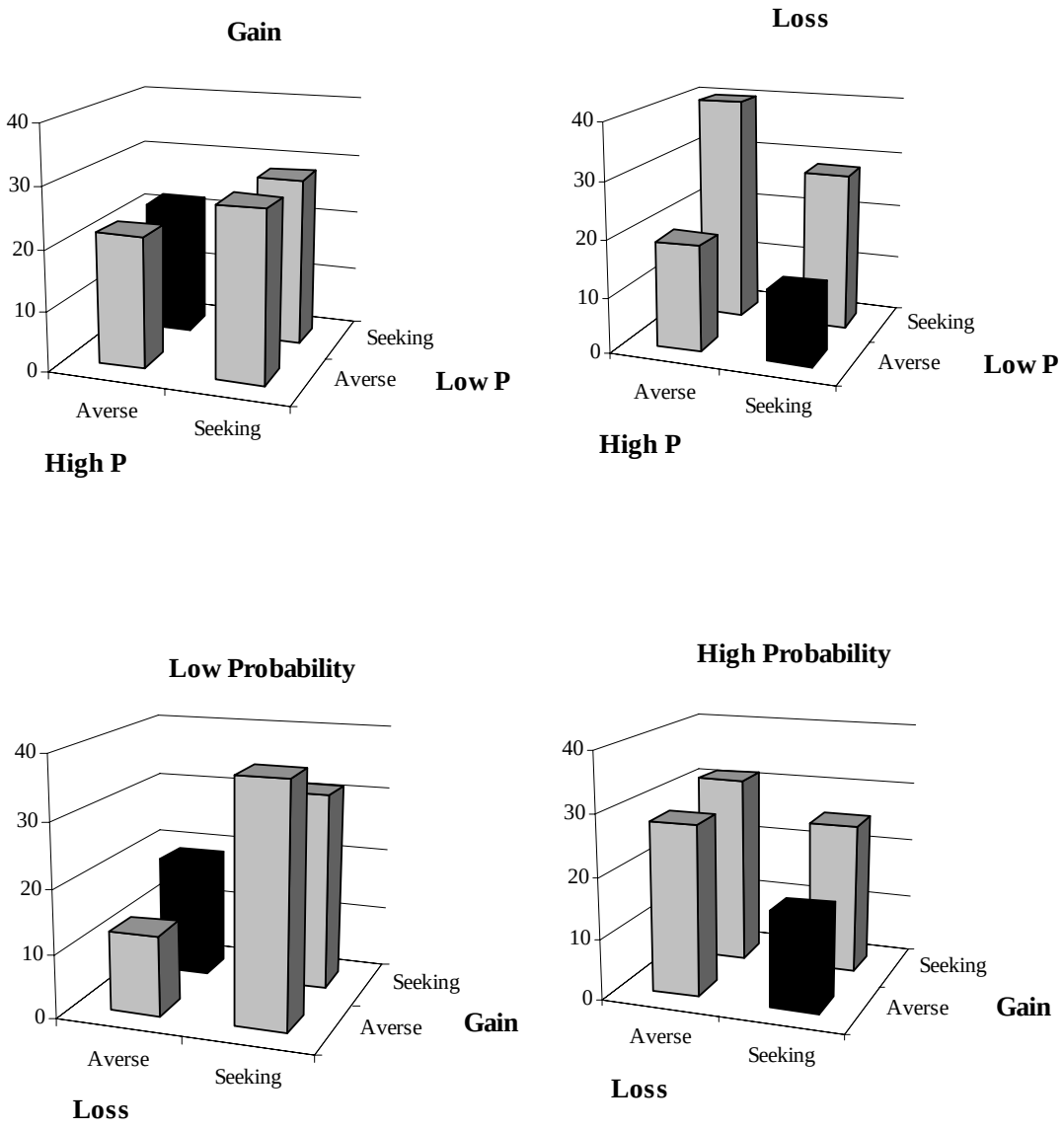
Table 4: Choice-participants in the Choice Task

Prospect		Expected Value	Percentage Choosing Gamble	p-value for Exact Test	Median Risk Attitude
Gain +$20	1. p=0.1	+$2	50.0	1.000	Neutral
	2. p=0.4	+$8	39.1	0.103	Averse
	3. p=0.8	+$16	56.3	0.382	Seeking
Loss -$20	4. p=0.1	-$2	68.8	0.004	Seeking
	5. p=0.4	-$8	56.3	0.382	Seeking
	6. p=0.8	-$16	40.6	0.169	Averse

Notes: 64 participants, first-round decisions. The test is an exact binomial test of the null hypothesis that the proportion choosing the gamble = 0.5.

