ELICITING RISK PREFERENCES USING CHOICE LISTS

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Abstract. We study the effect of embedding pairwise choices between lotteries within a choice list on measured risk attitude. Using an experiment with online workers, we find that subjects choose the risky lottery rather than a sure payment significantly more often when responding to a choice list. This behavior can be rationalized by the interaction between non-expected utility and the random incentive system, as suggested by Karni and Safra (1987).

Keywords: random incentive system, isolation, independence axiom, multiple price list, reduction of compound lotteries, preference reversals, certainty effect.

1. Introduction

A preference relation is, by definition, a binary relation over alternatives. As such, the "gold standard" for revealing preferences through choice is the observation of a single pairwise choice. However, such an experiment provides very limited information about individual preferences – for example, it cannot reveal a lottery's certainty equivalent. To elicit finer information about preferences, a common experimental practice presents a subject with a sequence of related pairwise choices arranged in a list, known as a Choice List (or Multiple Price List). A randomization device is used to pick one decision to determine the subject's payment, a procedure known as the Random Incentive System (RIS). In recent years, choice lists have become the workhorse method in experimental economics to measure individual preferences. Usually, each pairwise choice a subject makes in a list is interpreted as if she had faced only a single pairwise choice (Bardsley, Cubitt, and Loomes, 2009, pages 272-273).

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This paper investigates whether subjects' choices between lotteries are influenced by whether or not they are embedded in a choice list. In one group of treatments, subjects respond to one or two choice lists. In a second group of treatments, subjects make a single (or two) pairwise choice(s); each such choice corresponds exactly to a single line of the corresponding choice list.

We find that embedding a pairwise choice in a choice list increases the fraction of subjects choosing the riskier lottery from 23% to 45% when the safer alternative is certain ($p < .001$), but does not significantly affect choices when the safer alternative is risky ($p = .17$). This suggests that embedding choices in a list can affect subjects' responses, especially when comparing sure outcomes to risky lotteries.

Our findings suggest an interaction between the choice list and subjects' risk preferences. Experiments have consistently shown that decision makers tend to be particularly averse to risk when a riskless option is available, compared to situations where certainty is absent – the so-called *certainty effect* (Allais, 1953).[1] Since in expected utility risk aversion is captured solely by the curvature of the utility function over payments, this behavior can only be accomodated by non-expected models. We conjecture that the list presentation induces subjects to account for the risk generated by the RIS, eliminating the "certainty" attribute from a riskless alternative, and thereby affects their choices in the experiment. Below, we provide a simplified example that demonstrates how this approach can account for our findings.

Our work includes a practical recommendation for experimentalists who would like to continue to use the more precise information contained in choice lists. We believe that the between-subject design employed in the current study, in which a control group of subjects who make a single pairwise choice is used to test for systematic bias in the choice list, could and should be easily incorporated in future studies – particularly for studies involving choices between risky and riskless alternatives.

How Non-Expected Utility Rationalizes our Results. Consider a subject with the following preferences over lotteries. She prefers receiving \$3 for sure to the lottery that has an 80% chance of paying \$4 and zero otherwise, but prefers \$4 if it is paid with probability of 90%; denote this preference by $(\$4, .9) \succ (\$3, 1) \succ (\$4, .8)$. However, she also prefers the lottery where she receives \$4 with a 40% chance to the lottery where she receives \$3 with a 50% chance, denoted by $(\$4, .4) \succ (\$3, .5)$. These preferences exhibit the certainty effect (as the probabilities in the latter pair of lotteries are

[1]See Section 6 in Cerreia-Vioglio, Dillenberger, and Ortoleva (2015) for a recent discussion of this evidence.

exactly half of the first pair), so they violate the independence axiom by exhibiting a greater preference for a safer option when it is riskless. If this subject faces an experiment where she makes a single choice between $(\$4, .8)$ and $(\$3, 1)$, she would choose the safer option – $(\$3, 1)$. If instead she faces an experiment where she makes a single choice between $(\$4, .4)$ and $(\$3, .5)$, she would choose the riskier option – $(\$4, .4)$.

Now consider an experiment in which this subject is asked to make two choices, displayed in a list and incentivized using the RIS, so one line will be chosen at random for payment. In line 1 of the list, the subject chooses between $(\$3, 1)$ and $(\$4, .9)$, while in line 2 of the list the subject chooses between $(\$3, 1)$ and $(\$4, .8)$.

Suppose the subject chooses $(\$4, .9)$ over $(\$3, 1)$ in line 1 of the list, according to her original preference. Then, she has at least a 5% chance of making \$0 in the experiment, since there is a 50% chance that her choice in line 1 will be selected by the RIS to determine her payment. The choice list makes apparent to the subject that choosing $(\$3, 1)$ in line 2 of the list would not guarantee a sure prize. As line 2 has no truly certain option now, the certainty effect evident in her underlying preference $(\$3, 1) \succ (\$4, .8)$ is no longer at play, making the riskier option $(\$4, .8)$ more attractive when embedded in the list. Thus, the certainty effect can lead to different behaviors in this experiment as compared to an experiment with only a single choice.

But now consider how the subject would instead behave in a second list, involving choices away from certainty, where the above winning probabilities are halved for all options. In line 1 of this list, the subject chooses between $(\$3, .5)$ and $(\$4, .45)$, while in line 2 of this list the subject chooses between $(\$3, .5)$ and $(\$4, .4)$. In this list, all options in both lines are risky. The RIS and the subject's choice in line 1 changes the risk faced by the subject in line 2, but does not alter the fact that line 2 is a choice between two risky options. Similar to the first list, the subject's choices in line 2 may not reveal her true preference, but unlike the first list, we have no strong reason to believe that the RIS will systematically bias subjects' choices in either direction.

The above example shows that when a subject makes a single choice, certainty is certainty. But when the subject makes more than one choice under the RIS and the subject takes this into account, choosing a sure option in one question may no longer give the subject certainty, and thus the certainty effect will not affect decisions. We believe that the list presentation makes the presence of many choices and the RIS particularly evident to subjects, making subjects particularly likely to account for them when making decisions. In Section 4, we show that leading models of the certainty effect, including cautious expected utility (Cerreia-Vioglio, Dillenberger, and Ortoleva, 2015), can be applied to model the results of our experiment.

Related Literature. Experimental economists have long been concerned with the conditions under which a mechanism for eliciting preferences is *incentive compatible* – that is, the ranking between any two alternatives inferred from the mechanism coincide with how the subject would choose between these alternatives if she faced a single pairwise choice. By definition, an experiment with a single pairwise choice is incentive compatible and reveals underlying preferences. Becker, DeGroot, and Marschak (BDM, 1964) proposed a convenient method for measuring the valuation of an alternative by asking a subject to match an alternative to a value (a "matching" task). The BDM mechanism is incentive compatible if subjects' preferences satisfy a version of the independence axiom.[2] The "preference reversal" literature demonstrated that BDM-elicited valuations can be systematically inconsistent with subjects' pairwise choices among lotteries (Grether and Plott, 1979). The psychology literature has suggested that since subjects respond by stating a number (rather than making a pairwise choice), this response mode might lead to differences in behavior as compared to choice tasks (Lichtenstein and Slovic, 1971), independently of incentives. Alternatively, theoretical work by Karni and Safra (1987) and Segal (1988) suggested that in incentivized experiments, failure of a version of the independence axiom may rationalize the systematic inconsistencies between BDM-elicited valuations and pairwise choices.[3]

Meanwhile, the experimental economics literature (confronted with the challenges involving the BDM in other domains) opted to use choice lists (e.g. Cohen, Jaffray, and Said (1987); Andersen, Harrison, Lau, and Rutström (2006)), which have become the workhorse method of experimental economists studying individual preferences. Choice lists are a discrete implementation of the BDM through a sequence of related pairwise choices.[4] It has been pointed out that such a design will be incentive compatible under Kahneman and Tversky's (1979) "isolation hypothesis" - the hypothesis that a subject, when making multiple decisions, makes each decision as if

[2]The original BDM mechanism asked subjects to report a monetary valuation. A variation of the BDM where subjects report by matching a probability was used by Grether (1981) and studied by Karni (2009).

