Econometrica Supplementary Material

SUPPLEMENT TO "TESTING HURWICZ EXPECTED UTILITY"

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IN THIS ONLINE EXPERIMENT, we give some additional results, results of the pilots, and explanation about details of the experiments reported in the main paper.

APPENDIX C: ADDITIONAL ANALYSES

C.1. *Correlation Between Difference in α and Difference in β*

Table C.I shows the pairwise correlations between the difference in α and the difference in β in the first experiment for each source separately. None of these correlations is significant showing that α and β measure different concepts.

TABLE C.I

THE CORRELATIONS BETWEEN DIFFERENCES IN α AND IN β.

HEU	$\alpha_P - \alpha_M$	$\alpha_P - \alpha_C$	$\alpha_C - \alpha_M$
$\beta_P - \beta_M$	0.06		
$\beta_P - \beta_C$		0.03	
$\beta_C - \beta_M$			−0.17

C.2. *Pairwise T-Test*

We used within-subject t-tests to test whether the difference of α has zero mean.[1]

TABLE C.II

T-TEST FOR DIFFERENCES IN α.

	$\alpha_P - \alpha_M$	$\alpha_P - \alpha_C$	$\alpha_C - \alpha_M$
P-value	0.61	0.19	0.51

Table C.II shows that we cannot reject the null that alpha is the same for all sources, which is consistent with the ANOVA test we reported in the main text.

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[1] α_P : α for Paris temperature, α_M : α for Match attendance, and α_C : α for Canberra temperature.

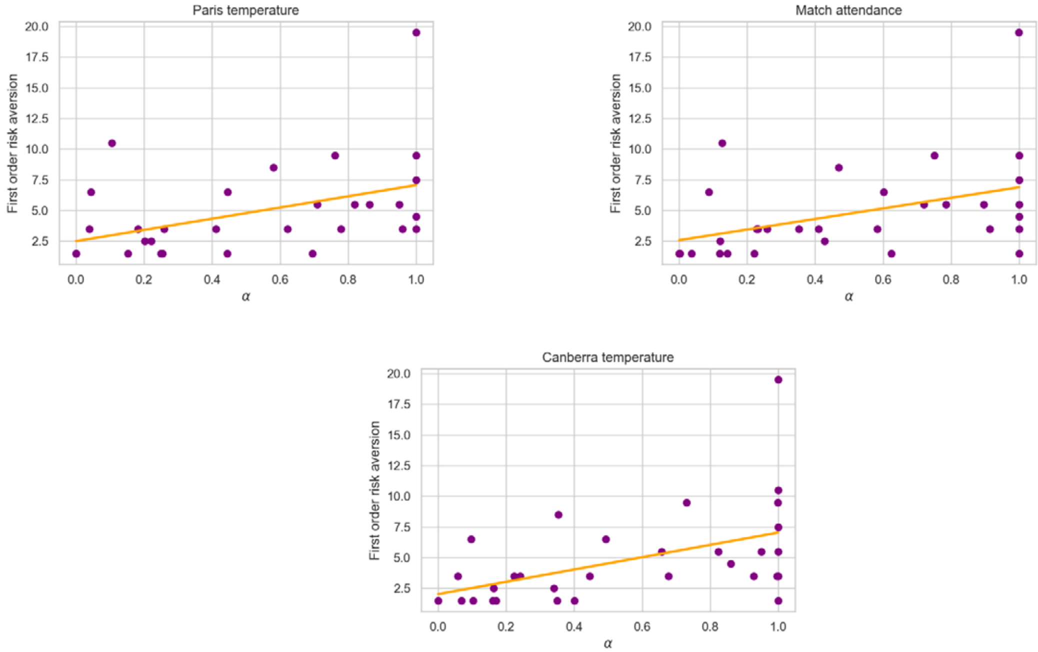


FIGURE C.1.—Correlations between each α and first-order risk aversion.

