



Hedging, ambiguity, and the reversal of order axiom[☆]

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ABSTRACT

We ran experiments that gave subjects a straight-forward and simple opportunity to hedge away ambiguity in an Ellsberg-style experiment. Subjects had to make bets on the combined outcomes of a fair coin and a draw from an ambiguous urn. By modifying the timing of the draw, coin flip, and decision, we are able to test the reversal-of-order axiom. Our main result is that the reversal-of-order axiom seems to hold. We also confirm low levels of ambiguity hedging despite the relative obviousness of the opportunity.

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1. Introduction

As a thought experiment, the Ellsberg paradox (Ellsberg, 1961) has given rise to a huge theoretical literature on ambiguity.¹ When it comes to implementing the Ellsberg paradox in an incentivized experiment, however, there remain some important challenges. In this paper, we address two noteworthy topics using an experiment. First, to our knowledge, this experiment presents the first explicit test of Anscombe and Aumann's (1963) "Reversal of order" axiom. Second, we study whether subjects use potential hedging opportunities when faced with several decisions as is typically the case in ambiguity experiments.²

The second question is of relevance to almost all ambiguity experiments.³ In particular, it is still unclear how to pay subjects for multiple decisions without allowing for hedging. Consider a standard two-color Ellsberg urn consisting of an unknown number of blue and yellow balls and suppose a subject is asked to bet 5 euro on the outcome of one draw from this urn. If he is ambiguity averse, he may attach a low value to betting on a blue ball. In isolation, the same would happen

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¹ Schmeidler (1989), Gilboa and Schmeidler (1989), Klibanoff et al. (2005) to name just a few. There is also a large experimental literature, recently surveyed by Trautmann and van de Kuilen (2016) or Oechssler and Roomets (2015).

² Most ambiguity experiments involve at least two decisions for each subject in order to establish a contradiction to expected utility theory.

³ For recent examples, Voorhoeve et al. (2016) and Cubitt et al. (2018) both go so far as to discuss hedging concerns in the context of the design and/or analysis of their ambiguity experiments, despite neither paper being specifically focused on ambiguity hedging.

if he is asked to bet on a yellow ball. However, if he is asked to bet twice and both bets are paid (and only one ball is drawn), the subject may combine the two bets and realize that if he bets once on blue and once on yellow, he can guarantee himself a fixed payment of 5 euro. This already shows that it not a good idea to pay for both questions in this setting.

The Random-Lottery Incentive System (RLIS) was designed to address such problems (see e.g. Starmer and Sugden, 1991). The RLIS pays for one randomly chosen decision (e.g. chosen by a coin toss). However, as pointed out recently by Oechssler and Roomets (2014), Bade (2015), and Kuzmics (2017) this does not help much if the coin toss that determines the decision to be paid out comes at the end of the experiment. In this case betting once on blue and once on yellow guarantees in total the (objective) 50:50 lottery of winning 5 euro. This way all ambiguity is hedged away, an observation which recalls Raiffa's (1961) critique of Ellsberg's experiment.

In fact, if Anscombe and Aumann's (1963) "Reversal of order" axiom holds, the hedge works regardless of the order in which the urn draw and the coin toss are performed since the axiom states that it is immaterial for a decision maker whether the coin is tossed first and then the ball is drawn from the urn or vice versa. Azrieli et al. (2018) conduct a very careful theoretical analysis of the conditions under which the RLIS is incentive compatible. They show that one of the few conditions under which the RLIS is not incentive compatible is under ambiguity when the reversal of order axiom is maintained. However, the axiom need not be satisfied (see e.g. Seo, 2009, and Saito, 2015, for criticism and alternatives to the reversal of order axiom). Baillon et al. (2014) depart from the reversal of order axiom and show theoretically that incentive compatibility can be rescued when the coin is tossed (but not revealed) before decisions are taken.