[3]Holt (1986) pointed out that when the independence axiom is not satisfied, subjects may respond differently to a single matching task (BDM) and to few matching tasks incentivized by the RIS.

[4]A choice list with varying probabilities, like the one used in the present study, was first used (without incentives) by Davidson, Suppes, and Siegel (1957), revisited by McCord and De Neufville (1986), and was revisited (with the RIS) by Sprenger (2015).

she faced that decision in isolation. Starmer and Sugden (1991) and Cubitt, Starmer, and Sugden (1998) studied the incentive compatibility of RIS in experiments where a subject makes a small number of pairwise choices, but could not statistically reject incentive compatibility. More recently, Cox, Sadiraj, and Schmidt (2014; 2015) use comparable designs to Starmer and Sugden but find evidence against the incentive compatibility of RIS (we discuss these studies in greater detail in Section 4.3), as do Harrison and Swarthout (2014), who compare subjects who make a single choice to subjects who make a large number of choices.

None of the aforementioned experimental studies of incentive compatibility use choice lists. Moreover, the earlier experimental papers that support incentive compatibility when subjects make a small number of pairwise choices have been taken to justify the use of choice lists. For example, Bardsley, Cubitt, and Loomes (2009, pages 272-273) conclude that since a choice list is basically a sequence of pairwise choices, individuals will approach them in this way (i.e. isolate), unlike BDM - in which the response mode is different (i.e. subjects are asked to state a numerical valuation rather than make a direct choice). This justification ignores the existing theoretical analysis (Karni and Safra, 1987; Segal, 1988) of the BDM mechanism, which is based on incentives and not on response mode, and *applies equally to choice lists*. Our results point to the empirical relevance of these theoretical critiques for experiments that use choice lists.

2. Experimental design

We recruited 571 subjects by posting a task to the mTurk online labor market from September 2011 to July 2012.[5] Participants were paid $1 for completing the experiment, and up to $4 as a 'bonus' based on their choices and an element of chance. The experiment took at most 15 minutes to complete and the potential bonus payments of $3 or $4 provided high incentives for this subject pool. In Appendix **??** we discuss mTurk as a subject pool for economic experiments.

The experiment consisted of sixteen different treatments. Our main treatment variation was between "pairwise choice" treatments in which a subject faced one or two pairwise choice tasks, and "choice list" treatments in which a subject faces one or two choice list tasks. We also incorporated secondary treatment variation in the number of choice tasks, their order, and the payment mechanism. Throughout the

[5] The full details of the experimental procedure are described in Appendix **??**.

Table 1. The list tasks

	List 1		List 2	
Line	Option A	Option B	Option A	Option B
1	($3, 1)	($4, 1)	($3, .5)	($4, .50)
2	($3, 1)	($4, .98)	($3, .5)	($4, .49)
⋮	⋮	⋮	⋮	⋮
11	($3, 1)	($4, .80)	($3, .5)	($4, .40)
⋮	⋮	⋮	⋮	⋮
26	($3, 1)	($4, .50)	($3, .5)	($4, .25)

study, we employed a between-subject design in which each subject was randomly assigned to one of the treatments.

In "pairwise choice" treatments (denoted by P), each subject faced either a single or two pairwise choice tasks. In Q1 the subject had to choose between ($3, 1) and ($4, .80), and in Q2 the subject chose between ($3, .50) and ($4, .40). In "one task" treatments (P1 and P2), subjects made only a single pairwise choice and were paid based on their choice. Subjects in P1 responded to Q1, while subjects in P2 responded to Q2. In the "two tasks" treatments (P12 and P21) subjects made two pairwise choices, displayed on separate screens, one of which was randomly selected to determine payment at the end of the experiment. Subjects in P12 made a choice in Q1 and then in Q2, while the order was reversed in the P21 group.

In "choice list" treatments, each task consisted of a list of pairwise choices in which the left hand side lottery ("Option A") was held constant throughout the list while the probability of winning the higher prize in the right hand side lottery ("Option B") decreased as subjects proceeded down the list. Table 1 presents the two choice list tasks employed in the list treatments. Line 11 in List 1 is exactly the pairwise choice Q1, while line 11 of List 2 corresponds to the pairwise choice Q2. In "one task" treatments subjects responded to a single choice list, while in the the "two tasks" treatments subjects responded to both choice lists. Subjects were informed that if a list task determines their payment, one line from that list would be selected to determine their bonus. We allowed subjects to switch from Option A to Option B at any number of points on the list, but used a pop-up to warn subjects who switched from Option B to Option A and then back to Option B.

In the standard list treatments (denoted by L), subjects faced the list(s) shown in Table 1 immediately after the instructions. In the separate screens treatments

Table 2. Treatments and treatment labels

<table>
<tr><th colspan="3" rowspan="2"></th><th colspan="2">One Task</th><th colspan="2">Two Tasks (Order)</th></tr>
<tr><th>Q1 (1)</th><th>Q2 (2)</th><th>Q1, Q2 (12)</th><th>Q2, Q1 (21)</th></tr>
<tr><td colspan="3">Pairwise choice (P)</td><td>39</td><td>41</td><td>20</td><td>22</td></tr>
<tr><td rowspan="4">Lists</td><td rowspan="2">Standard List (L)</td><td>Pay One List (O)</td><td rowspan="2">47 (43)</td><td rowspan="2">45 (41)</td><td>36 (27)</td><td>35 (29)</td></tr>
<tr><td>Pay Both Lists (A)</td><td>36 (31)</td><td>33 (26)</td></tr>
<tr><td rowspan="2">Separate Screens then List (S)</td><td>Pay One List (O)</td><td rowspan="2">48 (46)</td><td rowspan="2">49 (48)</td><td>37 (36)</td><td>32 (29)</td></tr>
<tr><td>Pay Both Lists (A)</td><td>26 (25)</td><td>25 (25)</td></tr>
</table>

Entries indicate the number of subjects and, for L and S treatments, the number of subjects who exhibit single-switching in brackets (where applicable)

(denoted by S), before completing each list, subjects responded to a sequence of (non-incentivized) pairwise choices that appeared on separate screens. These hypothetical pairwise choice tasks were presented so as to converge towards the switching point in the list for a subject with monotone preferences. Subjects then responded to an incentivized list that was already filled in using their responses to the pairwise choice tasks but was otherwise identical to that in the corresponding L treatment. Crucially, subjects in the S treatment were free to change their answers in the (incentivized) list. Among subjects in list treatments, we varied whether subjects responded only to a single list (as in L1, L2, S1, and S2)[6] or to two lists (as in all treatments ending with 12 or 21). For subjects who responded to two lists, we varied the order of the tasks (denoted by 12 vs. 21) and whether a subject's bonus payment was determined by one pairwise choice randomly picked from the two lists (O treatments), or two pairwise choices with one randomly picked from each list (A treatments).

