Ambiguous Correlation - Online Appendix*

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Abstract

The online appendix analyzes additional choice problems and includes the instructions used in all the experiments and treatments of the study.

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1 More choice problems (2013-2014)

The 2013-2014 experiments included two additional choice problems that are not the main focus of the study and are reported in this online appendix.

1.1 Same vs Different

Two questions elicited subjects' ranking between a bet that the balls drawn from the two urns are of identical color or different colors. The rationale for inclusion of these questions was twofold. First, it permitted us to confirm that the ranking implied by the first four questions (that concerned One vs Two) is acyclic. As noted above, the results reported in Appendix A.2 exclude 7 subjects from the 2013 experiment and 2 subjects from the two-urn treatment of the 2014 experiment who made cyclic choices. Second, it allowed us to test if subjects used the RIS for hedging. As reported in Appendix A.2.4, we find that almost one half of ambiguity sensitive subjects exhibited a strict preference between $Same$ and $Diff$, which constitutes evidence against hedging.

Though the choice between $Same$ and $Diff$ was not our motivating behavior, it is nevertheless related to One vs Two and experimentally observed choices provide another measuring stick for candidate models. There are notable differences between the two experiments in this question. In the first experiment less than 50% of subjects were indifferent between $Same$ and $Diff$, roughly 12% strictly preferred $Same$, and the remaining 39% strictly preferred to bet on $Diff$. In the second experiment, 80% of subjects with color symmetric choices did not exhibit strict preference between $Same$ and $Diff$ and the other 20% strictly preferred $Diff$ to $Same$. We outline below how the source model can easily rationalize these findings.

Assuming linear u_3, compute that $u_1 \circ U\,(Same)$ and $u_1 \circ U\,(Diff)$ are given respectively by

$$\sigma u_1 \circ u_2^{-1}\left[\int_p u_2\left(1-2p\left(1-p\right)\right)dF\right]+(1-\sigma)u_1 \circ u_2^{-1}\left[\int_p u_2\left(2p\left(1-p\right)\right)dF\right]$$

$$\sigma u_1 \circ u_2^{-1}\left[\int_p u_2\left(2p\left(1-p\right)\right)dF\right]+(1-\sigma)u_1 \circ u_2^{-1}\left[\int_p u_2\left(1-2p\left(1-p\right)\right)dF\right]$$

Since $1-2p\,(1-p) \geq 2p\,(1-p)$ for all p, it follows that $Same$ is preferred if and only if $\sigma > \frac{1}{2}$ and that they are indifferent if $\sigma = \frac{1}{2}$. The latter is assumed in Section 5.2 and Appendix A.3 when deriving the predictions of the model regarding *One* vs *Two* and the Ellsberg experiment. However, those predictions are robust to the changes in σ that we describe next.

To accommodate strict preference between *Same* and $Diff$, σ can be taken to be slightly above or below $\frac{1}{2}$ while (by continuity) not changing any of the strict rankings relating to Ellsbergian aversion and One vs Two.

The two rankings in (2.2) cannot be rationalized by small perturbations of σ about $\frac{1}{2}$. However, they can be rationalized if we take σ sufficiently different from $\frac{1}{2}$. For example, if σ is sufficiently close to 0, then the individual is extremely confident that the urns are complementary and this leads to the ranking $Diff \succ R_1 \succ Same$; moreover, this ranking is consistent with Ellsbergian ambiguity aversion. In the same way, the ranking $Same \succ R_1 \succ Diff$ can be rationalized if σ is sufficiently close to 1.

1.2 The correlation certainty effect (2013)

Two final questions in the 2013 experiment posed to subjects involved a different choice problem between non-binary acts. Our goal in designing the problem was to identify an additional behavior, different from One vs Two, that can be interpreted as revealing an aversion to ambiguity about the relation between urns.

Consider the following choice pattern that we term the *Correlation Certainty Effect (CCE)*:

$$f_0 \equiv \begin{bmatrix} 100 & \text{if } R_1B_2 \\ 0 & \text{if } B_1R_2 \\ 0 & \text{if } R_1R_2 \\ 0 & \text{if } B_1B_2 \end{bmatrix} \sim \begin{bmatrix} x & \text{if } R_1B_2 \\ x & \text{if } B_1R_2 \\ 0 & \text{if } R_1R_2 \\ 0 & \text{if } B_1B_2 \end{bmatrix} \equiv g_0 \text{ and} \tag{1.1}$$

$$f_1 \equiv \begin{bmatrix} 100 & \text{if } R_1B_2 \\ 0 & \text{if } B_1R_2 \\ x & \text{if } R_1R_2 \\ x & \text{if } B_1B_2 \end{bmatrix} \prec \begin{bmatrix} x & \text{if } R_1B_2 \\ x & \text{if } B_1R_2 \\ x & \text{if } R_1R_2 \\ x & \text{if } B_1B_2 \end{bmatrix} \equiv g_1 \tag{1.2}$$

The indifference $f_0 \sim g_0$ indicates that x is a conditional certainty equivalent for the bet on R_1B_2, where conditioning is on the two draws yielding different colors. Because the pair f_1 and g_1 is obtained from f_0 and g_0 by a change in common payoffs, (from 0 to x on the event $\{R_1R_2, B_1B_2\}$), the

Sure Thing Principle (STP) would require that f_1 and g_1 be indifferent. However, there is intuition that aversion to ambiguity about heterogeneity can lead to g_1 being strictly preferable. For the indifference $f_0 \sim g_0$ to obtain the individual might require a large value of x to compensate for the fact that the event where different colors are drawn is ambiguous. However, that ambiguity is completely eliminated when payoffs are changed as indicated which means that the individual is left with what now seems like an exceedingly large constant payoff. Put another way, ambiguity about the relation between urns means that there is "complementarity" between what happens on $\{R_1B_2, B_1R_2\}$ and on its complement, contrary to the weak separability required by STP. The change in common payoffs also improves f_1 relative to f_0 but the effect is plausibly smaller there.