Our experiment asks subjects to make bets on the combined outcomes of a fair coin and a draw from an ambiguous urn. We then manipulate the order of the decision, the urn draw, and the coin flip. Our main result is that the reversal of order axiom seems to hold. Subjects are not significantly influenced by the order of coin flip, urn draw, and decision. We also confirm results of Dominiak and Schnedler (2011) that subjects do not seem to have a strict preference for hedging away ambiguity.⁴

2. Experimental design: the main treatments

The experiment consisted of four parts. At the end of the experiment, one part was chosen for payment by rolling a four-sided die. In addition, each subject received a show-up fee of 5€.

Part 1 addresses our main question. Here subjects had to make bets on the combined outcomes of a fair coin and a draw from an urn with 24 balls.⁵ The urn contained blue and yellow balls in a composition that was unknown to subjects. Subjects were told that any combination from 0 blue balls (and 24 yellow balls) to 24 blue balls (and 0 yellow balls) was possible.

In particular, subjects had to place one bet on the color of the drawn ball if the coin came up heads and one bet if it came up tails (see Appendix A for the decision sheet). The questions were framed like this. "Please select exactly one of the two options in case the coin shows head: 'blue' if 'Head' or 'yellow' if 'Head'. Please select exactly one of the two options in case the coin shows tail: 'yellow' if 'Tail' or 'blue' if 'Tail'." The order of these questions was randomized across subjects and sessions such that on average all possible orders were roughly equally frequent.

One can also illustrate the four alternatives as in Table 1. Implicitly, subjects just had to select one of the four combined choices. In case the correct color was predicted, they received 9€. If not, they received nothing.

Notice that betting on either "blue if Head & blue if Tail" (from now on shortened to "bb") or "yellow if Head & yellow if Tail" ("yy") results in an ambiguous payoff (determined by the distribution of blue and yellow balls). Meanwhile, betting on either "blue if Head & yellow if Tail" or "yellow if Head & blue if Tail" results in the same objective 50:50 lottery ("roulette wheel") regardless of which ball is drawn. The latter two options, then, allow for a rather clear opportunity for subjects to hedge away all ambiguity (but not risk).

The main treatments of our experiment differed with respect to the timing in which the four design elements listed in Table 2 were performed. The two main treatments are called DecDrawFlipReveal (first, subjects make a decision, then the ball is drawn from the urn, then the coin is flipped, then the coin is revealed) and DecFlipRevealDraw. Although there are more ways to arrange the timing of these elements, we focus our investigation here on these two timings in the interest of efficiently testing our hypotheses, which are explained in Section 3.

Parts 2 and 3 of the experiment together allow us to identify subjects with color-symmetric beliefs. In Part 2, subjects were asked to consider again the same urn as in Part 1. They were told that at the end of the experiment, a subject would draw one ball from this urn if this part was selected for payment. They then had the option of betting on "blue" which meant they would receive €9.75 if a blue ball is drawn from this urn. Or they could bet on "yellow" and receive €9.00. In Part 3 they faced exactly the same options only that now a draw of a blue ball would yield €9.00 and the draw of a yellow

⁴ See also Blanco et al. (2010) who find a similar result in the context of belief elicitation and hedging.

⁵ In the actual experiment, we used a non-transparent bag and blue and yellow marbles. For expositional reasons, we employ the more customary urns and balls in the text. In our experiment, we used an even number of total marbles so that a true 50/50 split would be possible. We also wanted enough marbles to allow for a reasonable number of possible discrete distributions in the urn. The number 24 fits both of our desired criteria, but is not unique in doing so.

Table 1
Bets and payoffs.

Possible choices	Coin shows Head		Coin shows Tail	
	Ball is blue	Ball is yellow	Ball is blue	Ball is yellow
Blue if Head & blue if Tail (“bb”)	9€	0€	9€	0€
Blue if Head & yellow if Tail (“by”)	9€	0€	0€	9€
Yellow if Head & blue if Tail (“yb”)	0€	9€	9€	0€
Yellow if Head & yellow if Tail (“yy”)	0€	9€	0€	9€

Table 2
Elements of the design.