Table 2 outlines the treatments described above, and notes the number of subjects in each treatment.

3. Findings

3.1. **Main results: choice lists versus pairwise choice.** Figure 1 compares, for Q1 and Q2, the distribution of choices in the pairwise choice treatments to those made on line 11 in the list treatments. In Q1 only 23% of subjects in the pairwise choice treatments chose the risky (B) option, but 45% of subjects in the choice list

[6] Subjects in L1 and S1 responded to List 1, while subjects in L2 and S2 responded to List 2.

treatments chose this option, a significant difference ($p < .001$, Fisher's exact test). In Q2, 30% of subjects chose lottery B in the pairwise choice treatments, and 38% chose this lottery in the choice list treatments, a difference that is not statistically significant ($p = .17$, Fisher's exact test). This is our main finding - embedding a pairwise choice in a choice list increases the fraction of subjects choosing the riskier lottery when the safer alternative is certain but does not significantly affect choices when the safer alternative is risky.

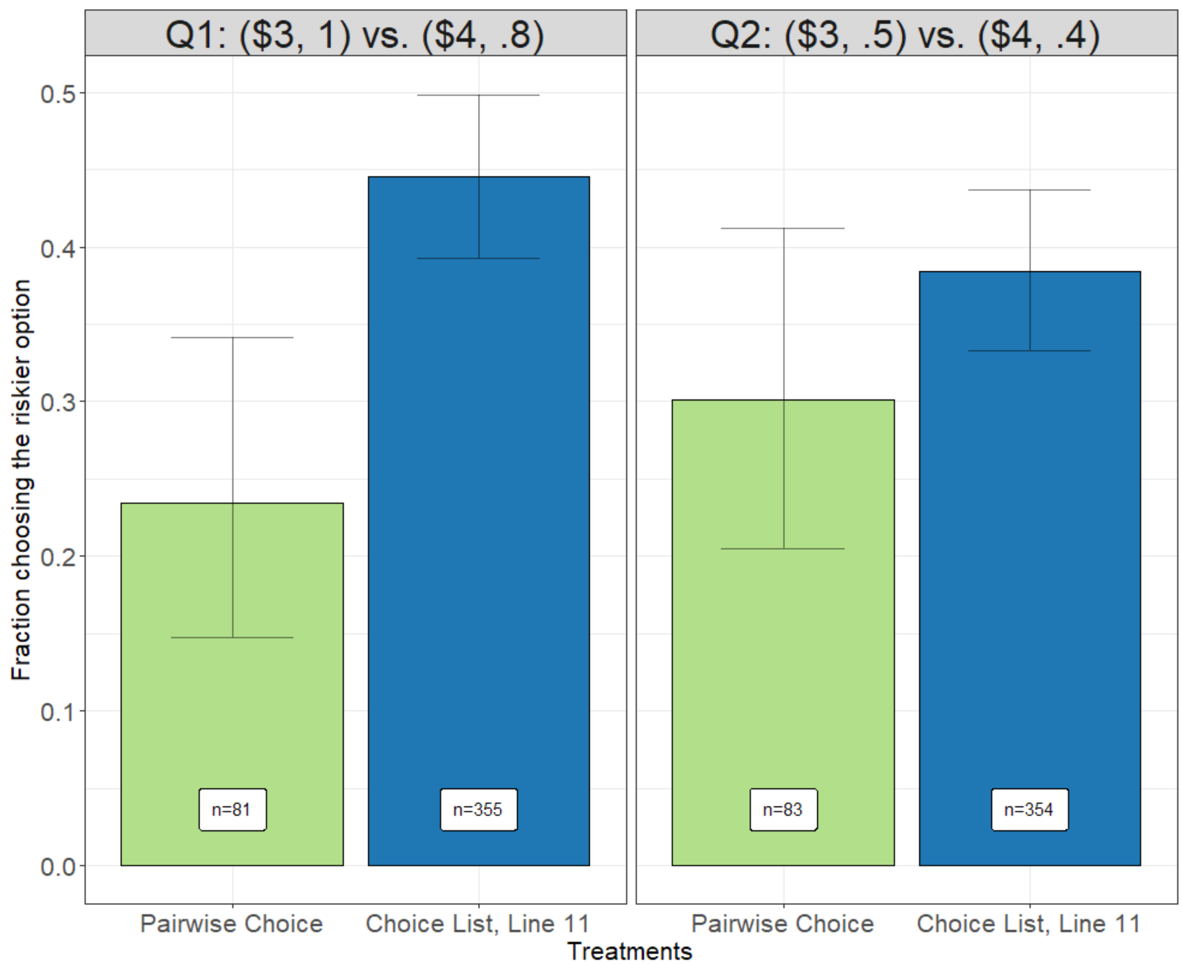

FIGURE 1. The fraction of subjects choosing the riskier option B in Q1 and Q2. Under the Q1 heading, "Pairwise Choice" groups include P1, P12, and P21, and "Choice List, Line 11" groups include L1, S1, and all LO, LA, SO, and SA treatments. Under the Q2 heading, "Pairwise Choice" groups include P2, P12, and P21, and "Choice List, Line 11" groups include L2, S2, and all LO, LA, SO, and SA treatments. 95% confidence intervals shown.

3.2. **Direct tests of the independence axiom.** In Section 4 we model our main findings as stemming from the interaction of choice list presentation and the failure of the independence axiom around certainty. One relevant question then is whether the certainty effect is detected directly in our data.

First, consider pairwise choice. The single pairwise choice treatments (P1 and P2) are incentive compatible by definition, and we could not statistically reject incentive compatibility of the two pairwise choice treatments (P12 and P21, see subsection 3.3). However, since these two questions only look at very particular lotteries, we cannot view a failure to reject the independence axiom as providing strong evidence in its favor. We find that aggregate choices exhibit a slight common ratio effect – 23% of subjects who faced Q1 choose the riskier option, as compared to 30% in Q2. These violations of the independence axiom are not significant ($p = .80$ for a Fisher's exact test for P1 vs P2, $p = .38$ when pooling all of the pairwise choice treatments). At the individual level (relying only on the 42 subjects who responded to P12 and P21), pairwise choice data only detects violations of the independence axiom (AB and BA choice patterns) for 29% of subjects, with 19% of subjects exhibiting the certainty effect.[7] We note that the 19% of subjects who exhibit the certainty effect is on the same order of magnitude as the observed 22 percentage point difference in proportions of risky choices in Q1 between pairwise choice treatments and list treatments.

Second, consider behavior in the list and separate screens treatments. If our L and S treatments had been incentive compatible, then we could interpret each choice as indicating a subject's preference and comparing responses in the two tasks would enable us to test the independence axiom. We rejected incentive compatibility of List 1 in section 3.1, and now we ask what conclusions we would draw if we set aside that finding and erroneously interpreted subjects' responses in each list as directly measuring their preferences. We find that aggregate responses are close to expected utility with choices exhibiting a slight reverse common ratio effect. Pooling all the list treatments and ignoring the within-subject nature of part of the treatments, the median switching points (for single-switching subjects) in the choice lists are consistent with the following ranking: $(\$4, .86) \succ (\$3, 1) \succ (\$4, .84)$ and $(\$4, .44) \succ (\$3, .5) \succ (\$4, .43)$, which is inconsistent with the independence axiom in the reverse direction of the standard common-ratio effect. This violation of the independence axiom is quantitatively small and is statistically significant at 5% ($p = .02$, rank-sum

[7]However, due to small sample size, we cannot reject that the direction of the deviation from the independence axiom is symmetric ($p = .39$, McNemar's test).