However, there is an alternative interpretation of CCE that is unrelated to ambiguity. The individual could be probabilistically sophisticated but, after using her predictive prior to translate acts into lotteries, she does not use vNM expected utility theory to evaluate the induced lotteries; for example, she may attach extra weight to certainty (and thus to g_1) as in variants of the Allais paradox. More broadly, even in the absence of probabilistic sophistication, the choice in (1.2) may be due to an attraction to certainty. Our hope was that the experimental design would permit us to distinguish between the "certainty effect" and the ambiguity interpretations at the individual level–support for the latter would be indicated if the forms of ambiguity aversion in the Ellsberg problem and in One vs Two were associated across subjects with CCE.

Investigation of CCE was implemented via questions 9 and 10. In question 9 the subject was presented with a choice list in which she was asked to choose between a bet paying \$100 if the colors of the balls drawn are red from urn i and black from urn j (i and j, $i \neq j$, were chosen by the subject ex-ante[1]), and \$$x$ if the two balls are of different colors. The choice list varied x between 1 and 100, permitting elicitation of an approximate conditional certainty equivalent. Denote by $\overline{x}$ the highest value of x for which the subject preferred the \$100 bet. After answering this question, $\overline{x}$ was inserted into question 10, which was not revealed to the subject beforehand, and the subject was asked to choose between receiving \$$\overline{x}$ for sure and a bet paying: \$100 (\$0) if the colors of the balls drawn from urns i and j are red and black, and \$$\overline{x}$ if the

[1] That is, the subject chose the urns to determine if she will be paid \$100 in R_1B_2 or B_1R_2.

two balls have the same color.

We note two important differences from the other choice problems, and in particular from One vs Two which is our focal test. First, $\overline{x}$ in question 9 was elicited using a choice list. This is the only question in which a choice list was used (so the expected incentives for this question were much lower than for other questions). Second, the two CCE questions were the only chained questions in the experiment. We decided to ask these questions at the end of the experiment to eliminate any possible contamination of the other questions.

The analysis of CCE is based on 49 subjects,[2] of which 28 (57%) exhibited the CCE. The remainder chose consistently with the STP.[3] As noted above, behavior consistent with CCE may result from ambiguity about the relation between urns or from the certainty effect (or both). In the former case, one would expect to see an association between CCE and aversion to ambiguity in the senses of Ellsberg and One vs Two. However, the data do not indicate such an association. For example, 20 (15) of the 28 (21) subjects who (do not) exhibit CCE are not probabilistically sophisticated in Ellsberg; 12 (12) of the 28 (21) subjects who do not exhibit CCE are not probabilistically sophisticated in One vs Two; and p-values of all relevant Fisher exact tests are greater than 0.1. Thus we conclude that the main source of CCE behavior as measured in the current study is the certainty effect rather than ambiguity.[4]

[2] Out of 56 subjects, the answers of 7 subjects to questions 9 and 10 were omitted. For two of them there was an error by the research assistants in inserting the conditional certainty equivalents in question 10 based on the responses to the previous question, and the rest had extremely low (0 or 1) or extremely high (99 or 100) switching points, which we thought did not make any economic sense. Since the first of the CCE questions involved a choice list, while the rest of the questions involved only binary choices, we believe these choices resulted from a misunderstanding of the experimental protocol in this question and did not reflect on other questions.

[3] Note that 57% is a lower bound on the proportion of subjects exhibiting CCE, since the approximate conditional certainty equivalent used in question 10 is the largest integer x such that, for example, $(100, \{R_1B_2\}) \succsim (x, \{R_1B_2, B_1R_2\})$, and does not necessarily reflect indifference.

[4] This conclusion is robust to the less strict inclusion criteria.

2 Experimental instructions

The original instructions were formatted in MS-Word and are available upon request. Subjects also signed a standard consent form upon arriving to the experiment.

2.1 2013 experiment

Each of the two jars (Jar #1 and Jar #2) contains 10 marbles. Each marble is either green or blue. The number of green (and blue) marbles in each jar is unknown – it could be anything between 0 and 10. The two jars may contain different numbers of green (and blue) marbles.
At the end of the experiment, one marble will be drawn from each jar.

Each of the 10 questions below offers you a choice between bets on the colors of the 2 marbles that will be drawn at the end of the experiment. One of the questions will be selected at random according to the protocol specified in the following paragraph, and your chosen bet in that question will determine your payment. For example, suppose that in the question that was selected for payment you choose the bet "$100 if the marble drawn from the Jar #1 is green, otherwise $0". If the marble drawn from Jar #1 is indeed green – you will win $100, and if it is blue – you will win nothing (both are in addition to the payment of $10 you received for arriving to the experiment on time).

To select the question that will determine your payment, participants will be divided into two groups. One participant from each group will be randomly selected and will roll 3 dice for each participant in the other group: a 10-sided die that produces a number between 1 and 10, and two 10-sided dice that produce a number between 1 and 100. They will write the two numbers on notes that will be folded and inserted into sealed envelopes distributed among participants in the experiment. The first number will be used to select the question that will determine your payment. In case question 9 (which includes many sub-questions) is selected by the first die, the second number will be used to select the sub-question that will determine your payment. Do not open the envelope you receive until you complete answering all the questions and you are told to open it. Remember that the question is chosen before you make any choices.

This protocol of determining payments suggests that you should choose in each question as if it is the only question that determines

your payment.