C.3. *Correlation Between Each α and First-Order Risk Aversion*

In the main text of our paper, we reported the correlation between the mean value of α and our measure of first-order risk aversion. Here, we show the correlations for each source separately. In the first experiment, the correlation between ambiguity aversion (α) and our measure of first-order risk aversion for sources Paris temperature, Match attendance, and Canberra temperature are 0.44 ($p < 0.01$), 0.41 ($p < 0.05$), and 0.49 ($p < 0.01$), respectively. In the second experiment, the correlation between ambiguity aversion (50-matching probability) and our measure of first-order risk aversion for sources Paris temperature, Match attendance, and Canberra temperature are 0.18, –0.06, and 0.23, respectively. Figure C.1 plots the individual data pairs for each source.

C.4. *Procedure to Elicit the Matching Probabilities in the Second Experiment*

We illustrate the procedure to elicit the matching probabilities in the second experiment using the source match attendance as an example. Figures C.3 and C.4 are choice lists that we use to elicit the matching probability of the event that at least 30,000 people would attend the first home match of FC Barcelona in the 2022/2023 season. In the first choice list, it varied in steps of 10%; in the second, in steps of 1%. For example, in Figure C.3, subjects switched from Option A to Option B between 40% and 50%. The next choice list then asked them to indicate for probabilities 41%, ..., 49%, which option they preferred.

Now we explain how we elicited the matching probability (MP) of the event with subjective probability 1/2.

- Elicit the MP (m_l^1) for the event that at most 30,000 people would attend the first home match of FC Barcelona in the 2022/2023 season and the MP (m_r^1) for the event that at least 30,000 people would attend this match.
- If $m_l^1 > m_r^1$, then elicit the MP (m_l^2) for the event that at most 28,000 people would

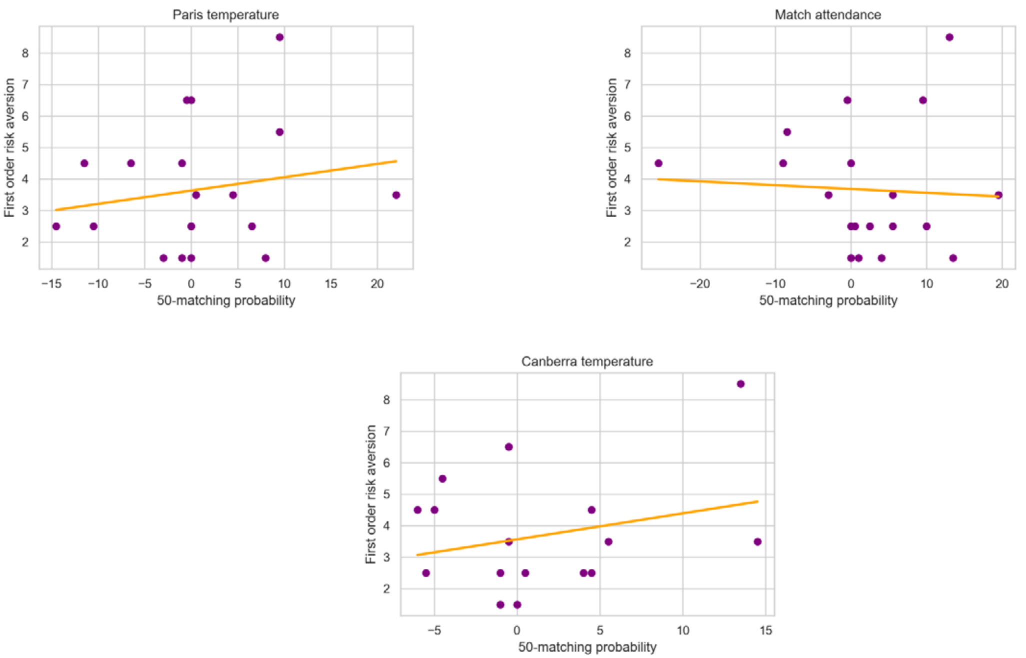


FIGURE C.2.—Correlations between 50-matching probability and first-order risk aversion.