TABLE 3. Behavior relative to the independence axiom: within-subject

	Common Ratio	Independence	Reverse Common Ratio
Choice List (L and S)[a]	33.3%	21.5%	45.2%
Choice List (L and S), line 11[b]	11.4%	68.0%	20.6%
Pairwise Choice (P)[c]	19.1%	71.4%	9.5%

[a] percentage of single-switching subjects who switched earlier to lottery A in Q1 than in Q2 (common ratio), switched on the same line in Q1 and Q2 (independence), or switched on an earlier line to lottery A in Q2 than in Q1(reverse common ratio).

[b] percentage of single-switching subjects who answered both Q1 and Q2 and: chose lottery A in Q1 and lottery B in Q2 on line 11 (common ratio), made similar choices on line 11 (AA or BB, independence), chose B in Q1 and A in Q2 on line 11.

[c] percentage of subjects in the P12 and P21 treatments, who chose A in Q1 and B in Q2 (common ratio), made similar choice in Q1 and Q2 (independence), chose B in Q1 and A in Q2 (reverse common ratio).

test). At the individual level we detect violations of the independence axiom for 78.5% of single-switching subjects, split between standard common ratio and reverse common ratio violations with the latter being slightly more frequent (Table 3), but this difference is statistically insignificant at 5% ($p = .052$, sign test).[8]

3.3. **Differences across treatments.** Our experiment had numerous different choice list treatments, yet the only significant treatment effect from our main comparisons is subjects' greater willingness to take risks in Q1 of the list treatments as compared to the pairwise choice treatments. We report tests for other treatment effects for completeness.

We test whether subjects respond differently depending on whether they are in the "one task" or "two tasks" treatments. In pairwise choice treatments we find that of the subjects who face only one choice, 23% choose the risky option in Q1 and 27% choose the riskier option in Q2. In comparison, 24% of subjects who respond to both pairwise choices on different screens choose the risky option in Q1, and 33% of them choose the riskier option in Q2. These differences between the "one task" (P1/P2) and "two tasks" (P12 and P21) pairwise choice treatments are statistically insignificant ($p = .92$ for Q1 and $p = .53$ for Q2, Fisher's exact tests). This finding is consistent with the literature supporting the incentive compatibility of the RIS in which subjects respond

[8]In a sign test one omits the zeroes to achieve the uniformly most powerful test. See Lehmann and Romano (2005) page 136.

Table 4. Display, payment mechanism and order effects in choice list

	List 1	List 2
Separate screens effect (L=S)	.94	.81
Order effect (12=21)	.15	.05
Payment mechanism effect (O=A)	.38	.77

p-values reported for a Wilcoxon rank-sum test of equality of distribution
Tests use only subjects who exhibit single-switching

to a small number of pairwise choices (Starmer and Sugden, 1991; Cubitt, Starmer, and Sugden, 1998). We also do not find significant differences between switching points in "one list" and "two lists" treatments ($p = .21$ for List 1, $p = .91$ for List 2, rank-sum tests including all L and S subjects who choose B on line 1 and switch from B to A at most once). While our choice lists may not be incentive compatible, we can still test whether different variations on choice lists produce different behavior. The 2x2x2 design embedded in the treatments ($\{L,S\}\times\{O,A\}\times\{12,21\}$) allows us to separately test for the presence of display (separate screens), payment mechanism, and order effects in each task. We find that only one of these effects (Table 4) is marginally significant at 5% before, but not after, correcting for multiple hypothesis testing by the Holm-Bonferroni method.

One interesting treatment effect that is not the focus of the current investigation, is that the proportion of subjects who exhibit single-switching behavior is higher in the separate screens (S) treatments than in the list (L) treatments (96% vs. 85%; $p < .001$, Fisher's exact test, see Table 2). As one might expect, there are relatively more (94% vs. 88%; $p = .02$, Fisher's exact test) single-switching subjects in the treatments in which subjects faced only a single list (as opposed to two). Neither order nor payment mechanism significantly affect the proportion of single-switching subjects ($p = .85$, .57 respectively, Fisher's exact tests).

We introduced the separate screens treatment later in our experimental investigation, hoping it would bridge the gap between standard choice list and pairwise choice treatments. We conjectured that a combination of isolation in pairwise choices made on different screens, a lack of influence of hypothetical versus real incentives, and a creation of a default when the actual list was displayed, would eliminate the observed differences in responses made in choice list versus pairwise choice treatments. Table 4 shows that the incentivized choice data do not support this view. Moreover, comparing the incentivized responses to line 11 in the separate screens treatments to pairwise choices, we find a significant difference in Q1 ($p < 0.001$, Fisher's exact test) and an insignificant difference in Q2 ($p = 0.21$, Fisher's exact test), similar to the list treatments.[9]

4. Theory: Pairwise choice versus choice lists

Faced with the experimental findings documented so far, this section demonstrates they can be rationalized within existing theoretical models of non-expected utility preferences. The theory provides the tools to evaluate the robustness of inference from existing studies to the behavior documented here, and enables one to improve future experimental designs.

There are two main empirical regularities that we want to account for by the models we will consider. First, subjects are more risk averse when making a pairwise choice involving certainty than when making the identical choice in a list. However, this effect is not present in choices without a riskless option. Second, while there is strong prior evidence of the certainty effect in experiments that study pairwise choices, we do not detect this choice pattern when looking only at choices made in lists.

Consider a simple lottery $p = (x_i, p_i)_{i=1}^{n}$ paying x_i with probability p_i, where $x_i > x_{i+1}$ for each i. A compound lottery $\pi = [p^i, \pi_i]_{i=1}^{m}$ pays the simple one-stage lottery p^i with probability π_i.[10]

A subject at line i in List 1 faces a pairwise choice between two lotteries $(\$3, 1)$ (option A) and $(\$4, 1 - 0.02\,(i-1))$ (option B). Combining their choices in each of the lines with the RIS creates a two-stage compound lottery. Specifically, a subject with a single switching point who chooses option B for the last time at line i receives the two-stage compound lottery:

$$\left[(\$4, 1)\,, \frac{1}{26}; \ldots; (\$4,\ 1.02 - .02i)\,, \frac{1}{26}; (\$3, 1)\,, \frac{26-i}{26}\right] \tag{1}$$

When applied to compound lotteries, the independence axiom can be separated into two components (Segal, 1990): mixture independence that applies to lotteries

[9] We find that 29% of single-switching subjects who faced one list and 43% of single-switching subjects who faced two lists in the S treatments amended at least one of their choices. They switched in both directions, with 65% of switches involving a move from riskier-preliminary to safer-incentivized choices. Looking only at line 11, the aggregate distribution of preliminary choices made in Q2 is identical to the incentivized choices, and the preliminary choices in Q1 are slightly more risk-taking (by 5 subjects) than the incentivized choices.