Remember that the compositions of both jars are unknown, so it does not matter if a bet is placed on a green or a blue marble. Similarly, it does not matter if a bet is placed on Jar #1 or #2. Below are some examples that demonstrate this principle:

- "\$100 if the marble drawn from the Jar #1 is *green*" and "\$100 if the marble drawn from the Jar #1 is *blue*" are equally good.
- "\$100 if the marble drawn from the Jar *#1* is green" and "\$100 if the marble drawn from Jar *#2* is green" are equally good.
- "\$100 if both marbles drawn are *green*" and "\$100 if both marbles drawn are *blue*" are equally good.
- "\$100 if the marble drawn from the Jar #1 is green and the marble drawn from the Jar #2 is blue" and "\$100 if the marble drawn from the Jar #1 is blue and the marble drawn from the Jar #2 is green" are equally good.

Do you agree that the two bets in each pair are equally good? <u>YES</u> <u>NO</u> (circle one)

Before choosing between bets please choose a fixed color (green or blue) and a jar (#1 or #2) for which you will be paid if you choose certain bets in the questions below. For example, in question 1 you can choose to be paid if the marble drawn from Jar #1/#2 is green/blue. Note that you must make the same choice for all the questions below.

<u>Please circle and choose your set jar and color:</u>

Your fixed jar:	#1 / #2
Your fixed color:	green / blue

The choice of jar and color will apply to bets 1, 3, 5, 7, 13 and 15 below.

Question 1 (circle 1 or 2)

1. \$100 if the marble drawn from the fixed jar is of the fixed color
2. \$101 if the two marbles drawn are of different colors (one green and one blue)

Question 2 (circle 3 or 4)

3. \$101 if the marble drawn from the fixed jar is of the fixed color
4. \$100 if the two marbles drawn are of different colors (one green and one blue)

Note: Bets 1 and 3 pay under the same conditions but Bet 3 offers more money if you win (\$101) than Bet 1 (only \$100). Therefore anyone who prefers to earn more money would view Bet 3 as better than Bet 1. Similarly, Bets 2 and 4 pay under the same conditions but Bet 2 pays more money if you win than Bet 4. Therefore anyone who prefers to earn more money would view Bet 2 as better than Bet 4. If in one of the questions you choose the bet that pays \$100, it makes sense that in the other question you choose the corresponding bet. This follows since the corresponding bet pays \$101 (instead of \$100), and the payment to the alternative bet decreases from \$101 to \$100. *Please review your choices in questions 1 and 2 in light of this logic.* Notice that identical logic applies to the other questions (3-4, 5-6, 7-8).

Question 3 (circle 5 or 6)

5. \$100 if the marble drawn from the fixed jar is of the fixed color
6. \$101 if the two marbles drawn are of the same color (two greens or two blues)

Question 4 (circle 7 or 8)

7. \$101 if the marble drawn from the fixed jar is of the fixed color
8. \$100 if the two marbles drawn are of the same color (two greens or two blues)

Question 5 (circle 9 or 10)

9. $101 if the two marbles drawn are of the same color (two greens or two blues)

10. $100 if the two marbles drawn are of different colors (one green and one blue)

Question 6 (circle 11 or 12)

11. $100 if the two marbles drawn are of the same color (two greens or two blues)

12. $101 if the two marbles drawn are of different colors (one green and one blue)

I will now fill an empty third jar (#3) with 5 green and 5 blue marbles. The following two questions ask you to choose between a bet on the color of a marble drawn from this jar and a bet on the set jar (#1 or #2) and set color.

Question 7 (circle 13 or 14)

13. $100 if the marble drawn from the fixed jar is of the fixed color

14. $101 if the marble drawn from Jar #3 (that is known to contain 5 green and 5 blue marbles) is green.

Question 8 (circle 15 or 16)

15. $101 if a marble drawn from the fixed jar is of the fixed color

16. $100 if a marble drawn from Jar #3 (that is known to contain 5 green and 5 blue marbles) is green.

Question 9

Bet A pays $100 if the marble drawn from Jar #1 is green/blue (circle one) and the marble drawn from Jar #2 is green/blue (circle the other color).
Bet B pays $x if the two marbles drawn are of different colors.

Before you choose between the two bets above, you must know the value of x. For example, if x=100, then you will probably choose Bet B. The rationale behind this is that if you win with Bet A, then you will also win with Bet B, but there are cases in which only Bet B wins. Similarly, if x=0, then you will probably choose Bet A since it alone provides some chance of winning money.

Below, you are asked to choose between Bet A and Bet B for each value of x indicated in the list below (note that the list is on two pages). Note that while Bet A does not change between the lines, the amount paid in Bet B increases as you move down the list. Therefore, if you choose B on some line, it makes sense to choose B in every subsequent line.

If this question is chosen to determine your payment and if the relevant line was chosen (according to dice rolled by the two participants in the beginning of the experiment), then your payment will depend on the bet you choose. Therefore, you should make the choice in every line as if this is the only choice that will determine your payment in the experiment.

Remember that Bet B pays the amount specified on the line (between $1 and $100) if the two marbles drawn are of different color. Therefore, you will be paid if the marbles are as you specified for Bet A, but also if the colors of the two marbles are reversed.[5]

Line	**Bet A**	**Bet B: the value of x**	**Chosen Bet (circle A or B)**	
1	$100	$1	A	B
2	$100	$2	A	B
3	$100	$3	A	B
⋮	⋮	⋮	⋮	⋮
98	$100	$98	A	B
99	$100	$99	A	B
100	$100	$100	A	B

[5] The table in the experiment had 100 lines. Question 10 was not available to the subjects when they answered Question 9.

Question 10 (circle 17 or 18)

17. Pays according to Bet A in Question 9 or ___$[6] if the two marbles drawn are of the same color (either both green or both blue).

18. Pays ___$ for sure.

Reminder:
Bet A in Question 9 pays $100 if the marble drawn from Jar #1 is green/blue <u>and</u> the marble drawn Jar #2 is green/blue
(see question 9 for your choice of colors).