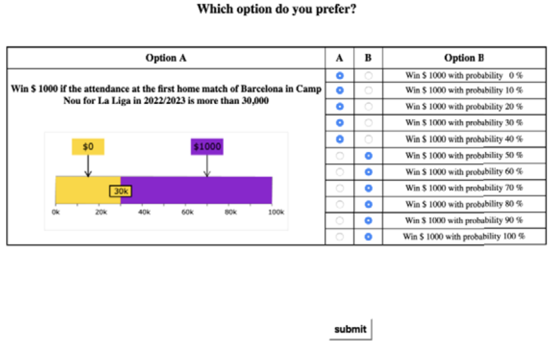


FIGURE C.3.—Screenshot of the experiment for matching probability of the match attendance.

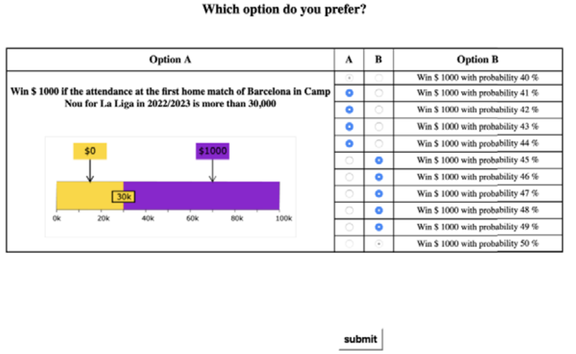


FIGURE C.4.—Screenshot of the experiment for matching probability of the match attendance.

attend the match and the MP (m_r^2) for the event that at least 28,000 people would attend the match. If $m_l^2 > m_r^2$, then elicit the MP (m_l^3) for the event that at most 26,000 people would attend the match and the MP (m_r^3) for the event that at least 26,000 people would attend the match, etc.

- If $m_l^1 < m_r^1$, then elicit the MP (m_l^2) for the event that at most 32,000 people would attend the match and the MP (m_r^2) for the event that at least 32,000 people would attend the match. If $m_l^2 < m_r^2$, then elicit the MP (m_l^3) for the event that at most 34,000 people would attend the match, and the MP (m_r^3) for the event that at least 34,000 people would attend the match, etc.
- If $m_l^1 = m_r^1$, stop and $m_l^1 = m_r^1$ the matching probability we are looking for.

The procedure stops until subjects switch from $m_l^1 > m_r^1$ to $m_l^i \leq m_r^i$ or from $m_l^1 < m_r^1$ to $m_l^i \geq m_r^i$ for i steps of 2000. We use the $\frac{m_l^i + m_r^i}{2}$ as the elicited matching probability if

$$\left|m_l^i - m_r^i\right| \leq \left|m_l^{i-1} - m_r^{i-1}\right|$$

and $\frac{m_l^{i-1} + m_r^{i-1}}{2}$ as the elicited matching probability if

$$\left|m_l^i - m_r^i\right| > \left|m_l^{i-1} - m_r^{i-1}\right|.$$

APPENDIX D: ABDELLAOUI, BAILLON, PLACIDO, AND WAKKER'S (2011) TWO EXPERIMENTS

In Abdellaoui et al.'s (ABPW henceforth) first experiment, the subjects were 67 students from a French engineering school. The subjects faced two Ellsberg urns, a known urn and an unknown urn. In the second experiment, the subjects were 62 students from a French engineering school who were divided equally into two groups: the hypothetical treatment group and the real treatment group. Subjects faced acts concerning four sources of uncertainty: risk, the change in the French stock index (CAC40) on 31 May 2006, the temperature in Paris on 31 May 2006, and the temperature in a randomly drawn remote country on 31 May 2006.