[10] We continue to write (x, p) to denote a lottery with only one possible non-zero outcome, but include zero outcomes explicitly for lotteries with two or more non-zero outcomes.

that resolve in a single stage, and compound independence for two-stage lotteries.[11] Compound independence specifies that a subject facing the compound lottery in (1) evaluates it recursively according to (2):

$$\left(c\left((\$4,1)\right), \frac{1}{26}; \ldots; c\left((\$4, 1.02 - .02i)\right), \frac{1}{26}; c\left((\$3,1)\right), \frac{26-i}{26}\right) \tag{2}$$

where $c(\cdot)$ is a certainty equivalent function over one-stage lotteries. A subject who satisfies compound independence will choose the risky option on line i (Option B) whenever $c\left((\$4, 1.02 - .02i)\right) > c((\$3,1))$. Thus, she will make identical choices in each line of the choice list as she would have made in an experiment in which she only faced the single pairwise choice.[12] This prediction is inconsistent with the main finding of our experiment. It follows that any preferences that rationalize this finding and exhibit the certainty effect must not only violate the (mixture) independence axiom, but also compound independence.

We believe that the key observation in understanding our experimental findings is that a subject who chooses the risky option (B) on the first few lines of List 1 does *not* face a choice that involves certainty on line 11 of the choice list. In other words, choosing the sure outcome (A) on line 11 does not lead to payment with certainty since the RIS may select one of the first lines. This reduces the attractiveness of the safe option for a subject sensitive to certainty.

We suggest modeling this behavior by assuming that the subject chooses her switching line in the choice list *as if* she reduces the compound lottery in (1) according to the laws of probability (Reduction of Compound Lotteries Axiom, ROCL; Samuelson

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[11] We can formally define both axioms following Segal (1990). A preference relation $\succsim^1$ over single-stage lotteries satisfies *mixture independence* if, for any three lotteries $p = (x_i, p_i)_{i=1}^n, q = (x_i, q_i)_{i=1}^n, r = (x_i, r_i)_{i=1}^n$ (written with common support, without loss of generality), $p \succsim^1 q$ if and only if for all $\lambda \in (0,1)$, we have $(x_i, (1-\lambda)p_i + \lambda r_i)_{i=1}^n \succsim^1 (x_i, (1-\lambda)q_i + \lambda r_i)_{i=1}^n$. A preference relation $\succsim^2$ over compound lotteries satisfies *compound independence* if, for any compound lotteries $\pi = \left[p^1, \pi_1; \ldots; q, \pi_j; \ldots; p^m, \pi_m\right]$ and $\pi' = \left[p^1, \pi_1; \ldots; r, \pi_j; \ldots; p^m, \pi_m\right]$, we have $\pi \succsim^2 \pi'$ if and only if $[q,1] \succsim^2 [r,1]$. Any preference relation over compound lotteries induces two preference relations over single-stage lotteries: one from compound lotteries of the form $\left[(x_i,1), \pi_i\right]_{i=1}^m$ that resolve entirely at the first stage, and another from compound lotteries of the form $[p,1]$ that resolve entirely at the second stage. In our discussion, we implicitly assume that these two preference relations coincide – an assumption that Segal calls *time neutrality*.

[12] We can make a broader statement: an experiment studying choice among lotteries and employing the RIS is incentive compatible if and only if preferences over two-stage lotteries satisfy compound independence. In particular, (2) places no restriction on $c(\cdot)$, and therefore can accommodate non-expected utility preferences over one-stage lotteries.

1952).[13] In our view, the presentation of the choice list and instructions describing the RIS make the incentive structure particularly transparent to subjects, making such behavior more likely.

If one chooses option B for the last time on line i then reducing the compound lottery in (1) results in the one-stage lottery:

$$\left(\$4, \frac{1.01i - .01i^2}{26}; \$3, \frac{26-i}{26}; \$0, \frac{.01i^2 - .01i}{26}\right) \tag{3}$$

Hence, a subject who satisfies ROCL will choose the switching point to maximize her utility of (3). Figure 2 displays the set of feasible lotteries that correspond to switching points in both lists and the two pairwise choice problems. Our assumption of ROCL follows the modeling approach suggested by Karni and Safra (1987) to account for preference reversals between the valuations elicited through a BDM mechanism and choice tasks. This modeling simplification captures the idea that there may exist an interdependence between subject's willingness to take the risky option at each specific line of the list and her choices in other lines. This means that a subject will no longer make decisions in each line of the choice list as she would have made in an experiment in which she only faced the single pairwise choice, violating compound independence and rendering the mechanism not incentive compatible.[14]

We show by way of examples that plausible specifications of preferences from the non-expected utility literature can generate the type of behavior we observe in the experiment. That is, we show that these preference specifications both (i) allow a subject who prefers a riskless option A over a risky option B in Q1 to nevertheless choose the risky option when the choice is embedded in a list, while ruling out the opposite reversal, and (ii) either predict no effect or do not restrict the effect of embedding Q2 in a choice list. We study cautious expected utility (Cerreia-Vioglio, Dillenberger, and

[13] A preference relation $\succsim^2$ over compound lotteries satisfies *ROCL* if for every two compound lotteries $\pi = [p^1, \pi_1; \ldots; p^m, \pi_m]$ and $\pi' = [q^1, \pi'_1; \ldots; q^k, \pi'_{m'}]$ such that $\left(x_i, \sum_{j=1}^{m} p_i^j\right) = \left(x_i, \sum_{j=1}^{m'} q_i^j\right)$, then $\pi \sim^2 \pi'$. Segal (1990, Theorem 2) shows that compound independence and ROCL imply mixture independence, and mixture independence and ROCL imply compound independence.

[14] There exist evidence against ROCL as a descriptive axiom in other contexts (e.g. Halevy, 2007). We view the ROCL as a convenient modeling simplification that is sufficient but not necessary. For example, our arguments will go through, with appropriate modifications, if a person evaluates the compound lottery in (1) by a weighted average of their utility evaluation of the recursively-obtained lottery in (2) and their utility evaluation of the reduced lottery in (3) – so long as they put strictly positive weight on the latter component.