[6] Research assistants filled in the highest line in Question 9 on which the participant chose Bet A.

2.2 2014 Experiment

2.2.1 Two urns (main) treatment

In this session you will be asked to make 10 choices between bets. There are no correct choices. Your choices depend on your preferences and beliefs, so different participants will usually make different choices. You will be paid according to your choices, so read these instructions carefully and think before you decide.

The Protocol

Each of the 10 choice problems below offers you a choice between two bets. One of the choice problems will be selected at random according to the protocol specified in the following paragraph, and your chosen bet in that choice problem will determine your payment.

To select the choice problem that will determine your payment, the experiment coordinators will roll a 10 sided die that produces a number between 1 and 10 for each participant. They will write the numbers on notes that will be put into sealed envelopes that will be distributed among participants in the experiment. The number will be used to select the choice problem that will determine your payment. Please write your name on the envelope and do not open the envelope. Remember that the choice problem is chosen before you make any choices.

This protocol of determining payments suggests that you should choose in each choice problem as if it is the only question that determines your payment.

Examples of Choice Problems

In all the choice problems you will face during this experiment you will be asked to choose between two uncertain options. All questions will be organized in pairs that share a simple structure, which is explained below.

Consider a choice between being paid:

(b) $21 for sure or (d) $20 for sure

Obviously, being paid $21 is better than being paid $20.

Similarly, consider a bet in which you can win some money with a chance of 50%, and you are asked to choose between:

(a) $50 if you win or (c) $51 if you win

Obviously, being paid $51 if you win is better than being paid $50 if you win.

Now, the following two choice problems ask you to choose between the bets and the sure payments above.

Choice 1 (circle a or b)	**Choice 1' (circle c or d)**
(a) 50% chance of $50	(c) 50% chance of $51
(b) $21 for sure	(d) $20 for sure

If you choose (a) in Choice 1 it means that you think that (a) is better than (b). Since (c) is better than (a), and (d) is worse than (b), it makes sense that (c) is better than (d). So one would expect to choose (c) in Choice 1'.
Similarly, if you choose (d) in Choice 1' it implies that you think that (d) is better than (c). Since (b) is better than (d), and (a) is worse than (c), it makes sense that (b) is better than (a). So one would expect to choose (b) in Choice 1.
Choosing (b) in Choice 1 and (c) in Choice 1' is perfectly fine too. For example, if you think that winning $20 for sure is exactly as good as a 50% chance of winning $50 this is how you will likely choose.
However, choosing (a) in Choice 1 and (d) in Choice 1' does not make sense since you can increase your winnings by choosing (b) and (c), respectively.

The Experiment

Each of the two jars (Jar #1 and Jar #2) in front of you contains 2 marbles. Each marble is either green or blue. The number of green (and blue) marbles in each jar is unknown – it could be 0 green (2 blue) marbles, 1 green marble and 1 blue marble, or 2 green (0 blue) marbles. The two jars may contain different numbers of green (and blue) marbles.
<u>At the end of the experiment, one marble will be drawn from each jar.</u>
Suppose that in the choice problem that was selected for payment you choose the bet "$50 if the marble drawn from Jar #1 is green, otherwise $0". If the marble drawn from Jar #1 is indeed green – you will win $50, and if it is blue – you will win nothing (both are in addition to the payment of $10 you received for arriving to the experiment on time).
Before making your choices between bets please choose a fixed color (green or blue) and a fixed jar (#1 or #2) for which you will be paid if you choose certain bets in the choice problems below. For example, in option (a) of choice problem 1 you can choose to be paid if the marble drawn from Jar #1/#2 is green/blue. Note that your choice of jar and color applies to all the choice problems below.
<u>Please circle and choose your fixed jar and color:</u>

Your fixed jar:	#1	/	#2
Your fixed color:	green	/	blue

Choice problems 1 and 1' ask you to choose between bets on the color of the marble drawn from the fixed jar.

Choice 1 (circle a or b)
(a) $50 if the fixed colour is drawn
(b) $51 if the other colour marble is drawn

Choice 1' (circle c or d)
(c) $51 if the fixed colour is drawn
(d) $50 if the other colour marble is drawn

Choice 2 (circle a or b)
(a) $50 if the marble drawn from the fixed jar is of the fixed colour (irrespective of the colour drawn from the other jar).
(b) $51 if the two marbles drawn are of different colours (green from Jar #1 and blue from Jar #2, or blue from Jar #1 and green from Jar #2).

Choice 2' (circle c or d)
(c) $51 if the marble drawn from the fixed jar is of the fixed colour (irrespective of the colour drawn from the other jar).
(d) $50 if the two marbles drawn are of different colours (green from Jar #1 and blue from Jar #2, or blue from Jar #1 and green from Jar #2).

Choice 3 (circle a or b)
(a) $50 if the marble drawn from the fixed jar is of the fixed colour (irrespective of the colour drawn from the other jar).
(b) $51 if the two marbles drawn are of the same colour (green from Jar #1 and Jar #2, or blue from Jar #1 and Jar #2).

Choice 3' (circle c or d)
(c) $51 if the marble drawn from the fixed jar is of the fixed colour (irrespective of the colour drawn from the other jar).
(d) $50 if the two marbles drawn are of the same colour (green from Jar #1 and Jar #2, or blue from Jar #1 and Jar #2).

Choice 4 (circle a or b)
(a) $50 if the two marbles drawn are of different colours (green from Jar #1 and blue from Jar #2, or blue from Jar #1 and green from Jar #2).
(b) $51 if the two marbles drawn are of the same colour (green from Jar #1 and Jar #2, or blue from Jar #1 and Jar #2).

Choice 4' (circle c or d)
(c) $51 if the two marbles drawn are of different colours (green from Jar #1 and blue from Jar #2, or blue from Jar #1 and green from Jar #2).
(d) $50 if the two marbles drawn are of the same colour (green from Jar #1 and Jar #2, or blue from Jar #1 and Jar #2).

