List construction and lottery presentation modulate multiple price list responses

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January 20, 2016

Abstract

Multiple price list (MPL) elicitation of risk preferences is familiar through the Holt & Laury (2002) procedure. We assess the impact of varying list order and spacing, and the presentation via text and/or graphics. Some nonlinear transformations of lottery prices systematically increase elicited risk aversion, and graphical displays tend to reduce it, relative to the original MPL.

Keywords Multiple Price List, Elicitation, Risk Aversion, Experiment
JEL Classification C91, D81, D89

Acknowledgement We are grateful for support from the National Science Foundation under grant SES-1357867. As usual, the NSF played no role in the design of our study, nor in the collection, analysis and interpretation of data, nor in the writing of the report, nor in the decision to submit the article for publication. We also thank Tobias Schmidt for a helpful pointer to previous literature.

1 Introduction

Judging from its thousands of cites, the Holt & Laury (2002) Multiple Price List (MPL) procedure may now be the most widely used tool to elicit risk preferences. For each row in a MPL, subjects choose either Lottery A or B. Given the parameters in the first six columns of 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.

		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: The original Holt & Laury Multiple Price List parameters appear in the first six columns. 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). The remaining two columns show the difference in expected values of the two lotteries, and the approximate solution $\hat{r}$ to the equation EU[A] = EU[B] at that line, where $U(x) = \frac{x^{1-r}}{1-r}$.

Given the widespread use of MPLs, it is important to explore its sensitivity to perturbations. Bosch-Domènech & Silvestre (2013) finds that cropping the original Holt-Laury list of lottery choices leads to systematically different crossovers than in the original, and thus to different inferred preferences. Lévy-Garboua *et al.* (2012) finds that reversing the order in which the choices between lotteries are presented changes the inferred preferences, as does changing how much of the list the subjects can see at any one time. (The original Holt-Laury procedure presents all 10 choices at once, in a single list.)

The present paper continues the exploration. We too modulate list construction, but not by cropping the list. Instead we apply nonlinear payoff transformations (used in the first price auction by Cox *et al.* (1988) and in Becker-DeGroot-Marschak byJames (2007)). We also reverse the order of the MPL (as in Lévy-Garboua *et al.* (2012)) and add 0.15 to all prizes, or subtract .05 from all prizes and switch the left-right position of the columns.

We compare choices by the same subjects to all these MPLs, as well as their choices 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. None of our modulations would have any impact on expected utility maximizers, but several of them turn out to have economically and statistically significant effects on our human subjects.

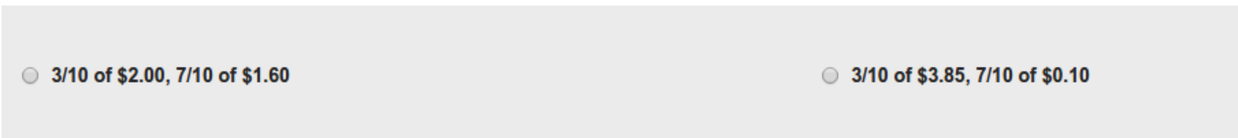

Figure 1: Text display for MPLa, row 3 only. Actual display stacks all 10 rows on the same page. Subject clicks a radio button to choose between the two lotteries.

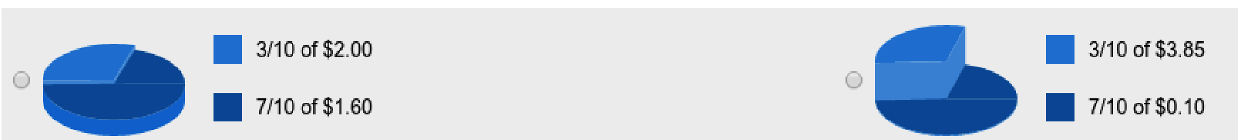

Figure 2: Graphical display TT for MPLa, row 3 only. Actual display stacks all 10 rows on the same page. Subjects can rotate each pie by clicking on it. Wedge angles encode probability and wedge height encodes prize amount.

2 Experiment

We test four 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 the first six columns of Table 1. Treatment MPLb subtracts 0.05 from all prizes and switches the A prizes (columns 3-4 of the Table) with the B prizes (columns 5-6). 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 to 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 schedule 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. For example, if she sees Text-MPLa somewhere in the first 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.

The natural null hypothesis is that none of our treatments has any systematic effect on subjects' choices. However, it is possible that different displays will engage subjects differently. For instance, as conjectured by Camerer (1989), the graphical display may make it easier for the subject to apprehend the expected values, which are proportional to the volumes of the displayed pies. An alternative hypothesis therefore is that the graphical displays will encourage subjects to reveal preferences closer to risk neutral.

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

	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.

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. 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.

	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.

