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Working Paper

Eliciting risk preferences: Text vs. graphical multiple price lists

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Abstract

Eliciting risk preferences:
*Text vs. graphical multiple price lists**

We introduce new graphical displays that present binary choice lotteries via three dimensional rotating pie charts whose heights represent the prize amounts. We compare four graphical versions to the original text–only Holt & Laury (2002) multiple price list. Parametric and non–parametric measures of risk preferences are found to shift towards risk neutrality for the graphical displays.

Keywords: Multiple Price List, Elicitation, Risk Aversion, Experiment

JEL classification: C91, D81, D89

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1 Introduction

The Holt & Laury (2002) multiple price list (MPL) has, over the last decade or so, become the most widely used method for eliciting risk preferences (e.g., Andersen *et al.* (2006), Holt & Laury (2014), and Charness *et al.* (2013)). For each row in a MPL, subjects choose either Lottery A or B. Given parameters such as in Table 1, the vast majority of subjects would choose lottery A in the first row and lottery B in the last row, and an expected utility maximizing subject would switch at most once at some point in between. Such a subject who switches between rows 3 and 4 is revealed to be slightly risk seeking, for example, while one who switches between rows 8 and 9 is highly risk averse.

Our goal is to test the consistency and robustness of such risk preference elicitation. We compare MPL choices by the same subjects and the same MPLs across display modes. Besides the usual text (or tabular) display as in Figure 1, we also offer graphical displays similar to that in Figure 2.

		Lottery A		Lottery B		Calculated	
Row	prob1	A-prize1	A-prize2	B-prize1	B-prize2	EV[A]-EV[B]	$\hat{r}$
1	0.1	2.00	1.60	3.85	0.10	1.16	-1.71
2	0.2	2.00	1.60	3.85	0.10	0.83	-0.95
3	0.3	2.00	1.60	3.85	0.10	0.49	-0.49
4	0.4	2.00	1.60	3.85	0.10	0.16	-0.15
5	0.5	2.00	1.60	3.85	0.10	-0.17	0.15
6	0.6	2.00	1.60	3.85	0.10	-0.51	0.41
7	0.7	2.00	1.60	3.85	0.10	-0.84	0.68
8	0.8	2.00	1.60	3.85	0.10	-1.18	0.97
9	0.9	2.00	1.60	3.85	0.10	-1.51	1.37
10	1	2.00	1.60	3.85	0.10	-1.85	-

Table 1: Original Holt & Laury Multiple Price List parameters. The probability in each row of receiving the lesser prize (1.60 in Lottery A and 0.10 in Lottery B) is prob2 = (1-prob1). EV[L] denotes the expected value of lottery L. The last column shows the approximate solution $\hat{r}$ to the equation EU[A] = EU[B] at that line, where $U(x) = \frac{x^{1-r}}{1-r}$.
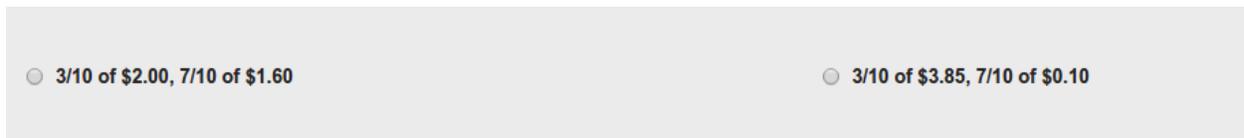

Figure 1: Text display for MPLa, row 3 only. Actual display stacks all 10 rows on the same page. Subject clicks a radio button to choose between the two lotteries.
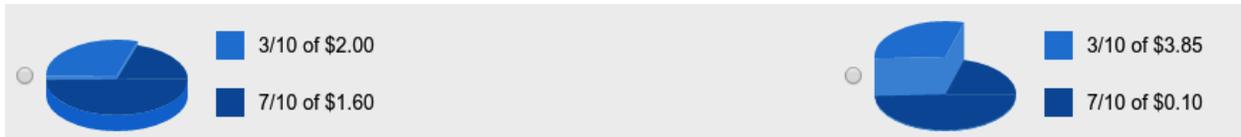
Figure 2: Graphical display TT for MPLa, row 3 only. Actual display stacks all 10 rows on the same page. Subjects can rotate each pie by clicking on it. Wedge angles encode probability and wedge height encodes prize amount.

Since a 10 row graphical MPL conveys precisely the same lottery choices as a standard 10 row text MPL, a consistent expected utility maximizing subject would make the same choices and reveal the same risk preferences across display modes. However, it is possible that different displays will engage subjects differently. For instance, the graphical display may make it easier for the subject to aprehend the expected values, which are proportional to the volumes of the displayed pies. An alternative hypothesis therefore is that the graphical display will encourage subjects to reveal preferences closer to risk neutral.