I will now fill an empty third jar (#3) with 2 marbles: 1 green and 1 blue, so the chance of drawing a green marble is exactly 50%. The following two choice problems ask you to choose between a bet on the color of a marble drawn from this jar and a bet on the set jar (#1 or #2) and set color.

Choice 5 (circle a or b)
(a) $50 if the marble drawn from the fixed jar is of the fixed colour.
(b) $51 if the marble drawn from Jar #3 (that is known to contain 1 green and 1 blue) is green.

Choice 5' (circle c or d)
(c) $51 if the marble drawn from the fixed jar is of the fixed colour.
(d) $50 if the marble drawn from the Jar #3 (that is known to contain 1 green and 1 blue) is green.

2.2.2 Risk control

In this session you will be asked to make 6 choices between bets. You will be paid according to your choices, so read these instructions carefully and think before you decide.

The Protocol and Examples of Choice Problems
Same as in the two-urn treatment (except the number of choice problems).

The Experiment
Each of the two jars (Jar #1 and Jar #2) contain 2 marbles: one green marble and one blue marble.
At the end of the experiment, one marble will be drawn from each jar. So the chance to draw a blue (or green) marble from Jar #1 (or Jar #2) is exactly 50%.
Suppose that in the choice problem that was selected for payment you choose the bet "$50 if the marble drawn from Jar #1 is green, otherwise $0". If the marble drawn from Jar #1 is indeed green (which happens with a chance of 50%) – you will win $50, and if it is blue – you will win nothing (both are in addition to the payment of $10 you received for arriving to the experiment on time).

Before making your choices between bets please choose a fixed color (green or blue) and a fixed jar (#1 or #2) for which you will be paid if you choose certain bets in the choice problems below. For example, in option (a) of choice problem 1 you can choose to be paid if the marble drawn from Jar #1/#2 is green/blue. Note that your choice of jar and color applies to all the choice problems below.

Please circle and choose your fixed jar and color:

Your fixed jar:	#1	/	#2
Your fixed color:	green	/	blue

Choice problems 1 and 1' ask you to choose between bets on the color of the marble drawn from the fixed jar.

Choice 1 (circle a or b)

(a) \$50 if the fixed colour is drawn

(b) \$51 if the other colour marble is drawn

Choice 1' (circle c or d)

(c) \$51 if the fixed colour is drawn

(d) \$50 if the other colour marble is drawn

Choice 2 (circle a or b)

(a) \$50 if the marble drawn from the fixed jar is of the fixed colour (irrespective of the colour drawn from the other jar).

(b) \$51 if the two marbles drawn are of different colours (green from Jar #1 and blue from Jar #2, or blue from Jar #1 and green from Jar #2).

Choice 2' (circle c or d)

(c) \$51 if the marble drawn from the fixed jar is of the fixed colour (irrespective of the colour drawn from the other jar).

(d) \$50 if the two marbles drawn are of different colours (green from Jar #1 and blue from Jar #2, or blue from Jar #1 and green from Jar #2).

Choice 3 (circle a or b)

(a) \$50 if the marble drawn from the fixed jar is of the fixed colour (irrespective of the colour drawn from the other jar).

(b) \$51 if the two marbles drawn are of the same colour (green from Jar #1 and Jar #2, or blue from Jar #1 and Jar #2).

Choice 3' (circle c or d)

(c) \$51 if the marble drawn from the fixed jar is of the fixed colour (irrespective of the colour drawn from the other jar).

(d) \$50 if the two marbles drawn are of the same colour (green from Jar #1 and Jar #2, or blue from Jar #1 and Jar #2).

2.2.3 Single-urn control

Introduction, Protocol and Examples of Choice Problems
Same as in the two-urn treatment.

The Experiment
The jar in front of you contains 2 marbles. Each marble is either green or blue. *The number of green (and blue) marbles in the jar is unknown* – it could be 0 green (2 blue) marbles, 1 green marble and 1 blue marble, or 2 green (0 blue) marbles.
At the end of the experiment, I will draw one marble from the jar and will record its color as "Draw 1".
I will then *return* the marble back to the jar and draw a marble again. I will record its color as "Draw 2".
Suppose that in the choice problem that was selected for payment you choose the bet "$50 if Draw 1 is green, otherwise $0". If the first marble drawn is indeed green – you will win $50, and if it is blue – you will win nothing (both are in addition to the payment of $10 you received for arriving to the experiment on time).
Before making your choices between bets please choose a fixed color (green or blue) and a draw (#1 or #2) for which you will be paid if you choose certain bets in the choice problems below. For example, in option (a) of choice problem 1 you can choose to be paid if the marble drawn in Draw #1/#2 is green/blue. Note that your choice of draw # and color applies to all the choice problems below.
Please circle and choose your fixed draw and color:

Your fixed draw:	#1	/	#2
Your fixed color:	green	/	blue

Choice problems 1 and 1' ask you to choose between bets on the color of the fixed draw:

Choice 1 (circle a or b)	**Choice 1' (circle c or d)**
(a) $50 if the fixed colour is drawn	(c) $51 if the fixed colour is drawn
(b) $51 if the other colour marble is drawn	(d) $50 if the other colour marble is drawn

Choice 2 (circle a or b)
(a) $50 if the fixed draw is of the fixed colour (irrespective of the colour of the other draw).
(b) $51 if the two draws are of different colours (green in Draw #1 and blue from Draw #2, or blue in Draw #1 and green in Draw #2).

Choice 2' (circle c or d)
(c) $51 if the fixed draw is of the fixed colour (irrespective of the colour of the other draw).
(d) $50 if the two draws are of different colours (green in Draw #1 and blue from Draw #2, or blue in Draw #1 and green in Draw #2).