We could reject that α was the same for ABPW's first experiment (within-sample t-test, $p = 0.004$) but not for their second experiment of both hypothetical and real groups (ANOVA, $p = 0.74$). Unlike in their second experiment, ABPW measured utility for both risk and uncertainty in their first experiment and calculated their decision weights using these different utility functions. This might have led to errors in different directions and to different biases in the decision weights and so the estimated HEU weighting functions. We also performed within-subjects t-tests for ABPW's second experiment.[2]

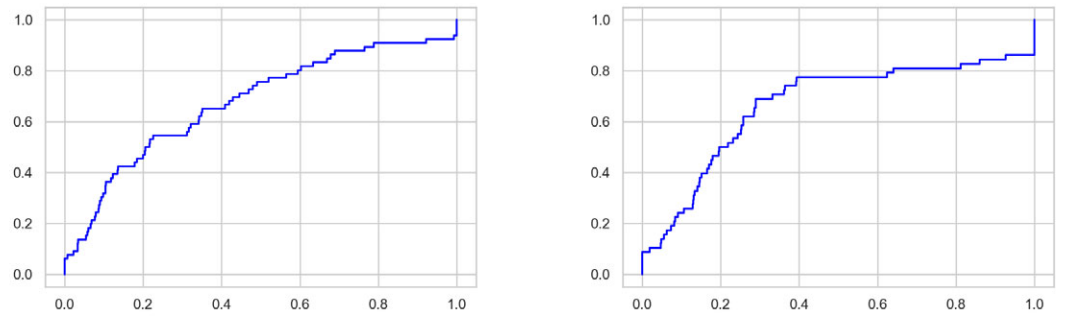
As in Table D.I, we could not reject α is the same for all four sources. We then perform an individual analysis as in the main text. We compute the maximum difference between

TABLE D.I

T-TEST BETWEEN DIFFERENCES IN α.

	$\alpha_{\text{CAC}} - \alpha_F$	$\alpha_{\text{CAC}} - \alpha_P$	$\alpha_{\text{CAC}} - \alpha_R$	$\alpha_F - \alpha_P$	$\alpha_F - \alpha_R$	$\alpha_P - \alpha_R$
P-value	0.64	0.78	0.21	0.86	0.12	0.19

[2] α_{CAC} : α for CAC40, α_F : α Foreign temperature, α_P : α for Paris temperature and α_R : α for Risk.



(a) ABPW's first experiment (b) ABPW's second experiment

FIGURE D.1.—CDF of α_D in ABPW's 1st and 2nd experiment.

α's, α_D:

$$\alpha_D = \max\{|\alpha_i - \alpha_j|\},$$

where α_i, α_j are the α's estimated according to HEU weighting function for each source. Figure D.1 shows the cumulative distributions. For around 50% of the subjects, the maximum difference was less than 0.20, which is consistent with our main experiment.

D.1. *Fit of the Weighting Functions*

Table D.II compares the fit of various widely-used weighting functions for risk and Ellsberg uncertainty in ABPW's first experiment.

Table D.III compares the fit of these weighting functions for three natural sources, CAC40, Foreign temperature, and Paris temperature in ABPW's second experiment. We pool the subjects in the real and hypothetical group, because there were no significant differences between these groups.

TABLE D.II

THE FIT OF THE HEU WEIGHTING FUNCTION IN COMPARISON WITH POPULAR ALTERNATIVES, ABPW 1ST EXPERIMENT.

		Sources			
		Ellsberg known urn		Ellsberg unknown urn	
Functional form	Expression	Sum of SSRs	No. Subjects	Sum of SSRs	No. Subjects
HEU	Eq. (9)	6.77	24	1.84	23
Goldstein Einhorn	$\frac{\alpha p^\beta}{\alpha p^\beta + (1-p)^\beta}$	6.84	8	1.76	13
Prelec	$\exp(-\alpha(-\ln p)^\beta)$	6.51	35	1.59	25
Neo-additive	$\begin{cases} 0, & p=0, \\ \beta(1-\alpha)+(1-\beta)p, & p \in (0,1), \\ 1, & p=1 \end{cases}$	7.81	13	3.36	13

TABLE D.III

THE FIT OF THE HEU WEIGHTING FUNCTION IN COMPARISON WITH POPULAR ALTERNATIVES, ABPW 2ND EXPERIMENT.