2 Experiment

We test 4 variations of the graphical displays against the standard text display. Treatment TT is as in Figure 2, while treatment TF suppresses the text label for prize amounts, FT suppresses the text label for the probabilities, and FF suppresses both labels in the graphical display. The fifth display treatment, Text, suppresses the graphical display, and shows only the standard text lines defining the two binary lottery choices as in Figure 1.

The other treatment variable is the MPL parameter schedule. Treatment MPLa is shown in Table 1, treatment MPLb subtracts 0.05 from all prizes and switches the two columns, treatment MPLc adds 0.15 to all prizes in MPLa and reverses the row order, treatment MPLd replaces all prizes amounts in MPLa by their square roots (rounded to the nearest 0.01), and treatment MPLe replaces all prizes amounts in MPLa by their (rounded) squares.

Our experiment exposes each subject to each of the 5 MPL schedules and each of the 5 displays. This can be done in a sequence of 5 trials, but since there are $5! \times 5! = 14400$ different sequences, a full factorial design is impractical. We employ a fractional factorial design using just 25 of the sequences chosen so that each display and each MPL appears exactly 20% of the time in each of the five positions, and the two treatments vary independently.

Each subject completes two of the chosen 25 sequences, selected so that no subject sees any MPL twice in the same display. E.g., if she sees Text-MPLa somewhere in the first

	r			s		
Treatment	mean	s.d.	Nobs.	mean	s.d.	Nobs.
FF	0.45	0.59	40	1.80	2.20	47
FT	0.50	0.55	40	1.93	1.89	47
Text	0.55	0.52	41	2.13	1.84	47
TF	0.43	0.60	38	1.64	1.98	47
TT	0.56	0.55	38	1.98	1.84	47
MPLa	0.49	0.39	40	1.62	1.39	47
MPLb	0.66	0.52	38	1.71	1.67	47
MPLc	0.41	0.38	40	0.59	1.43	47
MPLd	0.30	0.91	40	1.37	1.71	47
MPLe	0.64	0.28	39	4.20	1.46	47

Table 2: Summary statistics by treatment in display sequence 1. For the parametric (r) and non-parametric (s) performance variables defined in the text, the average (mean) and standard deviation (s.d.) across all (Nobs) subjects in each treatment are shown.

sequence, then in the second sequence (trials 6-10) MPLa is displayed graphically.

Subjects are drawn from the LEEPS lab pool at UCSC. We report results from four sessions with a total of 47 subjects. Sessions begin with instructions describing the MPL choices and all display types. Subjects then proceed to make practice decisions in a sequence of 5 displays of the same practice MPL. Then subjects complete the 5 screens for sequence 1, and finally the 5 screens for sequence 2. Subjects are paid the realized outcome of their chosen lottery in a randomly chosen line from a randomly chosen trial, plus a $7 show-up fee. Sessions lasted about 45-60 minutes and average payout was around $10.

3   Results

Each subject makes 100 binary choices: either column A or column B in each of 10 rows of an MPL display in each trial of two 5-trial sequences. We summarize each trial outcome in two performance variables:

- r = the mean of $\hat{r}$ for the line just before and just after the unique column switch, and

- s = number of safe choices (from the column with prizes close together, e.g., 1.60 or 2.00 in MPLa) less number of rows where the safe choice has the larger EV.

4

The variable r is commonly used in the literature, but it depends on a particular parametric form (CRRA) and is sometimes not well defined. Following standard practice, in our r analysis we exclude trials with more than one column switch, or none: about 16% of observations. The non-parametric variable s is always well defined, even in the case of multiple switches. For example, in MPLa, the safe choice is Lottery A, and it has the larger expected value only in the first 4 rows. Suppose that the subject chose lottery A in rows 1-5 and 7 of an MPLa trial. Then $s = 6 - 4 = 2$ for that trial, while r is not defined due to multiple switches.

Table 2 collects summary statistics. It shows a very rough consistency across most treatments, and considerable variation across subjects' choices within each treatment. To save space, the analysis below focuses on s, but supplementary results (available on request) using r are qualitatively similar.