Choice 3 (circle a or b)
(a) $50 if the fix draw is of the fixed colour (irrespective of the colour of the other draw).
(b) $51 if the two draws are of the same colour (green in Draw #1 and Draw #2, or blue in Draw #1 and Draw #2).

Choice 3' (circle c or d)
(c) $51 if the fix draw is of the fixed colour (irrespective of the colour of the other draw).
(d) $50 if the two draws are of the same colour (green in Draw #1 and Draw #2, or blue in Draw #1 and Draw #2).

Choice 4 (circle a or b)
(a) $50 if the two draws are of different colours (green in Draw #1 and blue from Draw #2, or blue in Draw #1 and green in Draw #2).
(b) $51 if the two draws are of the same colour (green in Draw #1 and Draw #2, or blue in Draw #1 and Draw #2).

Choice 4' (circle c or d)
(c) $50 if the two draws are of different colours (green in Draw #1 and blue from Draw #2, or blue in Draw #1 and green in Draw #2).
(d) $50 if the two draws are of the same colour (green in Draw #1 and Draw #2, or blue in Draw #1 and Draw #2).

I will now fill an empty second jar (#2) with 2 marbles: 1 green and 1 blue, so the chance of drawing a green marble is exactly 50%. The following two choice problems ask you to choose between a bet on the fix draw (#1 or #2) and fixed color.

Choice 5 (circle a or b)
(a) $50 if the fixed draw is of the fixed colour.
(b) $51 if the marble drawn from Jar #2 (that is known to contain 1 green and 1 blue) is green.

Choice 5' (circle c or d)
(c) $51 if the fixed draw is of the fixed colour.
(d) $50 if the marble drawn from the Jar #2 (that is known to contain 1 green and 1 blue) is green.

2.3 2015 experiment

2.3.1 Pairwise choices

In this session you will be asked to make 18 choices between bets. There are no correct choices. Your choices depend on your preferences and beliefs, so different participants will usually make different choices. You will be paid according to your choices, so read these instructions carefully and think before you decide.

Each of the 18 choice problems below offers you a choice between two bets. One of the choice problems will be selected at random according to the protocol specified in the following paragraph, and your chosen bet in that choice problem will determine your payment.

The experiment coordinators will roll two dice (for each participant) which will select the choice problem that will determine your payment. They will write the choice problem number on a note that will be placed into a sealed envelope that will be distributed among participants in the experiment. Please write your name on the envelope and do not open the envelope. Remember that the choice problem is chosen before you make any choices.

This protocol of determining payments suggests that you should choose in each choice problem as if it is the only choice problem that determines your payment.

Examples of Choice Problems

In all the choice problems you will face during this experiment you will be asked to choose between two uncertain options. All choice problems will be organized in groups of three problems that share a simple structure, which is explained below.

Consider a choice between being paid:

(b) \$11 for sure   or   (d) \$10 for sure

Obviously, being paid \$11 is better than being paid \$10.

Similarly, consider a bet in which you can win some money with a chance of 50%, and you are asked to choose between:

(a) \$25 if you win   or   (e) \$26 if you win

Obviously, being paid \$26 if you win is better than being paid \$25 if you win.

Now, the following three choice problems ask you to choose between the bets and the sure payments above.

Choice 1 (circle a or b)	**Choice 1' (circle c or d)**	**Choice 1" (circle e or f)**
(a) 50% chance of \$25	(c) 50% chance of \$25	(e) 50% of \$26
(b) \$11	(d) \$10	(f) \$10

If you choose (c) in Choice 1', it makes sense to choose (e) in Choice 1" since the alternative (\$10 for sure) is the same while (e) is better than (c). Moving to Choice 1, you should consider whether (a) is better than \$11 for sure (rather than \$10 for sure as in (d)).

If you chose (d) in Choice 1', it makes sense to choose (b) in Choice 1 since the alternative (50% of winning \$25) is the same while (b) is better than (d). Moving to Choice 1", you should consider whether (f) is better than a 50% chance of winning \$26 (rather than \$25 as in (c)).

Therefore, choosing one or more of the combinations: (a) and (f), (a) and (d), or (c) and (f) is not consistent with the reasoning above. If you find yourself choosing in such a way, please review the rationale presented above in order to better guide your choices.

The experiment includes 6 sets of choice problems that share the structure above (each set includes 3 choice problems).

The Experiment

Each of the two jars (Jar #1 and Jar #2) in front of you contains 2 marbles. Each marble is either green or blue. The number of green (and blue) marbles in each jar is unknown – it could be 0 green (2 blue) marbles, 1 green marble and 1 blue marble, or 2 green (0 blue) marbles. The two jars may contain different numbers of green (and blue) marbles.

At the end of the experiment, one marble will be drawn from each jar.

Suppose that in the choice problem that was selected for payment you choose the bet "\$25 if the marble drawn from Jar #1 is green, otherwise \$0". If the marble drawn from Jar #1 is indeed green – you will win \$25, and if it is blue – you will win nothing (both are in addition to the payment of \$5 you received for arriving to the experiment on time).

Before making your choices between bets please choose a fixed jar (#1 or #2) for which you will be paid if you choose certain bets in the choice problems below. For example, in option (a) of choice problem 1 you can choose to be paid if the marble drawn from Jar #1/#2 is green. Note that your choice of jar applies to all the choice problems below.

Please circle and choose your fixed jar:

Your fixed jar: Jar #1 / Jar #2

Choice 1 (circle a or b)
(a) $25 if the marble drawn from the fixed jar is green (green from both jars, or green from the fixed jar and blue from the other jar).
(b) $26 if the two marbles drawn are of different colours (green from Jar #1 and blue from Jar #2, or blue from Jar #1 and green from Jar #2).

