

# For Online Publication

## Web Appendix I. Additional Analyses

### I.1. Do Choice Revisions Follow A Simple Heuristic?

One way that participants might revise their choices that would eliminate inconsistencies and intransitivities but *not* necessarily represent normatively relevant preferences is if they followed a heuristic. To obtain some germane evidence, we consider four heuristics that would be simple to follow in this experiment: choose the option that maximizes expected value (EV), choose the option that minimizes EV, choose the option shown on the top of the screen, and choose the option shown on the bottom of the screen. In our data, behaviors consistent with these heuristics are confounded: for participants randomized to the rightside-up orientation, the top option is always the safe option that minimizes EV, and vice-versa for participants randomized to the upside-down orientation. We break these correlations by restricting the sample to the 109 participants who were in both waves but were randomized to opposite rightside-up/upside-down orientations in the two waves, and we pool together their choices from wave 1 and wave 2. The top panel of Table I.1 in this appendix shows, for each heuristic, the percentage of participants all of whose choices are consistent with the heuristic. In the untutored (stage-0) and reconsidered (stage-4) choices, respectively, 97.3% and 93.6% of the participants do not fit any of the four heuristics. The bottom panel of Table I.1 examines a less stringent criterion: at least 90% of the choices are consistent with the heuristic. According to this criterion, the corresponding percentages are 88.1% and 81.7%. The participants whose choices do fit a heuristic are all described by the maximize-EV heuristic, but such behavior is also consistent with being relatively risk tolerant (and not following a heuristic). We interpret this evidence as casting doubt on the possibility that our results are driven by participants behaving according to the heuristics we examine.

### I.2 Additional Evidence on Whether Participants Revise Toward Greater Risk Tolerance

Section IV.C of the paper addresses the question of whether participants revise toward greater risk tolerance or risk aversion. Table I.2 in this appendix provides relevant evidence based on examining participants' revisions. For each reconsideration in the wave 1+2 sample, and for each axiom  $j = 1, 2, \dots, 6$  as well as overall, the top panel of Table I.2 shows how often participants revised toward their frame- $j$  or

frame- $(j + 1)$  choice in cases where their current frame- $j$  choice was riskier. The middle panel shows the revision frequencies in cases where participants' current frame- $(j + 1)$  choice was riskier. Although not relevant for our purposes, for completeness the bottom panel shows the cases where the current frame- $j$  and frame- $(j + 1)$  choices are not risk-ranked (e.g., CF vs. DE) (the first two rows have no observations because this is not possible for the choices in frames 1 and 2). As an example of how to read the table, consider the first row of the top panel, which shows results for Axiom 1 (Irrelevance of Background Counterfactuals). In cases of inconsistencies with Axiom 1 where participants' choice in frame 1 (Single Action in Isolation) was riskier than in frame 2 (Single Action with Backdrop), the first column shows that participants revised to make both choices consistent with their (riskier) frame-1 choice 33.3% of the time. The second column shows that they revised to make both choices consistent with their (less risky) frame-2 choice 20.5% of the time. The third column gives the  $p$ -value for the null hypothesis that these percentages are equal, which is 0.1236. (The fourth and fifth columns show how often participants did not revise either choice and swapped their choices, and the sixth column gives the number of observations.) To facilitate reading the table, in each row we have bolded whichever frame- $j$  or frame- $(j + 1)$  number is larger. The main result from the table can be seen from the "overall" rows of both panels: on average, when participants revise their choices, they do so toward the riskier choice. This tendency is also seen for most axioms (albeit sometimes with large  $p$ -values). This finding from examining revision behavior thus reinforces the conclusion from the analysis detailed in Section IV.D, which examined only the C vs. D and E vs. F choices.

### **I.3 Do Participants Revise Toward Choices In A Particular Frame?**

Section VII of the paper raises the question of whether participants revise toward the choices they made in a particular frame. As mentioned in Section VII, it is natural to hypothesize that participants revise their choices in the direction of what they chose in a "simpler" frame. We conjecture that the cognitively simplest nodewise frame is Single Action in Isolation (frame 1), and the cognitively simplest pairwise frame is Pairwise Choices Between Reduced Simple Lotteries (frame 7). We conduct two analyses relevant to the question of whether participants revise toward the choices they made in a particular frame and, more specifically, whether they revise toward choices made in one of the simplest frames.

The first analysis focuses on the C vs. D and E vs. F choices and examines whether, over the course of the experiment, the choice frequencies in other frames converge toward the choice frequencies in a particular frame. Looking at Figure 8, the frame Pairwise Choices Between Compound Lotteries is

the only candidate for having the property that choice frequencies in other frames converge toward its choice frequencies in both the C vs. D and E vs. F choices. However, given the large standard errors and incomplete convergence of choices across frames by the end of the experiment, we view this evidence as quite weak.

The second analysis is more complicated but aggregates across all revisions (not just those for C vs. D and E vs. F choices). We examine whether, in Table I.2, there is some frame toward which participants tend to revise their choices. There is no frame that clearly has property; on average, participants revise toward their choices in a frame if those were the riskier choices and away from them otherwise. The only frame where we see some evidence for participants revising toward their choice in that frame (regardless of whether their choice is that frame was more risk tolerant or not) is Complete Contingent Action Plan (frame 4). However, the evidence is very weak. In the top panel, the  $p$ -value for selecting the frame-4 choice over the frame-3 choice (the “Irrelevance of Counterfactual Choices” row) is 0.8895, and the  $p$ -value for selecting the frame-4 choice over the frame-5 choice (the “Irrelevance of Counterfactual Choices” row) is 0.2951. In the bottom panel, the  $p$ -value for selecting the frame-4 choice over the frame-5 choice is 0.8192, and participants were *less* likely to select the frame-4 choice than the frame-3 ( $p$ -value = 0.0050).