Element	Description
Coin Flip	A coin is flipped under a cup
Flip Reveal	The result of the coin flip is revealed to subjects
Ball Draw	A ball is drawn from the urn and revealed to subjects
Decision	Subjects make bets contingent on coin flip and ball draw

ball €9.75. We classify subjects who chose in both parts the color with the €9.75 payment as having color-symmetric beliefs.⁶

In Part 4 we want to elicit whether a subject is ambiguity averse by using a classical two-color Ellsberg urn experiment. In this part, two *new* urns were presented to subjects, urns B and C. Urn B contained 20 balls, each of them either white or green. Subjects were not told anything about the composition of this urn except that any combination from 0 white balls (and therefore 20 green balls) to 20 white balls was possible. Subjects were told that Urn C contained 10 white balls and 10 green balls. Subjects then had to choose a color to bet on and an urn.⁷ If the color from their chosen urn matched the color they had chosen, subjects received a prize. To break ties, we chose this prize to be €9.10 if subjects chose to bet on the ambiguous urn B and €9.00 if subjects chose to bet on the risky urn. Thus, any subject who bet on the risky urn C can be classified as strictly ambiguity averse. All ambiguity neutral or loving subjects should choose to bet on urn B.

Combined, Parts 2 through 4 allow us to classify subjects into two groups that become relevant in the next section: subjects who are strictly ambiguity averse and have color-symmetric beliefs and all other subjects.⁸

Instructions (see Appendix B) were written on paper and distributed at the beginning of each part. The draws from the urns and the tosses of coins were performed by different subjects.⁹ Urns were on display during the experiment, so that subjects could be certain that the urns' contents could not be manipulated. Subjects were allowed to verify the urns' contents after the experiment and some did. Participants were invited from a database using ORSEE (Greiner, 2015) and hroot (Bock et al., 2014). The experiment was conducted in the AWI-lab in Heidelberg at the University of Heidelberg, using pen and paper. For our two main treatments we had 7 sessions in DecDrawFlipReveal and 8 sessions in DecFlipRevealDraw. In total, we have 234 valid independent observations (117 in both treatments).¹⁰ Experiments lasted about 45 minutes including instruction time. Average earnings from the experiment amounted to approximately 10.60 euro. At the end, subjects answered two questions regarding their gender and whether they studies economics (see Appendix B).

2.1. An alternative specification

Initially we had some concerns about the fact that subjects in the main experiment had to make four choices, which made it necessary to use the random lottery procedure for payments. We still think this may be problematic as it introduces a compound lottery, which is known to cause theoretical and practical concerns in ambiguity environments (Halevy, 2007). For this reason, our initial experiment consisted only of one single paid decision. This alternative specification did not contain Parts 2–4. However, as a referee pointed out, this made it impossible to classify subject according to ambiguity aversion and symmetry of beliefs and some of our hypotheses regarding hedging (see the following section) depend on this classification. On the other hand, the alternative specification provided a very clean test of the Reversal of Order axiom since no other tasks could confound the main task. In this section, we shortly describe the design of this alternative specification. Fortunately, it turns out that the conclusions are robust with respect to the Reversal of Order axiom.

⁶ Subjects who are strongly ambiguity (or risk) seeking might bet twice on the option yielding €9.75 even if they have color-asymmetric beliefs. However, this misclassification would apply to both treatments equally and is likely to concern a small minority of subjects.

⁷ This procedure is standard (see e.g. Halevy, 2007) and should eliminate concerns about asymmetric beliefs.

⁸ Attanasi et al. (2014) demonstrates a relationship between beliefs about the urn composition and measures of ambiguity aversion, which suggests that eliciting beliefs about the urn composition can be useful for interpreting our results. For example, subjects in our experiment who have color-asymmetric beliefs may be less likely to choose a hedging option in Part 1 even when ambiguity averse.

⁹ These subjects also participated and were paid as normal in the decision-making parts of the experiment. However, this did not create a conflict. The subject flipping the coin could not see the coin through the cup before it was revealed. Similarly, the subject making the draw from the urn could not see the ball being drawn until visible to all present in the room.