3.1 Treatment Effects

Table 3 reports the results of a series of dummy regressions of all the display treatments (text excluded) and MPLs (MPLa excluded) for the non-parametric variable s. The signs of all estimated display coefficients are consistent with the alternative hypothesis that graphical displays encourage more nearly risk-neutral choices. The estimated impact is larger — about half a row on average in the first 5-trial sequence — in the treatments (FF and TF) that suppress the text for prize size. Display treatment effects are consistently smaller in the second sequence, as one might expect in a within-subject design. Even with our relatively small data sample, the TF coefficient is significant at the 10% confidence level in the first sequence and overall.

The MPL treatments a, b and d seem indistinguishable, as indicated by the economically and statistically insignificant coefficients in the MPLb and MPLd rows of the Table. By contrast, MPLc pushes choices towards risk neutrality — a whole row, statistically significant at the 1% level — and MPLe pushes behavior drastically towards risk aversion. The latter treatment effect of 2.5 to 2.8 rows may be due to an artifactual row effect documented in Bosch-Domènech & Silvestre (2013), since the safe choice has the larger expected value in only one row (the first) in MPLe versus four rows in most other MPLs.

An analogous regression (available on request) for the parametric performance variable r delivers qualitatively similar display treatment results, and less dramatic MPL treatment results.

	Dependent variable: s		
	display seq. 1	display seq. 2	full sample
	(1)	(2)	(3)
FF	−0.470 (0.302)	−0.103 (0.336)	−0.288 (0.225)
FT	−0.189 (0.302)	−0.147 (0.336)	−0.170 (0.225)
TF	−0.534* (0.302)	−0.336 (0.336)	−0.436* (0.225)
TT	−0.225 (0.302)	−0.076 (0.336)	−0.151 (0.225)
MPLb	0.199 (0.302)	−0.008 (0.336)	0.097 (0.225)
MPLc	−1.004*** (0.302)	−1.056*** (0.336)	−1.028*** (0.225)
MPLd	−0.047 (0.302)	−0.432 (0.336)	−0.238 (0.225)
MPLe	2.826*** (0.302)	2.323*** (0.336)	2.575*** (0.225)
Constant	1.876*** (0.288)	1.784*** (0.316)	1.830*** (0.213)
Observations	235	235	470
R^2	0.451	0.343	0.392

Note:			*p<0.1; **p<0.05; ***p<0.01

Table 3: Coefficient estimates (and standard errors) for performance variable s, of treatment variable dummies relative to the omitted treatments Text and MPLa.

3.2 Within subject tests

Since our design exposes each subject to each treatment twice, we can make within subject comparisons. These are potentially sharper in that they eliminate persistent individual idiosyncrasies from the pooled comparisons considered above. On the other hand, the within subject comparisons would be blunted by learning dynamics if subjects transfer insights gained from one treatment to subsequent treatments.

Table 4 summarizes the within subject effects of the display treatments. All estimated coefficients are positive, confirming the conclusion that graphical displays push subjects towards risk neutrality. The first column estimates consistently have larger magnitude than the corresponding regression coefficients in Table 3, suggesting that the within subject com-

Diff	Seq1	Seq1ne	Seq2	p-values
Text vs FF	0.510	0.214	0.148	0.15, 0.48, 0.63
Text vs FT	0.234	0.357	0.170	0.52, 0.28, 0.64
Text vs TF	0.574	0.964***	0.404	0.11, 0.00, 0.20
Text vs TT	0.234	0.074	0.085	0.52, 0.79, 0.77
Text vs all Graph	0.388	0.405**	0.202	0.18, 0.07 , 0.42

*** p<0.01, ** p<0.05, * p<0.1

Table 4: Within subject difference (Text-Graphical) in performance variable s. Column Seq1ne, with Nobs = 27, excludes differences involving MPLe. Columns Seq1 and Seq2 each have Nobs = 47. The last column shows p-values associated with the Diff=0 null hypothesis for the preceding three columns.

parisons tend to be a bit sharper. In the second column the largest effect again is for the TF treatment; once comparisons involving the anomalous parameter set MPLe are removed, the size of the effect is almost one full row, significant at the 1% level. A nonparametric Wilcox signed rank test gives qualitatively similar results.

Do subjects reveal less risk aversion over time? The means suggest so: the mean over the 47 subjects of average s in Sequence 1 (as in Table 2) minus that in Sequence 2 is 0.17, significant at the 10% level. More specifically, do subjects reveal less risk aversion with the standard display, Text, after they are exposed to graphical displays? The mean difference for Text over the 47 subjects is 0.32, and economically significant decline but (since there are only 1/5 as many observations) not statistically significant. Similar conclusions arise in comparisons using the parametric performance variable r and using non-parametric signs tests on s.