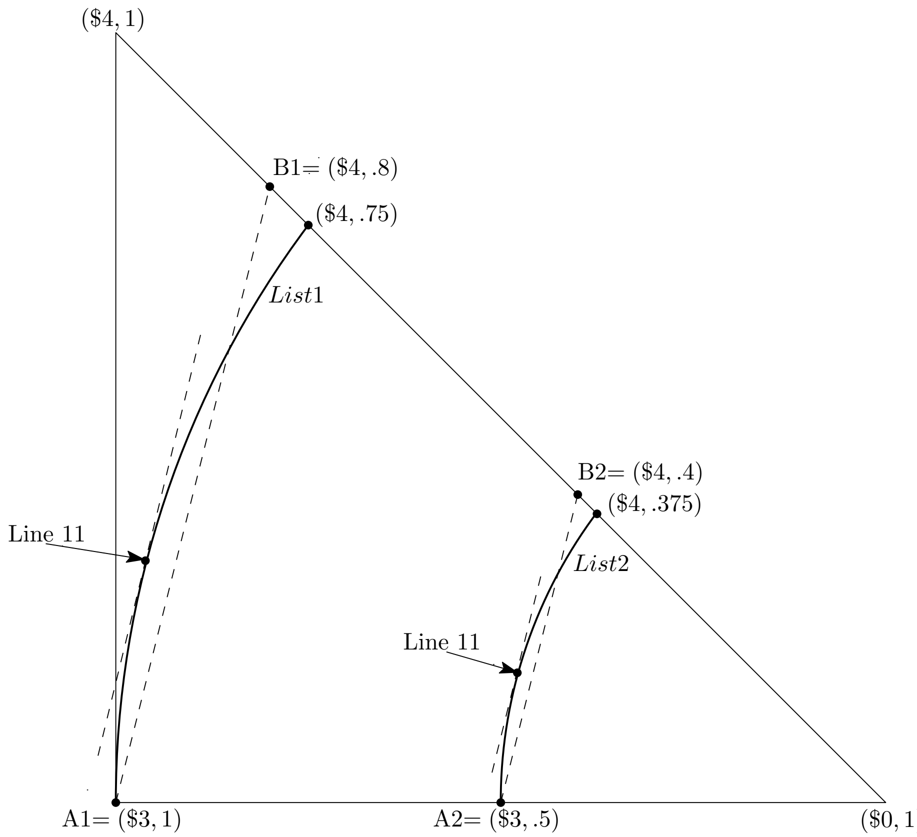

FIGURE 2. The decision problem in a Marschak-Machina triangle. Each point in the triangle represents a lottery over the outcomes \$4, \$3, and \$0. Any point on an edge of the triangle represents a lottery with only two possible outcomes, and a straight line between any two points in the triangle represents all mixtures (convex combinations) of the lotteries represented by these two points. The pairwise choice in Q1 is between A1 and B1. Under ROCL, the choice of a switching point in List 1 corresponds to a choice on the curve $List1$, such that an earlier switching point corresponds to a point on $List1$ that is closer to $A1$. The slope of $List1$ at line 11 equals the slope of $\overline{A1B1}$. Now consider an expected utility subject (satisfying compound independence in addition to ROCL) who is indifferent between A1 and B1. She will be indifferent between Option A and Option B on Line 11 of the choice list, and therefore will switch on this line. Since her indifference curves are parallel straight lines, it follows that she maximizes utility when her indifference curve are tangent to $List1$, which occurs at the point corresponding to Line 11.

Ortoleva, 2015) and rank dependent utility (Quiggin, 1982; Yaari, 1987) with the neo-additive weighting function (Chateauneuf, Eichberger, and Grant, 2007; Webb and Zank, 2011). The former model generalizes expected utility to accommodate failure of independence around certainty, while the latter weighting function transparently captures the certainty effect[15] within the widely-used class of rank dependent utility preferences.

4.1. **Cautious expected utility.** In this subsection, we apply cautious expected utility to study behavior in our experiment assuming that likelihoods of final outcomes are calculated according to the laws of probability (ROCL). We show that a subject described by this model who chooses the safe option (A) in the pairwise choice Q1 may choose the risky option (B) on line 11 of List 1, but a subject who chooses the risky option (B) in the pairwise choice Q1 must also do so on line 11 of List 1. The model places no restrictions on the relationship between choices in the pairwise choice Q2 and line 11 of List 2. As such, cautious expected utility is consistent with our two main empirical regularities.

Suppose a subject's preferences are represented by cautious expected utility; that is, she ranks any (single-stage) lottery according to $U\left((x_i, p_i)_{i=1}^n\right) = \min_{u \in \mathcal{U}} u^{-1}\left(\sum_{i=1}^n p_i u(x_i)\right)$, where $\mathcal{U}$ is a set of expected utility functions from $\mathbb{R}_+ \to \mathbb{R}$. Cerreia-Vioglio, Dillenberger, and Ortoleva (2015) show that the cautious expected utility is characterized by the negative certainty independence (NCI; Dillenberger, 2010) axiom (in addition to continuity and weak payoff monotonicity). In our setting, the NCI axiom implies that

$$
\begin{aligned}
(4) \quad (\$4, p) \succsim (\$3, 1) \implies & \\
& \lambda\left(\$4, p; \$0, 1-p\right) \oplus (1-\lambda)\left(\$4, \ell_1; \$3, \ell_2; \$0, 1-\ell_1-\ell_2\right) \\
& \qquad \succsim \lambda\left(\$3, 1\right) \oplus (1-\lambda)\left(\$4, \ell_1; \$3, \ell_2; \$0, 1-\ell_1-\ell_2\right)
\end{aligned}
$$

for any $\ell_1, \ell_2 \geq 0$ with $\ell_1 + \ell_2 \leq 1$ and any $\lambda \in (0,1)$ (where $\oplus$ is the mixture operator defined by $\lambda\left(x_i, p_i\right)_i \oplus (1-\lambda)\left(x_i, q_i\right)_i = \left(x_i, \lambda p_i + (1-\lambda) q_i\right)_i$). This is equivalent to:

$$
\begin{aligned}
& \left(\$4, \lambda p + (1-\lambda)\ell_1; \$3, (1-\lambda)\ell_2; \$0, 1-\lambda p-(1-\lambda)\ell_1-(1-\lambda)\ell_2\right) \\
& \qquad \succsim \left(\$4, (1-\lambda)\ell_1; \$3, \lambda+(1-\lambda)\ell_2; \$0, 1-(1-\lambda)\ell_1-\lambda-(1-\lambda)\ell_2\right)
\end{aligned}
$$

NCI has no implication for a subject who ranks $(\$3, 1) \succsim (\$4, .8)$, thus allowing the reversal we observe between the pairwise choice Q1 and line 11 of List 1.

To show that NCI rules out the opposite choice pattern, we now consider a subject who chooses the risky alternative in the pairwise choice Q1, and hence ranks $(\$4, .8) \succsim (\$3, 1)$. Monotonicity with respect to first order stochastic dominance and transitivity

[15]Most other weighting functions accommodate the certainty effect, but also try to match other nuances of choice patterns over risky prospects, which are of lesser interest here.

imply that:

$$(\$4, 1 - .02\,(i-1)) \succsim (\$3, 1) \text{ for } i \leq 11 \tag{5}$$

which means that the subject prefers the risky option (B) to the sure outcome (A) in pairwise choices that correspond to lines $1, \ldots 11$ of List 1. Note that for each line i of List 1, the reduced one-stage lottery, corresponding to arbitrary choices on all other lines and the risky or safe alternative on line i, can be written as a mixture of $(\$4, \ell_1^i; \$3, \ell_2^i; \$0, 1 - \ell_1^i - \ell_2^i)$ for some $\ell_1^i, \ell_2^i \geq 0$ for which $\ell_1^i + \ell_2^i \leq 1$ (corresponding to the lottery induced by choices on lines other than i), and $(\$4, 1 - .02\,(i-1))$ or $(\$3, 1)$ (corresponding to the choice on line i). By (5) and (4), for each $i \leq 11$ she would also rank

$$\frac{1}{26}\,(\$4, 1 - .02\,(i-1)\,; \$0, .02\,(i-1)) \oplus \frac{25}{26}\left(\$4, \ell_1^i; \$3, \ell_2^i; \$0, 1 - \ell_1^i - \ell_2^i\right)$$
$$\succsim \frac{1}{26}\,(\$3, 1) \oplus \frac{25}{26}\left(\$4, \ell_1^i; \$3, \ell_2^i; \$0, 1 - \ell_1^i - \ell_2^i\right)$$

Thus it follows that the subject will choose the risky option on line 11 and all preceding lines. Thus we have shown that a subject who satisfies NCI and chooses $(\$4, .8)$ over $(\$3, 1)$ in a single pairwise choice would also choose $(\$4, .8)$ over $(\$3, 1)$ in line 11 of List 1.