The same result appears when we look at within-participant reflections in Figure 3. The first panel examines the reflection of risk attitudes between high- and low-probability prospects conditional on the prospect being a gain or a loss, and the second panel illustrates reflection when changing a loss to a gain conditional on it being a low- or high-probability prospect. The highlighted cells illustrate reflections consistent with the fourfold pattern.

Figure 3: Risk Attitudes of Choice-participants in the Choice Task



Note: 64 participants, first-round decisions, percentages on vertical axis. The proportion with the expected reflection between high- and low-probability prospects is 22% for gains and 13% for losses. For low-probability prospects 19% exhibit the predicted reflection between losses and gains, the comparable number of high-probability prospects is 16%.

The first noticeable difference from Figure 2 is that the distribution of risk attitudes is less extreme, and that a much smaller fraction of individuals exhibit the reflection predicted by the fourfold pattern. In fact, in three of the four cases the cell predicted by the fourfold pattern is

observed with the lowest frequency. Statistical tests of the reflections confirm what one would expect from the patterns in Figure 3. In none of the four cases can we reject the null hypothesis that at most 25 percent of participants make the predicted choices in favor of the fourfold pattern prediction: all p-values exceed 0.75. While risk attitudes do reflect between gains and losses and low and high probabilities – reflections are the modal outcome in each of the 4 cases –the pattern tends to be the opposite of the fourfold pattern. With the exception of the gain prospects, we can reject the hypothesis that, of the people who reflect risk attitudes, at least half reflect in the predicted manner.[21] The preferences elicited with the choice task also provide limited evidence for the entire fourfold pattern. Only 4 of 64 participants make choices consistent with the full fourfold pattern, precisely the proportion we would expect if the fourfold pattern had no predictive power.[22]

As with the price task the opportunity to revise decisions in the choice task does not result in much change in the elicited risk attitudes. Table 5a presents the attitudes for the three rounds of decisions for the choice-participants. We can't reject the hypothesis that at most half the participants make choices consistent with the fourfold pattern in any of the twelve cases. Most p-values are above 0.80 and the lowest is 0.13. The results are similar for the price-participants in Table 5b. All p-values are above 0.80 except for low-probability gains, and the lowest of those is 0.19. Thus our finding that the fourfold pattern does not arise in the choice-based procedure is robust to ordering and to the expected wealth effect from participation in the first task. It is particularly striking that the results remain in the third round when participants simultaneously review their price and choice decisions. While our results show strong support for the fourfold pattern in the price task, this is not the case in the choice task.

[21] p=0.298 when prospects are gains, whereas the p-value is below 0.050 in the three other cases.
[22] With p=0.573 we cannot reject the null that at most 1/16 choose the predicted pattern. Note also that 7 participants make choices that are exactly opposite the fourfold pattern, and 10 participants pick the expected value only for prospect 6.

Table 5a: Choice-participants in the Choice Task, Risk Attitudes by Prospect and Round

	Low Probability (p=0.1)						High Probability (p=0.8)					
	Gain (+$20)			Loss (-$20)			Gain (+$20)			Loss (-$20)		
	Round			Round			Round			Round		
Risk attitude:	1	2	3	1	2	3	1	2	3	1	2	3
Averse	50	44	42	31	36	34	44	45	45	59	56	58
Seeking	50	56	58	69	64	66	56	55	55	41	44	42

Note: 64 participants, percentages in cells. Highlighted cells show the fourfold pattern predictions.

Table 5b: Price-participants in the Choice Task, Risk Attitudes by Prospect and Round

	Low Probability (p=0.1)						High Probability (p=0.8)					
	Gain (+$20)			Loss (-$20)			Gain (+$20)			Loss (-$20)		
	Round			Round			Round			Round		
Risk attitude:	1	2	3	1	2	3	1	2	3	1	2	3
Averse	50	41	44	44	38	41	41	41	41	72	69	69
Seeking	50	59	56	56	63	59	59	59	59	28	31	31

Note: 32 participants, percentages in cells. Highlighted cells show the fourfold pattern predictions.