MPL treatments a and b are indistinguishable, meaning that switching the left-right positions of the A and B columns in Holt-Laury does not change risk preference estimates. Likewise, we can not reject the null hypothesis that treatment MPLd, using square root transforms of payoffs, yields the same estimates as MLPa. However, reversing the top-to-bottom ordering of the lotteries in treatment MPLc does change parameter estimates; they move significantly closer to risk neutrality, consistent with a result reported in Lévy-Garboua *et al.* (2012). Treatment MLPe, implementing square transforms of payoffs, has a major impact in the opposite direction, yielding far more risk averse estimates of subjects' preferences than MPLa. This last result is consistent with results reported in Cox *et al.* (1988) for first price sealed bid auctions and in James (2007) for the Becker-DeGroot-Marschak procedure.

An analogous regression (available on request) for the parametric performance variable

r delivers qualitatively similar display treatment results, and similar but less dramatic MPL treatment results.

3.2 Within subject tests

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.

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, consistent with the hypothesis 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 comparisons 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 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

We affirm and extend earlier work on sensitivity of MPL-elicited risk preference estimates to the substance and form of the list of choices. Reversing the row order tends to make our subjects appear more risk-neutral, and taking a convex transform of the prize amounts tends to make our subjects appear much more risk averse. Holding constant the list construction, using more graphical presentation of the lotteries tends to make our subjects appear more risk-neutral.

It is beyond the scope of the present paper to seek models that can rationalize our results, or to otherwise interpret them. Together with earlier work, the results alone suggest that empirical researchers should exercise caution in applying standard risk elicitation procedures.

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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.

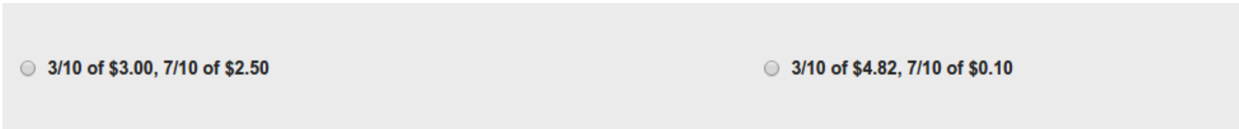

Figure A.1: Text Display

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.

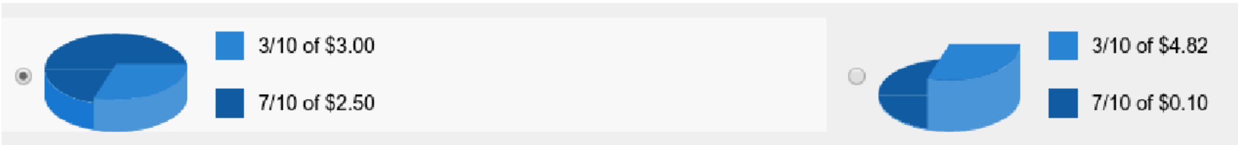

Figure A.2: TT Display: Graphical with text prize and probability

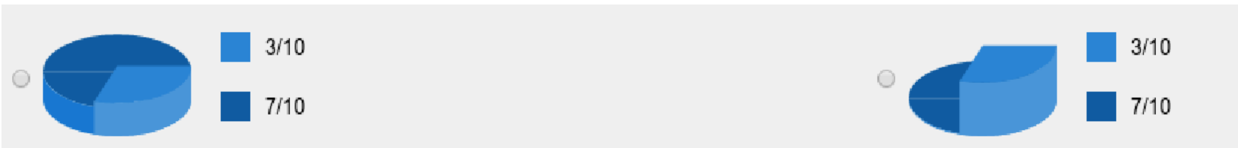

Figure A.3: TF Display: Graphical with text probability only

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).

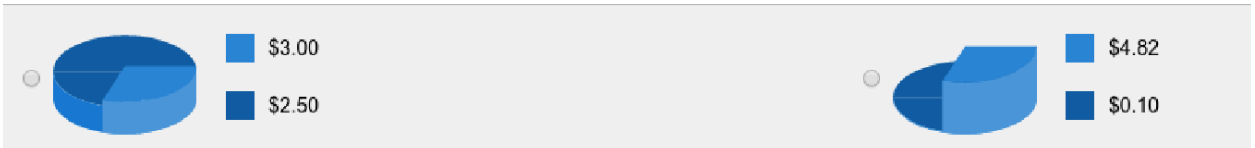

Figure A.4: FT Display: Graphical with text prize only

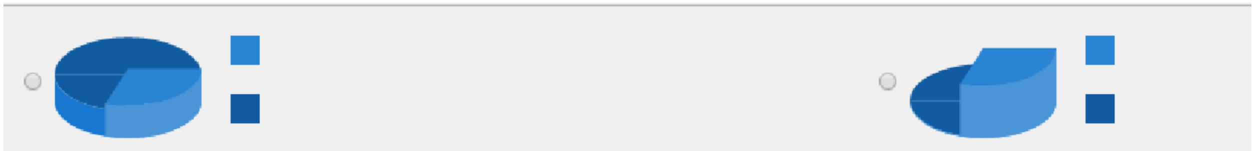

Figure A.5: FF Display: Graphical with no text

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.