4 Conclusion

Camerer (1989) conjectured that a graphical display showing both probability and prize amounts in binary lotteries would tend to encourage more nearly risk-neutral choices. Our Multiple Price List (MPL) experiment introduces an interactive 3-d graphical display of that sort, and our results support Camerer's conjecture. We reject the null hypothesis that subjects respond only to the lottery parameters and not to the display. Relative to the usual text-only display, our subjects make more risk neutral choices on average in all four graphical treatments. This is true for each of the 5 MPLs we consider, and the differences are often statistically significant even with our relatively small sample size.

Our finding can be interpreted in several ways. One can think of each elicitation procedure as having its own bias, and our new treatment variations all happen to have a bias towards risk neutrality. Alternatively, one can think of subjects as trying out various heuristics in an unfamiliar setting, and our new graphical treatments encourage them to use heuristics that offer higher expected payoffs. Consistent with this second interpretation, we find evidence that subjects on average reveal less risk aversion in the standard text-only display after they have encountered more graphical displays.

Another finding is consistent with results of previous studies such as Bosch-Domènech & Silvestre (2013) and James (2007). Different MPL parameters yield large and statistically very significant differences in revealed risk aversion. These differences fade somewhat with repetition, but remain significant.

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Appendix A Instructions

Welcome! You are about to participate in an experiment in the economics of decision-making. If you listen carefully and make good decisions, you could earn a considerable amount of money that will be paid to you in cash at the end of the experiment.

Please remain silent and do not look at other participants' screens. If you have any questions or need any assistance, please raise your hand and we will come to you. Do not attempt to use the computer for any other purpose than what is explicitly required by the experiment. This means you are not allowed to browse the Internet, check email, etc. If you interrupt the experiment by using your smart phone, talking, laughing, etc., you may be asked to leave and may not be paid. We expect and appreciate your cooperation today.

A.1 The Basic Idea

This experiment is composed of ten segments. In each of which you are asked to make a sequence of ten choices/decisions between two lotteries presented to you. Each decision is a paired choice between "Option A" and "Option B." In each segment you will make ten choices and record them by clicking the radio button next to the option you chose, A or B. To determine you payment, we will randomly pick one of the ten segments by rolling a ten-side die, we will then randomly select one of your ten choices within that segment by another roll of the ten-sided die. Final payment will be determined by the outcome of your chosen lottery, which will be determined by a third and final roll of a ten-sided die.

Before you start making your choices, please let me explain in more detail how these choices will affect your earnings. Here is a ten-sided die that will be used to determine payoffs; the faces are numbered from 1 to 10 (the "0" face of the die will serve as 10.) After you have made all of your choices, we will throw this die three times, once to select one of the ten segments to be used, a second time to determine one of the ten choices for that segment, and a third and final time to determine what your payoff is for the option you chose, A (left) or B (right), for the particular decision selected. Even though you will make ten decisions per segment, only one of these will end up affecting your earnings for that segment, but you will not know in advance which decision will be used.

Figure A.1: Text Display

A lottery is defined by probabilities and a set of payoffs associated with these probabilities. As shown in the example in figure A.1, you will be asked to choose between lottery A (on the left), which offers you a payoff of $3 with probability 0.3 (30%) and a payoff of $2.50 with probability 0.7 (70%), and lottery B (on the right), which offers you a payoff of $4.82 with probability 0.3 (30%) and a payoff of $0.10 with probability 0.7 (70%).

Again, in a given segment, you will face a list of ten pairs of lotteries. You must make one choice between the two displayed lotteries for each of the ten pairs in the list. Payment for the experiment will be based on the lotteries you choose. A random segment is picked and a random line will be chosen for payment by a roll of a die and payment will be determined for each subject by the outcome of the chosen lottery (also by a roll of a die) on the randomly selected line.