An alternative way to understand the implications of NCI in our setting is through Figure 2. By Lemma 3 in Dillenberger (2010), NCI implies that a subject's steepest indifference curve must run through $A1$ and be linear. Thus the highest indifference curve feasible on $List1$ (which determines her switching point in $List1$) must be flatter than her indifference curve through $A1$. This creates the possibility that a subject who chooses $(\$3, 1)$ over $(\$4, .8)$ in a pairwise choice would switch after line 11 in the list – corresponding to a point on $List1$ to the right of the point representing line 11. Thus, preferences that satisfy NCI can be consistent with our first empirical regularity: choosing $(\$3, 1)$ over $(\$4, .8)$ in a pairwise choice and $(\$4, .8)$ on line 11 of $List1$. At the same time, the opposite reversal is ruled out: a subject cannot choose $(\$4, .8)$ over $(\$3, 1)$ in a pairwise choice and $(\$3, 1)$ on line 11 of List 1.

Preferences that satisfy NCI are also consistent with our second empirical regularity: no evidence of a certainty effect when studying choices from List 1 and 2. Given information on a subject's pairwise choice in Q1, NCI does not have any implication for Q2, except that it is inconsistent with the combination of choosing $(\$3, .5)$ in Q2 and $(\$4, .8)$ in Q1. This is because a choice of $(\$4, .8)$ over $(\$3, 1)$ in a pairwise choice would imply that the slope of the subject's indifference curve through $A1$ is flatter than the line $A1B1$. NCI would then require that the slope of her indifference curve through $A2$ be flatter than the line $A2B2$. Thus, cautious expected utility preferences can be consistent with a subject using the same switching point in both List 1 and List 2 - which would produce no evidence of a certainty effect when using choice lists.

4.2. **Rank dependent utility.** In this subsection, we apply the model of rank dependent utility with the neo-additive weighting function to study behavior in List 1 and List 2 assuming that likelihoods of final outcomes are calculated according to the laws of probability (ROCL). We show that a subject who would be indifferent between the safe option (A) in the pairwise choice Q1 would choose the risky option (B) on line 11 of List 1. Further, a subject must choose the same switching point in List 1 and List 2. As such, rank dependent utility with the neo-additive weighting function can generate our two main empirical regularities.

Suppose a subject has rank dependent utility preferences; that is, she ranks any (single-stage) lottery according to

$$U\left((x_i, p_i)_{i=1}^n\right) = \sum_{i=1}^n \left[f\left(\sum_{j \le i} p_j\right) - f\left(\sum_{j<i} p_j\right)\right] u\left(x_i\right)$$

Consider a subject who is indifferent between $(\$3, 1)$ and $(\$4, .8)$ in the pairwise choice Q1. Suppose further the subject evaluates her choices in our experiment according to (1). Take the neo-additive weighting function f (see Wakker, 2010, pages 208-210) of the form:[16]

$$f(p) = \begin{cases} bp & \text{if } 0 \le p < 1 \\ 1 & \text{if } p = 1 \end{cases} \tag{6}$$

where $0 \le b \le 1$. Normalize $u(0) = 0$ and $u(4) = 1$. Risk aversion implies that $u(3) \ge .75$ (Chew, Karni, and Safra, 1987). Then $(\$3, 1) \sim (\$4, .8)$ implies that $u(3) = f(0.8) = 0.8b$. If $b < 1$ it follows that $(\$3, .5) \prec (\$4, .4)$, and thus the subject exhibits the certainty effect.[17] We will now show that when $b < 1$, this subject will switch after line 11 in both lists.

Consider a continuous approximation to the choice lists in which the subject chooses a switching point from B to A, q_1 and q_2 in List 1 and List 2 respectively, each

[16] It is trivial to add a constant $a \ge 0$ to the weighting function in order to capture the possibility effect, and the same results as below hold as long as $a + b < 1$ and $a + 0.8b < 0.8$.

[17] Since $U((\$4, 0.4)) = 0.4b > 0.4b^2 = (0.5b)(0.8b) = U((\$3, 0.5))$.

of which denote Option B's probability of not winning on a particular line of the list.[18] Let each line be selected for payment with a uniform probability on $[0, .5]$ in List 1 and on $[.5, .75]$ in List 2. Choosing q_1 induces the reduced lottery $Q1\,(q_1) = (\$4, 2q_1 - q_1^2; \$3, 1 - 2q_1; \$0, q_1^2)$ so the subject will choose q_1^* to maximize:

$$U\left(Q1\left(q_1\right)\right) = f\left(2q_1 - q_1^2\right) + u\left(3\right)\left[f\left(1 - q_1^2\right) - f\left(2q_1 - q_1^2\right)\right]$$

Substituting the neo-additive weighting function (6), we can derive the optimal switching point in List 1, which corresponds to $q_1^* = 1 - u(3)$.[19] From our assumption of indifference in the pairwise choice Q1, we can rewrite this optimal switching point as $q_1^* = 1 - f\,(.8) = 1 - .8b$. Since $0 \leq b < 1$ and $u\,(3) \geq .75$, the subject will switch to the safe outcome between the lines corresponding to losing probabilities of .2 and .25 in the choice list.[20] As such, these preferences are consistent with our first empirical regularity: choosing $(\$3, 1)$ over $(\$4, .8)$ in the pairwise choice and $(\$4, .8)$ on line 11 of List 1. Likewise, the opposite reversal is ruled out: the subject will not choose $(\$4, .8)$ over $(\$3, 1)$ in the pairwise choice and $(\$3, 1)$ on line 11 of List 1.

Similarly, choosing q_2 induces the reduced lottery $Q2\,(q_2) = \left(\$4, -2q_2^2 + 4q_2 - \frac{3}{2}; \$3, \frac{3}{2} - 2q_2; \$0, 1 - 2q_2 + 2q_2^2\right)$. So the subject will choose q_2 to maximize:

$$U\left(Q2\left(q_2\right)\right) = f\left(-2q_2^2 + 4q_2 - \frac{3}{2}\right) + u\left(3\right)\left[f\left(-2q_2^2 + 2q_2\right) - f\left(-2q_2^2 + 4q_2 - \frac{3}{2}\right)\right]$$

Substituting the neo-additive weighting function (6) and calculating the optimal switching point yields $1 - q_2^* = \frac{u(3)}{2} = \frac{1 - q_1^*}{2}$. Therefore, the subject will switch at the same line in List 1 and List 2. These preferences are consistent with our second

[18] So the probability of winning \$4 at the switching point is $1 - q_i$. We use the continuous approximation for simplicity and have obtained comparable results without this simplification.

[19] Since utility is discontinuous around certainty in this model, we need to verify that the subject's payoff at q_1^* is higher than her payoff of always choosing $(\$3, 1)$ when deriving a subject's optimal switching point.

$$\begin{aligned} U\left(Q1\left(q_1^*\right)\right) &= f\left(1 - \left(1 - q_1^*\right)^2\right) + u(3)\left[f\left(1 - q_1^{*2}\right) - f\left(1 - \left(1 - q_1^*\right)^2\right)\right] \\ &= b\left[1 - \left(.8b\right)^2\right] + \left(.8b^2\right)\left[1.6b - \left(.8b\right)^2 - \left(1 - \left(.8b\right)^2\right)\right] \\ &= b + b\left(.8b\right)\left(\left(.8b\right) - 1\right) \end{aligned}$$

Thus since $.75 \leq .8b \leq .8$,$U\left(Q1\left(q_1^*\right)\right) - U\left(\left(\$3, 1\right)\right) = b\left[.2 - \left(.8b\right)\left(1 - .8b\right)\right] \geq 0$. This rules out the riskless corner solution.