¹⁰ We have 118 observations in DecFlipRevealDraw but one subject did not answer the second question in Part 1.

The alternative specification consisted of Part 1 only. There were three treatments, ADecDrawFlipReveal (“A” stands for alternative specification) and ADecFlipRevealDraw as described above plus one additional treatment AFlipDecRevealDraw, in which the coin was flipped (under a cup) before the decisions of subjects. However, the coin was revealed only after the decision was made. This treatment was included as it is suggested by Baillon et al. (2014) who argue that this sequence makes the RLIS incentive compatible. One argument would be that given that the coin is already tossed (but not revealed) when subjects make their decisions, subjects face a fully ambiguous decision. This implies that, from a practical standpoint, hedging would be even less of an issue using this type of design.¹¹

There are a number of other differences in design that make the alternative specification not directly comparable to the main experiment. In particular, the order of questions on the decision sheet was not randomized, which lead to a noticeable imbalance in decisions. Also subjects received €5 if they bet on the correct color rather than €9 in the main treatments.¹²

The alternative specification treatments were also conducted in the AWI-lab in Heidelberg at the University of Heidelberg, using pen and paper. For each of the three treatments, we have 60 independent observations (58 in ADecDrawFlipReveal due to no-shows). Experiments lasted about 30 minutes including instruction time. Average earnings from the experiment amounted to approximately 5.50 euro. Instructions for the alternative specification are available in Appendix C.

We report the results of the alternative specification in Subsection 4.1

3. Hypotheses

Saito (2015) nicely illustrates the situation subjects face in Part 1 of our experiment with diagrams like the ones shown in Fig. 1. The left tree shows a situation as in our DecDrawFlipReveal treatment when a subject bets on “blue if Head & yellow if Tail”. First, the winning ball is drawn from the urn, then the coin is tossed. The tree on the right in Fig. 1 shows the same bet “by” with the timing as in our DecFlipRevealDraw. Here, first the coin is tossed, then the ball is drawn. Whether or not subjects consider the situation in the left and the right panel as different is an important question that has not been studied experimentally. Theoretically it depends on whether the Reversal of Order axiom holds. “[The RoO axiom says that] if the prize you receive is to be determined both by a horse race and the spin of a roulette wheel, then it is immaterial whether the wheel is spun before or after the race.” (Anscombe and Aumann, 1963, p. 201). Both Seo (2009) and Saito (2015) express doubts whether the RoO axiom holds and develop their theories under the assumption that it does not. This leads to our first hypothesis.

Hypothesis I The Reversal of Order axiom holds: Choice behavior is not influenced by the order in which the coin flip and the draw from the urn is performed.

Our second main question is whether subjects see and prefer the opportunity to hedge. By choosing bet “by” or “yellow if Head & blue if Tail” (“yb”) the subject can guarantee himself an objective lottery of 50:50 for winning 9€. ¹³ All ambiguity is thus hedged away. Regardless of whether a blue ball or a yellow ball is drawn, the subject receives the same Anscombe-Aumann act. If, on the other hand, the subjects chooses blue (or yellow) regardless of the coin toss (as in the center tree), the ambiguity about the number of blue and yellow balls is still very much present. Nevertheless, even an ambiguity averse subject might prefer “bb” or “yy” if he has strongly asymmetric beliefs with respect to the color distribution in the urn.

Thus, our second hypothesis concerns whether ambiguity averse subjects with color-symmetric beliefs recognize and prefer the opportunity to hedge. In a sense, the following hypothesis is a direct consequence of the very definition of uncertainty aversion (see Schmeidler, 1989, or Saito, 2015). Subjects with color-symmetric beliefs should be indifferent between betting on blue or betting on yellow. If they are strictly uncertainty averse, they should thus strictly prefer the hedge “by” or “yb”.

Hypothesis II Ambiguity averse subjects with color-symmetric beliefs will strictly prefer bets “by” and “yb” over “bb” and “yy” in treatment DecDrawFlipReveal.