		Sources							
		CAC40		Foreign temperature		Paris temperature		Risk	
Functional form	Expression	Sum of SSRs	No. Subjects	Sum of SSRs	No. Subjects	Sum of SSRs	No. Subjects	Sum of SSRs	No. Subjects
HEU	Eq. (9)	1.51	33	1.21	22	1.30	19	0.71	19
Goldstein Einhorn	$\frac{\alpha p^\beta}{\alpha p^\beta+(1-p)^\beta}$	1.50	16	1.19	12	1.28	15	0.69	6
Prelec	$\exp(-\alpha(-\ln p)^\beta)$	1.68	14	1.14	22	1.22	23	0.67	20
Neo-additive	$\begin{cases} 0, & p=0, \\ \beta(1-\alpha)+(1-\beta)p, & p\in(0,1), \\ 1, & p=1 \end{cases}$	2.39	7	1.93	8	2.24	8	1.00	16

FIGURE E.1.—A screenshot of the interface for matching probability.

APPENDIX E: PILOT OF FIRST-ORDER RISK AVERSION

Subjects were 94 students from Erasmus University. They received a €5 participation fee. In addition, one of their randomly selected choices was played out for real. Subjects earned €13.69 on average. We measured subjects' matching probability for the Ellsberg 2-color urn (Figure E.1) and first-order risk aversion. In addition to the two color measurements of first-order risk aversion reported in the paper, we also tried out two three color problems in which, besides yellow and purple chips there were also 20 light blue chips. In one three-color problem, drawing a light blue chip paid €8.65 and subjects could avoid risk by putting also €8.65 on yellow and purple. In the other three-color problem, the light blue chips paid €0 and subjects could not avoid risk. This problem tested conditional first-order risk aversion. See Figure E.2 for examples of the three-color problems.

Thirty-five out of the 94 subjects (37.2%) had $\varepsilon_{\max}$ equal to 0 in all three tests and behaved consistent with EU. The correlations between matching probability and first-order risk aversion were slight to fair: 0.25 for the two-color problem, 0.20 for the three-

FIGURE E.2.—Screenshots of the interface for the three-color problems to test first-order risk aversion..

color problem with €8.65 on light blue, and 0.14 for the three-color problem with €0 on light blue. The correlations are not significant.

APPENDIX F: INSTRUCTIONS OF THE TWO EXPERIMENTS IN THE PAPER

We now present the instructions of the experiments in the main paper. We start with the instructions for match attendance in the first and second experiment. The instructions for Paris temperature and Canberra temperature in the first and second experiment were similar.

F.1. *Instruction for Match Attendance in the First Experiment*

In this part, we ask you to choose between two lotteries which payoffs depend on the attendance of the football match between Barcelona and Atletic de Bilbao on 27 February 2022. Barcelona has the biggest stadium, Camp Nou, of Europe with a capacity of 99,354. Over the past 10 seasons, Athletic has been a pretty good team, and its rankings in the Spanish league were 6, 10, 12, 4, 7, 5, 7, 16, 8, 11, 10. Right now they are number 8, slightly ahead of Barcelona. Attendance over the past 10 seasons to the Barcelona–Athletic match was 83,533, 88,027, 68,346, 57,090, 80,181, 66,234, 82,123, 75,851, 0, 0 (the last two due to Covid). But during the past 10 years Barcelona had Lionel Messi who is widely considered one of the best players ever, and won the prize for best player of the world 7 times, more than anyone else. Messi has now left.

Figure F.1 gives an example. It shows a lottery, which pays $1000 if the attendance is less than 67,000 and $0 otherwise.