[20] By a similar calculation, any subject who chooses the risky option (B) in Q1 will switch after line 11 in List 1, and some subjects who strictly preferred the safe option (A) in the pairwise choice Q1 will switch to the risky option before line 11 when facing List 1.

empirical regularity: even if a subject exhibits the certainty effect in pairwise choice, the choices made in the two lists will be consistent with expected utility.

These results can be visualized using Figure 2. The indifference curves of the neo-additive weighting function are parallel straight lines in the interior of the triangle, but are discontinuous on its boundary where the probability of earning \$0 equals 0 (when $b < 1$). For a subject indifferent between between $(\$3, 1)$ and $(\$4, .8)$, the indifference curves are flatter (their slope equals $\frac{u(3)}{1-u(3)}$) than the dashed line A1B1, so the indifference curve passing through B1 approaches the vertical axis above A1.[21] Such a subject therefore chooses a switching point on $List1$ that is to the right of Line 11. Since the indifference curves in the interior of the triangle are parallel straight lines, this subject will strictly prefer B2 to A2 in pairwise choice (exhibit the certainty effect) but will have the same switching point in List 2 as in List 1 (just like an expected utility subject).

4.3. **Alternative explanations and their relation to existing findings.** Our leading explanation for the results reported in this study was initially posited by Karni and Safra (1987) as a potential explanation for the preference reversal phenomenon. But in contrast to experiments in the preference reversal literature, we compare behavior in pairwise choice treatments to behavior in identically-framed pairwise choices contained in a list, thus procedure-based explanations of the preference reversal phenomenon do not obviously apply to our study. Nonetheless, for completeness, we review a leading explanation for the preference reversal phenomenon as well as two potential sources of bias in choice lists and argue that they cannot explain our findings.

Contingent weighting and scale compatibility. One explanation for preference reversals between pairwise choice and the BDM is that subjects' preferences depend on how they are elicited, in violation of the principle of "procedure invariance." In particular, Tversky, Slovic, and Kahneman (1990) posit that subjects facing a "matching task" as in the BDM put more weight on the attribute being matched – their "scale compatibility hypothesis." Unlike in earlier studies of preference reversals, our paper compares behavior in pairwise choice treatments to behavior in an identically-framed pairwise choice contained in a list (not a matching task), so this explanation does not obviously apply. But if we did treat the list as akin to a BDM-matching task where subjects match an indifference probability, then the scale compatibility hypothesis

[21]The limit on the vertical axis equals $\frac{0.8(1-b)}{1-0.8b}$.

would predict that subjects would put more weight on the probability dimension when facing the list. This would generate more risk averse choices in the lists, which is the opposite of what we find in Q1. Moreover, this hypothesis would apply equally in choice lists with and without a certain option, while we only find a significant difference in choices involving certainty.

Middle-switching heuristic. It has been conjectured that when choices are presented in a list, subjects are biased towards switching at the middle of the list (Andersen, Harrison, Lau, and Rutström, 2006; Beauchamp, Benjamin, Chabris, and Laibson, 2015). Any subject who switches at the middle of the list would choose the risky option on line 11, which can qualitatively provide a possible explanation for our results. To see whether this can quantitatively explain our results, we re-run our main analysis after discarding the 32 monotone subjects who switched at the middle of the Q1 list (immediately after line 13), and we find that 39.0% of the remaining 323 subjects picked the risky option on line 11, which is still significantly different from the 23.5% who chose the risky option in the Q1 pairwise choice treatments ($p = .01$, Fisher's exact test).[22] We thus conclude that a middle-switching heuristic cannot quantitatively explain our results.

Fixed side of the list as a reference point. An alternative explanation is that subjects facing a list treat the fixed side of the list as a reference point (Sprenger, 2015). However, if subjects were loss averse and treated the lottery on the fixed side of the list as the reference point, they would demonstrate more risk aversion in List 1 than in the pairwise choice Q1 – the opposite of what we observe.

Relation to other existing findings. The renewed interest in empirically evaluating the incentive compatibility of various payment mechanisms when responding to risk tasks should be credited to Cox, Sadiraj, and Schmidt (2015), who use a between-subjects design to compare a large number of payment schemes (including RIS) to a single pairwise choice. In some comparisons, they find significant differences between behavior in the RIS to behavior in a single pairwise choice. They do not, however, study choice lists, which are a crucial intermediate case between their design and the BDM mechanism.[23] In another study, Cox, Sadiraj, and Schmidt (2014) demonstrate

[22] This is an extremely conservative correction, since it also discards subjects who intentionally switched at line 13.

[23] Related work by Castillo and Eil (2014) also explores behavior in choice lists by proposing and testing a model inspired by status-quo bias; however they do not compare behavior in choice lists to behavior in pairwise choice. Recent work by Brown and Healy (2014) follows up the current study

that using RIS while including additional comparisons among similar lotteries that either dominate or are dominated by the original lotteries may affect subjects' choices. In the choice list used in the current investigation, we vary only one alternative (Option B), and include both better and worse lotteries than the lottery included in line 11. Naturally, this framing may have an effect on choices made in line 11, but we believe that this is similar in nature to the effect discussed in the "middle-switching" above – which we showed could not account for our findings.

5. Conclusion

This study documents that embedding a pairwise choice between a sure option and a risky lottery in a list significantly increases the likelihood that the risky lottery will be chosen. We demonstrate how this finding could be understood in light of the interaction between non-expected utility preferences and the RIS (Karni and Safra, 1987).

A typical experiment whose primary goal is to measure preferences at the individual level must present a subject with a sequence of decision problems. Usually (but not always) one of them is selected for payment. A core feature of our design is a between-subject comparison with a group of subjects who make a single pairwise choice. We believe that this design feature can and should be incorporated into future studies to evaluate existing or proposed methods for eliciting preferences, especially when studying choices that involve a certain option.

We found that embedding a choice in a list, incentivized using the RIS, substantially affected risk-taking when a certain option was available. Since this effect differed depending on whether a safe option was available, our explanation in terms of an interaction between the RIS, list presentation, and a certainty effect was the most natural candidate explanation. Yet we found that the RIS did not lead to different behavior between our "one task" and "two tasks" pairwise choice treatments – a finding consistent with most (but not all) of the literature on the RIS that studies a small number of pairwise choices. We acknowledge that this creates a grey area, as our study alone cannot provide a clearly delineated set of necessary and sufficient conditions for when the RIS will affect behavior. We believe that future work could play an

by considering behavior in choice lists that do not involve sure payments, and indeed cannot reject the incentive compatibility of RIS in a treatment similar to ours. Work in progress by Loomes, Maadi, and Pogrebna (2015) also compares choices made in choice lists to pairwise choices. In recent theoretical work, Azrieli, Chambers, and Healy (Forthcoming) generalize Karni and Safra's results and study the conditions for the existence of incentive compatible mechanisms for eliciting preferences.

important role in exploring this grey area by studying intermediate cases between our choice lists with RIS treatments and our pairwise choice treatments.

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