In summary, we cannot identify any frame with the property that participants tend to revise their choices toward the choices they made in that frame. Moreover, the only candidates we have for such frames in our data are not among the frames that we conjecture are cognitively simplest.

**Table I.1: Percentage of participants whose reconsidered choices can be rationalized by a simple heuristic**

<b>Heuristic followed in all choices</b>	<b>Percentage of Participants</b>	
	Untutored Choices (Stage 0)	Reconsidered Choices (Stage 4)
Maximize expected value	2.8%	6.4%
Minimize expected value	0.0%	0.0%
Choose top option	0.0%	0.0%
Choose bottom option	0.0%	0.0%
None of the above	97.3%	93.6%

<b>Heuristic followed in <math>\geq 90\%</math> of choices</b>	<b>Percentage of Participants</b>	
	Untutored Choices (Stage 0)	Reconsidered Choices (Stage 4)
Maximize expected value	11.9%	18.4%
Minimize expected value	0.0%	0.0%
Choose top option	0.0%	0.0%
Choose bottom option	0.0%	0.0%
None of the above	88.1%	81.7%

**Note:** Wave 1+2 sample, restricted to the 109 participants who saw the “rightside up” randomization (i.e., with option A at the top and E at the bottom, as in the master decision tree) in one wave and the “upside down” randomization (i.e., with E at the top and A at the bottom) in another. Total number of choices included in each column is 74 (37 per wave). Percentages are rounded to the nearest 0.1%.

**Table I.2: Direction of revising inconsistencies**

<b>Axiom (defined by frames <math>j</math> and <math>j+1</math>, listed in parentheses)</b>	<b>Frame-<math>j</math> Choice Wins</b>	<b>Frame <math>-(j+1)</math> Choice Wins</b>	<b><math>p</math>-value Both Frames Win Equally</b>	<b>Keep Original Choices</b>	<b>Swap Choices</b>	<b>#Obs</b>
<b>Choice in frame <math>j</math> was riskier</b>						
Irrelevance of Background Counterfactuals (defined by frames $j = 1, j+1 = 2$ )	<b>33.3%</b>	20.5%	0.1236	43.6%	2.6%	78
Simple Actions = State-Contingent Actions (2, 3)	<b>25.6</b>	6.1	0.0013	64.6	3.7	82
Irrelevance of Counterfactual Choices (3, 4)	25.8	<b>26.8</b>	0.8895	41.2	6.2	97
Fusion + Shift from Nodewise to Pairwise (4, 5)	<b>23.2</b>	17.6	0.2951	56.3	2.8	142
Complete Strategies = Implied Lotteries (5, 6)	<b>26.0</b>	21.5	0.1219	48.5	4.0	550
Reduction of Compound Lotteries (6, 7)	<b>33.2</b>	16.0	<0.0001	45.2	5.6	832
Overall	<b>29.4</b>	18.1	<0.0001	47.7	4.7	1781
<b>Choice in frame <math>j+1</math> was riskier</b>						
Irrelevance of Background Counterfactuals (1, 2)	14.4	<b>32.5</b>	0.0154	50.6	2.4	83
Simple Actions = State-Contingent Actions (2, 3)	12.3	<b>16.0</b>	0.5349	66.7	4.9	81
Irrelevance of Counterfactual Choices (3, 4)	<b>32.7</b>	13.9	0.0050	48.5	5.0	101
Fusion + Shift from Nodewise to Pairwise (4, 5)	<b>18.5</b>	17.5	0.8192	57.8	6.2	211
Complete Strategies = Implied Lotteries (5, 6)	17.3	<b>31.0</b>	<0.0001	46.6	5.2	562
Reduction of Compound Lotteries (6, 7)	20.2	<b>25.4</b>	0.0522	49.0	5.5	635
Overall	19.1	<b>25.5</b>	0.0001	50.2	5.3	1673
<b>Choices in frames <math>j</math> and <math>j+1</math> were not risk-ranked</b>						
Irrelevance of Background Counterfactuals (1, 2)	-	-	-	-	-	0
Simple Actions = State-Contingent Actions (2, 3)	-	-	-	-	-	0
Irrelevance of Counterfactual Choices (3, 4)	14.3	<b>28.6</b>	0.2554	46.4	10.7	28
Fusion + Shift from Nodewise to Pairwise (4, 5)	<b>23.8</b>	11.9	0.2003	57.1	7.1	42
Complete Strategies = Implied Lotteries (5, 6)	20.0	<b>23.8</b>	0.4382	52.4	3.8	185
Reduction of Compound Lotteries (6, 7)	<b>28.0</b>	18.3	0.0243	48.4	5.3	246
Overall	<b>24.0</b>	20.4	0.2274	50.5	5.2	501

**Note:** Wave 1+2 sample.  $P$ -values are from two-sided tests for differences in proportions. To facilitate reading the table, we have bolded whichever frame- $j$  or frame- $(j+1)$  number is larger in each row. Percentages are rounded to the nearest 0.1% and therefore row percentages may not add up to 100%.