Choice 1' (circle c or d)
(c) $25 if the marble drawn from the fixed jar is green (green from both jars, or green from the fixed jar and blue from the other jar).
(d) $25 if the two marbles drawn are of different colours (green from Jar #1 and blue from Jar #2, or blue from Jar #1 and green from Jar #2).

Choice 1" (circle e or f)
(e) $26 if the marble drawn from the fixed jar is green (green from both jars, or green from the fixed jar and blue from the other jar).
(f) $25 if the two marbles drawn are of different colours (green from Jar #1 and blue from Jar #2, or blue from Jar #1 and green from Jar #2).

Choice 2 (circle a or b)
(a) $25 if the marble drawn from the fixed jar is blue (blue from both jars, or blue from the fixed jar and green from the other jar).
(b) $26 if the two marbles drawn are of different colours (green from Jar #1 and blue from Jar #2, or blue from Jar #1 and green from Jar #2).

Choice 2' (circle c or d)
(c) $25 if the marble drawn from the fixed jar is blue (blue from both jars, or blue from the fixed jar and green from the other jar).
(d) $25 if the two marbles drawn are of different colours (green from Jar #1 and blue from Jar #2, or blue from Jar #1 and green from Jar #2).

Choice 2" (circle e or f)
(e) $26 if the marble drawn from the fixed jar is blue (blue from both jars, or blue from the fixed jar and green from the other jar).
(f) $25 if the two marbles drawn are of different colours (green from Jar #1 and blue from Jar #2, or blue from Jar #1 and green from Jar #2).

Choice 3 (circle a or b)
(a) $25 if the marble drawn from the fixed jar is blue (blue from both jars, or blue from the fixed jar and green from the other jar).
(b) $26 if the two marbles drawn are of the same colour (green from both jars, or blue from both jars).

Choice 3' (circle c or d)
(c) $25 if the marble drawn from the fixed jar is blue (blue from both jars, or blue from the fixed jar and green from the other jar).

(d) $25 if the two marbles drawn are of the same colour (green from both jars, or blue from both jars).

Choice 3" (circle e or f)
(e) $26 if the marble drawn from the fixed jar is blue (blue from both jars, or blue from the fixed jar and green from the other jar).

(f) $25 if the two marbles drawn are of the same colour (green from both jars, or blue from both jars).

Choice 4 (circle a or b)
(a) $25 if the marble drawn from the fixed jar is green (green from both jars, or green from the fixed jar and blue from the other jar).
(b) $26 if the two marbles drawn are of the same colour (green from both jars, or blue from both jars).

Choice 4' (circle c or d)
(c) $25 if the marble drawn from the fixed jar is green (green from both jars, or green from the fixed jar and blue from the other jar).
(d) $25 if the two marbles drawn are of the same colour (green from both jars, or blue from both jars).

Choice 4" (circle e or f)
(e) $26 if the marble drawn from the fixed jar is green (green from both jars, or green from the fixed jar and blue from the other jar).
(f) $25 if the two marbles drawn are of the same colour (green from both jars, or blue from both jars).

I will now fill an empty third jar (#3) with 2 marbles: 1 green and 1 blue, so the chance of drawing a green marble is exactly 50%. The following two choice problems ask you to choose between a bet on the colour of a marble drawn from this jar and a bet on the colour of a marble drawn from the fixed jar.

Choice 5 (circle a or b)
(a) $25 if the marble drawn from the fixed jar (whose colour composition is unknown) is green.
(b) $26 if the marble drawn from Jar #3 (that contains 1 blue and 1 green marbles) is green.

Choice 5' (circle c or d)
(c) $25 if the marble drawn from the fixed jar (whose colour composition is unknown) is green.
(d) $25 if the marble drawn from Jar #3 (that contains 1 blue and 1 green marbles) is green.

Choice 5" (circle e or f)
(e) $26 if the marble drawn from the fixed jar (whose colour composition is unknown) is green.
(f) $25 if the marble drawn from Jar #3 (that contains 1 blue and 1 green marbles) is green.

Choice 6 (circle a or b)
(a) $25 if the marble drawn from the fixed jar (whose colour composition is unknown) is blue.
(b) $26 if the marble drawn from Jar #3 (that contains 1 blue and 1 green marbles) is blue.

Choice 6' (circle c or d)
(c) $25 if the marble drawn from the fixed jar (whose colour composition is unknown) is blue.
(d) $25 if the marble drawn from Jar #3 (that contains 1 blue and 1 green marbles) is blue.

Choice 6" (circle e or f)
(e) $26 if the marble drawn from the fixed jar (whose colour composition is unknown) is blue.
(f) $25 if the marble drawn from Jar #3 (that contains 1 blue and 1 green marbles) is blue.

2.3.2 Choice lists

In this session you will be asked to make a sequence of choices between bets and sure amounts. There are no correct choices. Your choices depend on your preferences and beliefs, so different participants will usually make different choices. You will be paid according to your choices, so read these instructions carefully and think before you decide.

Examples of Choice Problems

In all the choice problems you will face during this experiment you will be asked to choose between a bet with uncertain payment and a sure amount. All choice problems will be organized in lists that share a simple structure, which is explained below. The following example illustrates, but is not directly related to the choice problems that determine your payment.

Suppose you are offered a bet (called bet A) that pays $100 with a probability of 30% (3 out of 10), and $0 otherwise (with a probability of 70%). You are asked to make a series of choices between this bet, and sure amounts that vary from $0 to $100. For example:

Choice Problem	A	B	Choose: A or B
0	30% of $100	$0	A
1	30% of $100	$10	
2	30% of $100	$20	
3	30% of $100	$30	
4	30% of $100	$40	
5	30% of $100	$50	
6	30% of $100	$60	
7	30% of $100	$70	
8	30% of $100	$80	
9	30% of $100	$90	
10	30% of $100	$100	B

Choice Problem 0 is simple (and is filled up for you): 30% of winning $100 is better than $0 for sure (since in the former you have some chance of winning $100), so you should choose "A" in this problem. Similarly, winning $100 for sure is better than winning $100 with some chance, so you should choose "B" in Choice Problem 10. The key is to note that as you move to lower lines in the list, the sure payment in column B becomes higher. So if, for example, you choose B in Choice Problem 5 ($50 for sure), it makes sense to choose B in Choice Problems 6, 7, 8, 9 and 10. The problem boils down to: "what should be the first choice problem in which I choose the sure payment (B) and not the bet (A)?" We can call this line your "switching line" for the bet in A. In general, different people will have different switching lines for the same bet.