Once you select the lottery you prefer, it will be highlighted with a black border and the button “Next” will appear on the bottom right. If you are sure about your choice, click “Next” to proceed to the next choice. If you want to change your choice, click the other option. You will not be able to change your choice after you click on the “Next” button.

To check your understanding of the instructions, consider Figure F.2.

Option A pays $1000 if the attendance is less than 21,000 and $0 otherwise. Option B pays $1000 if the attendance is between 21,000 and 32,000 and $0 otherwise. The black border indicates that you have chosen option B.

Please answer the following questions according to Figure F.2.

QUESTION 1: If the attendance is 25,000, how much do you get?

- $0
- $1000
- $500

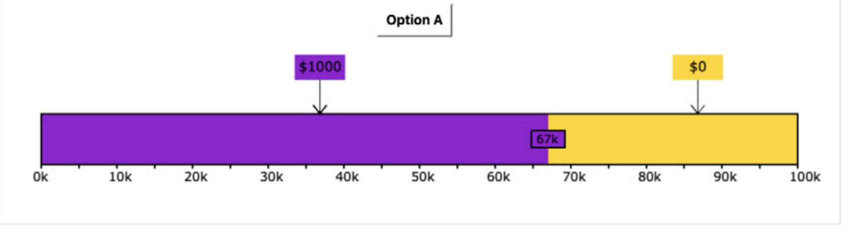


FIGURE F.1.—An example of the lottery.

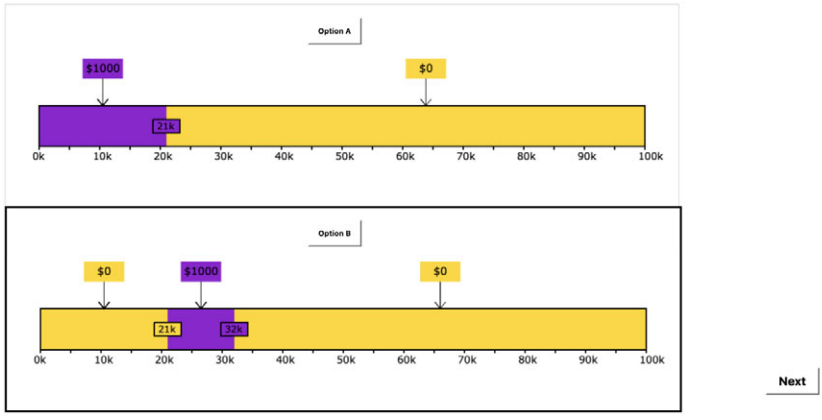


FIGURE F.2.—Example of your choice.

QUESTION 2: If the attendance is 20,000, how much do you get?

- $500
- $1000
- $0

F.2. *Instructions for Match Attendance in the Second Experiment*

In this part, we ask you to choose between two lotteries. One lottery is a bet on the attendance of the first home match of Barcelona in Camp Nou for La Liga in 2022/2023. Barcelona has the biggest stadium, Camp Nou, of Europe with a capacity of 99,354. Right now it is unknown against which team Barcelona will play its first match in the season 2022/2023 as the game schedule has not been released yet.

Attendance over the past 10 seasons of the first home match of Barcelona in Camp Nou for La Liga were 57,721 (against Real Sociedad), 73,812 (Levante UD), 68,105 (Elche CF), 80,812 (Malaga CF), 65,731 (Real Betis), 56,560 (Real Betis), 52,356 (CD Alaves), 70,160 (Real Betis), 0 (Villareal CF), 20,384 (Real Sociedad) (the last two with restricted attendance due to Covid).

But during the past 10 years Barcelona had Lionel Messi who is widely considered one of the best players ever, and won the prize for best player of the world 7 times, more than anyone else. Messi has now left. Figure F.3 gives an example of the questions you will face.