6. Discussion and Conclusion

Presenting participants with a few simple gambles we find that the fourfold pattern of risk attitudes is sensitive to the preference elicitation mechanism. While the fourfold pattern accurately characterizes people's pricing decisions, it does no better than chance at predicting their choices between gambles and the corresponding expected value. These results hold regardless of whether we start with the price or the choice task and are robust to simultaneously reviewing decisions under the two tasks.

Our study raises the question of why the elicited risk attitudes are consistent with the fourfold pattern under the price task but not under the choice task. One possible explanation is that the transparency varies between the two elicitation mechanisms. Making a choice between a lottery and a sure outcome is a simple and familiar task, while the pricing method used here and

in previous experiments is more complicated. Individuals have limited experience pricing objects and may find it particularly difficult to price a gamble. Perhaps the inexperience causes them to adopt rules of thumb that generate the fourfold pattern of risk attitudes. For example, participants may pick a naïve rule whereby the price is selected about halfway between the best and the worst outcomes of the gamble, but moved a bit towards the more likely outcome. While the price rule may be the same for gains and losses, the risk attitudes implied by these prices would be the reverse of one another. For example, if a 10 percent chance of $20 is assessed at $5 in the gain domain and -$5 in the loss domain, then the individual is said to be risk seeking over gains and risk averse over losses. Thus naïve pricing rules could give rise to the fourfold pattern. It may be argued that the similarity in the absolute value of the reported prices for losses and gains in Table 2 is consistent with similar pricing rules in the two domains. The BDM procedure used to secure that the price elicitation is incentive compatible may be another reason why the fourfold pattern arises in the price task. Even if well understood this procedure may bias the reported prices in favor of the fourfold pattern. Specifically, the bounds on the distribution of the randomly determined prices may truncate the reported willingness to pay for gambles of low expected value from the left, while those of high expected value are truncated from the right. Such a truncation can give rise to the fourfold pattern. Finally, the greater complexity of the BDM procedure may in and of itself cause the elicited preferences to differ between the two methods. As argued by the literature on dual selves, we may find greater behavioral anomalies when the cognitive load is high, because in such cases the restraint on the impulsive self is low. Thus the support of the fourfold pattern in the price task may be due to the cognitive load being greater than in the choice task.

Another reason why the price- and choice-based procedures elicit different preferences may be that they are less similar than they initially appear. While the evaluated prospects are the same, the possible payoffs vary between the two procedures. In addition to the randomly generated BDM price differing from the prospect's expected value, the potential outcomes of the price and choice task are rather different when evaluating gain prospects. In the price task participants are asked to pay for the gain gamble, whereas participants in the choice task are asked to choose between the gamble and its expected value.[23] Thus expected wealth is higher in

[23] This type of inconsistency is also present in previous comparisons between price and choice elicitations, see e.g. Slovic and Lichtenstein (1968).

the choice task and the prospect is solely in the gain domain. A participant either chooses the positive expected value or faces two possible outcomes: a gain of $20 or a gain of $0. In contrast it can be argued that the prospect in the price task is mixed over losses and gains. Specifically participants may end up paying for a gamble that does not win any money, thereby losing the BDM-generated price. The anticipation of such a loss may cause the elicited price to be influenced by loss aversion.[24]

While we cannot adjust for the differences between paying a randomly determined price versus the expected value, it is possible to make the price and choice procedure more similar in the gain domain. We conducted an additional treatment to examine if our results were sensitive to such a modification. Since the objective of the paper is to examine the support for, and procedural invariance of, the fourfold pattern of risk attitudes and since the price task clearly demonstrates this pattern, the choice task was revised to be more comparable to the price task. Specifically, participants were asked to choose whether they would give up the gamble's expected value in return for the gamble. In addition to modifying the choice task in the gain domain, we also expanded the participant's choice set to include an option of indifference.[25] That is, the participants could choose the prospect, its expected value, or a don't care option, where the flip of a coin determines whether they receive the expected value of the prospect or play the prospect.