Your switching line will change when you evaluate different bets. Consider, for example, that the bet in A is "60% chance of winning $100". Clearly this is a better bet than "30% chance of winning $100" so one would expect to have a greater switching line for it. Let's demonstrate this with an example: in the original Choice Problem 4 you are asked to choose between 30% chance of winning $100 (Option A) and $40 for sure (Option B). Suppose that you choose "B" ($40 for sure), which implies that your switching line is 4 or lower (you may have chosen "B" in Choice Problem 3 or 2 too). Now consider the choice between 60% chance of winning $100 and $40. It might be that with the higher chance of winning you are willing to take the chance and choose "A". This implies that your switching line for the "60% chance of winning $100" will be greater than line 4.

The Protocol

The following choice problems are organized in 6 lists, where the bet in column A changes across lists. One of the choice problems in one of the lists will be selected at random according to the protocol specified in the following paragraph, and your choice in that choice problem will determine your payment.

The experiment coordinators will roll 2 dice (for each participant) which will select the choice problem that will determine your payment. The first (6-sided) die will determine the list, and the second (20-sided) die will determine the choice problem in the randomly-selected list. They will write the choice problem number on a note that will be placed into a sealed envelope that will be distributed among participants in the experiment. Please write your name on the envelope and <u>do not open the envelope</u>. Remember that the choice problem is chosen before you make any choices. Your choice (A or B) in the randomly-selected problem will determine your payment in this experiment.

This protocol of determining payments suggests that you should choose in each choice problem as if it is the only problem that determines your payment.

The Experiment

Each of the th two jars (Jar #1 and Jar #2) in front of you contains 2 marbles. Each marble is either green or blue. The number of green (and blue) marbles in each jar is unknown – it could be 0 green (2 blue) marbles, 1 green marble and 1 blue marble, or 2 green (0 blue) marbles. The two jars may contain different numbers of green (and blue) marbles.

At the end of the experiment, one marble will be drawn from each jar.

Suppose that in the choice problem that was selected for payment you choose the bet "$25 if the marble drawn from Jar #1 is green, otherwise $0". If the marble drawn from Jar #1 is indeed green – you will win $25, and if it is blue – you will win nothing (both are in addition to the payment of $5 you received for arriving to the experiment on time).

Before making your choices between bets please choose a fixed jar (#1 or #2) for which you will be paid if you choose certain bets in the choice problems below. For example, in option (A) of choice problem 1 you can choose to be paid if the marble drawn from Jar #1/#2 is green. Note that your choice of jar applies to all the choice problems below.

Please circle and choose your fixed jar:
Your fixed jar: Jar #1 / Jar #2

List 1:

Option A: $25 if the marble drawn from the fixed jar is green (green from both jars, or green from the fixed Jar and blue from the other Jar), otherwise $0.

	A	B	Choose A or B
Choice 0	$25 if green from fixed jar	$0	A
Choice 1	$25 if green from fixed jar	$2	
Choice 2	$25 if green from fixed jar	$4	
Choice 3	$25 if green from fixed jar	$5	
Choice 4	$25 if green from fixed jar	$6	
Choice 5	$25 if green from fixed jar	$7	
Choice 6	$25 if green from fixed jar	$8	
Choice 7	$25 if green from fixed jar	$9	
Choice 8	$25 if green from fixed jar	$10	
Choice 9	$25 if green from fixed jar	$11	
Choice 10	$25 if green from fixed jar	$12	
Choice 11	$25 if green from fixed jar	$13	
Choice 12	$25 if green from fixed jar	$14	
Choice 13	$25 if green from fixed jar	$15	
Choice 14	$25 if green from fixed jar	$16	
Choice 15	$25 if green from fixed jar	$17	
Choice 16	$25 if green from fixed jar	$18	
Choice 17	$25 if green from fixed jar	$19	
Choice 18	$25 if green from fixed jar	$20	
Choice 19	$25 if green from fixed jar	$21	
Choice 20	$25 if green from fixed jar	$23	
Choice 21	$25 if green from fixed jar	$25	B

List 2:
Option A: \$25 if the marble drawn from the fixed jar is blue (blue from both jars, or blue from the fixed Jar and green from the other Jar), otherwise \$0.
In the table: A is "\$25 if blue from fixed jar"

List 3:
Option A: \$25 if the two marbles drawn are of different colours (green from Jar #1 and blue from Jar #2, or blue from Jar #1 and green from Jar #2), otherwise \$0.
In the table: A is "\$25 if different colours"

List 4:
Option A: \$25 if the two marbles drawn are of the same colour (green from both jars, or blue from both jars), otherwise \$0.
In the table: A is "\$25 if same colours"

I will now fill an empty third jar (#3) with 2 marbles: 1 green and 1 blue, so the chance of drawing a green marble is exactly 50%.

List 5:
Option A: \$25 if the marble drawn from Jar #3 (that is known to contain one green and one blue marbles) is green, otherwise \$0.
In the table: A is "\$25 if green from jar #3"

List 6:
Option A: \$25 if the marble drawn from Jar #3 (that is known to contain one green and one blue marbles) is blue, otherwise \$0.
In the table: A is "\$25 if blue from jar #3".