Option A: You win $1000 if if the attendance at the first home match of Barcelona in Camp Nou for La Liga in 2022/2023 is at least 12,000 and nothing otherwise.

Option B: You win $1000 with p% probability and nothing otherwise.

The left-hand side of Figure F.3 describes Option A with a graph. The right-hand side shows Option B with ascending p values. For each value of p, you are asked to choose between betting on the attendance at the match and betting on the lottery with the given probability of winning.

If $p = 100$, you will most likely prefer Option B because it gives a sure win of $1000. If $p = 0$, then you will most likely prefer Option A, as this at least gives a chance of winning something, while in Option B you have no chance of winning.

If you prefer the bet on the attendance at the match when, for instance, Option B offers you 40% chance of winning (i.e., $p = 40$), then for lower chances of winning, say 20% ($p = 20$), it makes sense that you again choose to bet on the attendance at the match

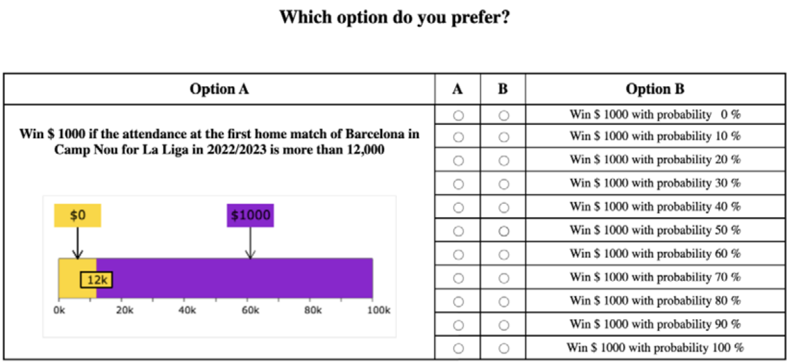


FIGURE F.3.—Example of one question.

over betting on probability. The computer will automatically select this once you click on a probability for which you prefer betting on attendance at the match.

Similarly, imagine that you like the probability option better than the bet on the attendance at the match when $p = 60$. Then, when the probability option offers an even better chance of winning, say $p = 70$, then it makes sense that you still prefer the bet on given probability to the bet on the attendance at the match. The computer will automatically select this once you click on a probability for which you prefer Option B.

PAYMENT: At the end of our experiment, if you are randomly selected and one of the questions in this part about the attendance at the match is selected for a real, we will pay you according to your choice in this selected question.

If you have chosen the bet on the attendance at the match, we will check the attendance of the first home match of Barcelona in Camp Nou for La Liga in 2022/2023. If you have chosen the bet on probability, we will pay you with the help of two 10-sided dice (depicted in Figure F.4).

One die has number $0, 1, 2, \dots, 9$ and the other one $0, 10, 20, \dots, 90$, which are all equally likely. By throwing the two dice and adding their result, we get any number between 0 and 99. Probability p% is equivalent to any number less than p. Thus, if the bet is "You win \$1000 with 20% probability and nothing otherwise," then if the sum of the two dice is strictly less than the value 20 you will win the bet and otherwise you will receive nothing.

To check your understanding of the instructions, consider Figure F.5. Suppose it shows how you have answered this question.

Please answer the following questions:

QUESTION 1: Which do you prefer, according to Figure F.5, the bet on the attendance of the match or the bet with winning probability 39%?

- Bet on the attendance of the match
- Bet with winning probability 39%
- Neither

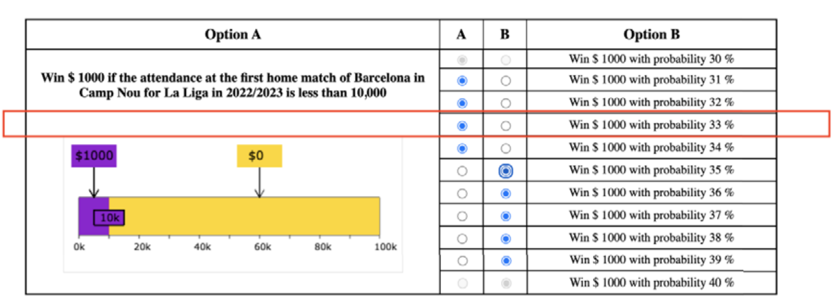
QUESTION 2: Assume that your choice indicated by the red bracket is selected for real payment. If the attendance at the first home match of Barcelona in Camp Nou for La

FIGURE F.4.—Two 10-sided dice.