A.2   Display Types

A.2.1   text Only

The following example illustrates one of the displays you will be seeing in this experiment. In the text only display you will be facing a list of different lotteries of the same form as in A.1. As you can see the probabilities and payoffs are displayed in text. In this specific line the lottery on the left has payoffs $3 with probability 0.3 (30%) and a payoff of $2.50 with probability 0.7 (70%), and lottery B (on the right), which offers you a payoff of $4.82 with probability 0.3 (30%) and a payoff of $0.10 with probability 0.7 (70%). You are to choose one of the two lotteries on this line for payment.
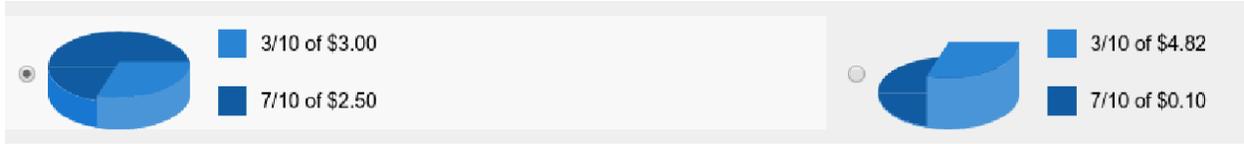
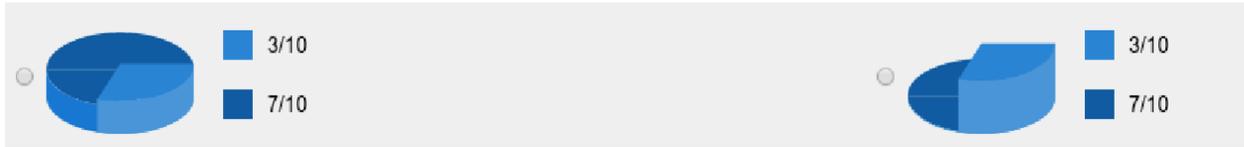Figure A.2: TT Display: Graphical with text prize and probability

Figure A.3: TF Display: Graphical with text probability only

A.2.2 Full graphics with payoff and probability in text

In this segment we combine a graphical and text representation of probabilities and payoffs. As demonstrated in figure A.2This display type will feature the probability of a given payoff in the size of the pie slice while the payoff is represented by the height of the pie slice. Therefore, a pie with two different (in color and volume) wedges represents each lottery; the size of a given wedge represents the probability while the height of the wedge represents the payoff. In order to get a full picture of the wedges you can rotate the pie graphs to the left and right by sliding your mouse over the figure (you don't need to click).

It's important to point out that both lotteries (A and B) are displayed on the same scale. This means that if a payoff in lottery A is $2 and a payoff in lottery B is $4, then the height of the $4 payoff in lottery B is twice as high as the height of the $2 payoff in lottery A. This is also true for payoffs in the same lottery. If lottery A pays $2 or 0.20, then the height of the $2 payoff will be ten times as high as the $0.20 payoff in the same lottery.

A.2.3 Full graphics with probability in text

This display type is similar to the full graphics with text. As you can see in figure A.3, the only difference is that now payoff is represented only in a graphical form (in the height of the pie slice), while the probabilities are display in text as well as graphically (in the size of the pie slice).
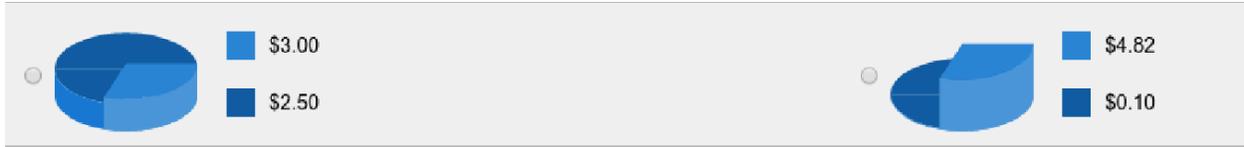
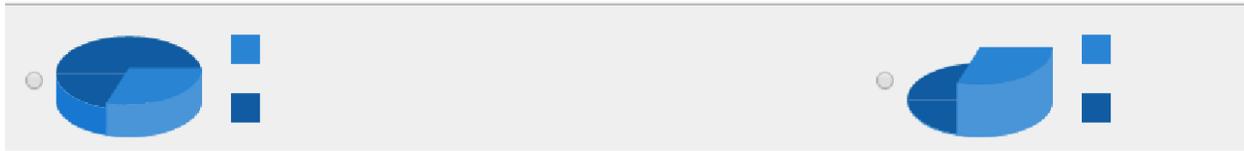Figure A.4: FT Display: Graphical with text prize only

Figure A.5: FF Display: Graphical with no text

A.2.4 Full graphics with payoff in text

This display type is similar to the full graphics with text. The only difference is that now probabilities are represented only in a graphical form (in the size of the pie slice), while the payoffs are display in text as well as graphically (in the height of the pie slice).

A.2.5 Fully graphical

This segment removes all text from the list and represents the lotteries in a fully graphical manner. The lotteries are again displayed with the probabilities represented by the size of the pie slice and the payoffs represented by the height of the pie slice. There is no text displaying probabilities or payoffs. Each lottery is fully characterized by the height and size of the pie wedges.

Are there any questions? Now you may begin making your choices. Please do not talk with anyone while we are doing this; raise your hand if you have a question.

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