A total of 32 new participants, from the same subject pool, participated in the new treatment. Participants were first given the new-choice task and then the original price task. Our results show, first, that very few participants select the 'don't care' option.[26] Second, our earlier finding is robust. With the exception of the low-probability gain the implied risk attitudes for the majority of participants in the choice task is the opposite of that predicted by the fourfold pattern. Furthermore, the reflections of risk attitudes are not consistent with the prediction.[27] In

[24] It may be argued that using a price task inherently results in mixed prospects. If participants instead were asked to state the amount they are willing to accept then a similar situation will arise over losses. Some participants would receive payments in return for accepting a negative prospect, and then not lose any money. Changing the price task to be similar to that of the choice task would require that we framed the price task in terms of willingness to pay in the loss domain and willingness to accept in the gain domain.

[25] In the price task participants indicate risk-neutrality by reporting that they are willing to pay the gamble's expected value to play the gamble.

[26] For each prospect, an average of 14.5% are indifferent.

[27] The proportion with the predicted reflection between high- and low-probability prospects is 16% for gains and 6% for losses. For low-probability prospects 16% reflect as predicted between losses and gains, and for high-probability prospects 6% exhibit the reflection.

none of the four examined reflections cases can we reject the hypothesis that the proportion reflecting according to the fourfold pattern is no larger than what we would expect from random choice.[28] With the exception of the low probability gain, the modal choices tend to be the exact opposite of the fourfold pattern prediction. In the three other cases, we reject the hypothesis that at least 50 percent of those who reflect risk attitudes do so in the predicted direction, with p-values below 0.004. Over the four relevant prospects none of the 32 participants made choices that were consistent with the full fourfold pattern. In fact the modal pattern was the exact opposite of the fourfold pattern, with 5 participants choosing this combination. After evaluating the six gambles with the new-choice task, participants were asked to evaluate the gambles using the price task. Examining these decisions we once again find that the risk attitudes derived with the price procedure are consistent with the fourfold pattern. Thus despite the greater similarity in the two procedures we continue to find evidence of the fourfold pattern in the price task, but not in the choice task.

Much like Slovic and Lichtenstein (1968) our results demonstrate that the price ordering of prospects can be very different from the choice ordering.[29] Looking only at third-round decisions we see that of the participants who were either risk-averse or risk-seeking in the price task, 42 percent had the opposite risk attitude when asked to evaluate the same gamble with the new-choice task.[30] If the majority of participants have one risk attitude in the price task then the majority of participants tend to have the opposite risk attitude in the choice task. For example, in the high-probability loss prospect, 3/4 of participants are willing to pay less than the gamble's

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[28] That is, we cannot reject that at most 1/9 of all participants reflect as predicted, nor can we reject that at most ¼ of the participants who never are risk-neutral exhibit the predicted reflection. The smallest p-value is 0.273.

[29] Their example involved two lotteries, one with a high probability of winning a small amount and the other with a low probability of winning a large amount, but with equal expected values. They showed that most participants choose the high probability lottery over the low probability one, but priced the low probability lottery higher than the high probability lottery (See Grether and Plott (1979) for a careful replication of these results). To explain this preference reversal they argue that when making a choice people focus on the probability of the prospects, but when determining a price they focus on the payoffs. It is not clear how one would apply this explanation to the present scenario.

[30] Tversky and Kahneman (1992) proposed that reversals of the Slovic-Lichtenstein type are caused by a tendency to overprice prospects. Thus, in the choice task participants should appear more risk-averse over gains. Since the predominant risk attitude in the choice task tends to be the opposite of that in the price task, the preference reversals between the two methods can not be explained by a systematic overpricing of prospects. Looking at third-round results over gains we find that 47 percent of the participants who were risk-averse in the price task become risk-seeking in the choice task, whereas only 36 percent of those who were risk-seeking in the price task become risk-averse in the choice task.

expected value to avoid the risky loss, yet half of these same participants choose the certain loss when given the choice between the gamble and a certain loss of the expected value.

The consequences of procedural variance in risk attitudes are substantial. Not only does it raise the serious question of determining which procedure is appropriate when eliciting risk attitudes, but it may also have important implications for how we choose to present risky outcomes. Consider for example a person purchasing a new car. She may have a choice between a car with a particular safety feature that will protect against a low probability of a large loss, and a car that does not have that feature. If this is perceived as a choice task, the car without the safety feature may be chosen. However, if the salesperson frames the decision as a feature available at an additional cost, it becomes a price task. The buyer may then approach the problem with a risk-averse attitude and buy the safety-equipped car.

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