Liga in 2022/2023 is 5000, how much do you get?
- $0
- $500
- $1000

F.3. *Instruction of the First-Order Risk Aversion Task*

In the second part of the experiment, you will be asked to create a lottery yourself. Consider an urn with 100 balls, blue or orange. In this part, the composition of the urn is always known. Figure F.6 is an example where 74 balls are blue and 26 balls are orange. We will always ask you to divide $17.30 over blue and orange. So, if you put $10.65 on



Which option do you prefer?

Option A	A	B	Option B
			Win $ 1000 with probability 30 %
Win $ 1000 if the attendance at the first home match of Barcelona in Camp Nou for La Liga in 2022/2023 is less than 10,000			Win $ 1000 with probability 31 %
			Win $ 1000 with probability 32 %
			Win $ 1000 with probability 33 %
			Win $ 1000 with probability 34 %
			Win $ 1000 with probability 35 %
			Win $ 1000 with probability 36 %
			Win $ 1000 with probability 37 %
			Win $ 1000 with probability 38 %
			Win $ 1000 with probability 39 %
			Win $ 1000 with probability 40 %

FIGURE F.5.—An example of your choices with a selected real payment question.

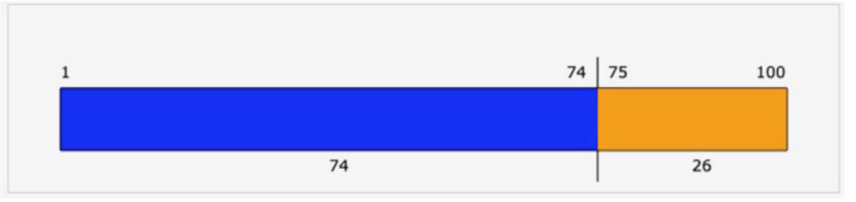


FIGURE F.6.—Example of two-color lottery: There are 54 yellow balls and 46 purple balls.

blue and $6.65 on orange in Figure F.6, you receive $10.65 if a blue ball is drawn from the urn and $6.65 if an orange ball is drawn from the urn as in Figure F.7.

You determine your optimal allocation by choosing from a list of allocations. We will give an example below. Click on your preferred allocation. Then a "Confirm" button will appear. This will make your choice definitive and you go to the next question. If you do not agree with your choice, you can change it. You can no longer change your choice after you have clicked on the *Confirm* button.

If a question from the second part of the experiment is randomly selected at the end of the experiment, then the computer will randomly draw a ball from the urn corresponding to the question and you will paid according to your selected allocation.

We will now test your understanding of the instructions.

Assume that at the end of the experiment the following question is selected and your optimal allocation is:

Please answer the following questions according to Figure F.8.

QUESTION 1: How many balls are orange?
- 50
- 74
- 26
- 20

QUESTION 2: If the computer draws a blue ball, you win
- $6.65
- $12.65
- $10.65
- $8.65

QUESTION 3: If the computer draws an orange ball, you win
- $6.65
- $10.65
- $2.65

FIGURE F.7.—Example of your choice.

FIGURE F.8.—Example of your choice.

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ABDELLAOUI, MOHAMMED, AURÉLIEN BAILLON, LAETITIA PLACIDO, AND PETER P. WAKKER (2011): "The Rich Domain of Uncertainty: Source Functions and Their Experimental Implementation," *American Economic Review*, 101 (2), 695–723. [4]

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