The right panel in Fig. 1 shows the situation in our treatment DecFlipRevealDraw when a subject bets on “by”. Arguably, after the coin is tossed, the subject faces again an ambiguous situation.¹⁴ However, a subject who satisfies the Reversal of Order axiom would treat the situations depicted in the left and the right panel of Fig. 1 the same. Thus, we have

Hypothesis III Ambiguity averse subjects who have color-symmetric beliefs and satisfy the Reversal of Order axiom will strictly prefer bets “by” and “yb” over “bb” and “yy” in treatment DecFlipRevealDraw.

¹¹ Another practical concern is, in experimental designs where the experimenter performs randomizations, whether randomizations before a session should be viewed as equivalent to similar randomizations done after decisions are made. This would be at issue, for example, when choosing a single round for payment in some RLIS, or when filling an urn randomly to generate a compound lottery.

¹² Subjects also received a show-up fee of €3.

¹³ We assume throughout that subjects consider a coin flip as an objective 50:50 lottery. Subjects were told in the instructions that the coin is fair.

¹⁴ It is often argued (see e.g. Saito, 2015) that the subject faces a commitment problem after letting the coin decide on which ball to bet. This is correct but we solved this problem for our subjects by providing automatic commitment.

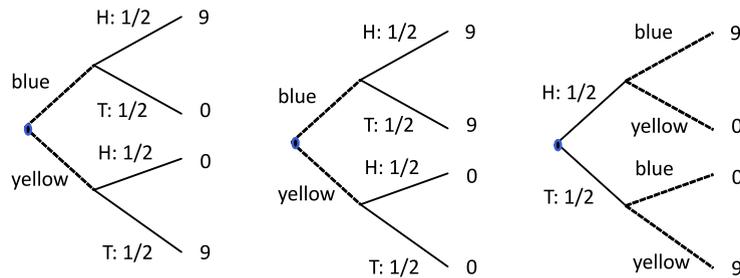


Fig. 1. Left panel: The situation induced by betting on “by” in treatment DecDrawFlipReveal. Center panel: betting on “bb” in treatment DecDrawFlipReveal. Right panel: betting on “by” in treatment DecFlipRevealDraw.

Note: The solid lines correspond to the risk introduced by flipping a coin, while the dotted lines correspond to the ambiguity of the color of the drawn ball. (For interpretation of the colors in the figure(s), the reader is referred to the web version of this article.)

Because we cannot measure whether individual subjects’ preferences satisfy the RoO axiom (and for some they may not), we would reasonably expect hedging rates in the DecFlipRevealDraw treatment among ambiguity averse subjects with color-symmetric beliefs to be lower than rates in the DecDrawFlipReveal treatment (by Hypothesis 1).

4. Results

First we take a look at the results for Parts 2 through 4. The results are summarized in Table 3. Of our 234 subjects in the main treatments, the answers to Part 4 reveal that 69.2% are strictly ambiguity averse. This is in line with previous findings, although it is slightly on the high side (see e.g. Oechssler and Roomets, 2015). According to their answers to Parts 2 and 3, slightly more than 50% of our subjects have color-symmetric beliefs with respect to the urn used in Part 1. This is somewhat lower than we had expected and shows that one cannot simply rely on the principle of insufficient reason to make assumptions about subjects’ beliefs. Of the remaining subjects, 40% indicated asymmetric beliefs by betting twice on the same color. There were also about 10% of subjects whose beliefs are difficult to rationalize since they bet twice on the color that yielded the lower payoff of €9.

Fig. 2 shows the frequency distribution of subjects’ choices in Part 1 of the main experiment. A Fisher exact test ($p = .87$) shows that we cannot reject Hypothesis 1, the timing of the coins flip and the draw from the urn does not seem to have any influence on subjects’ choices.¹⁵ In other words, the Reversal of Order axiom seems to hold.

The Reversal of Order axiom also seems to hold when we consider the percentage of hedgers across treatments in Fig. 3, where a subject is counted as hedger if he chose “blue if Head & yellow if Tail” or “yellow if Head & blue if Tail”. The top graph shows the percentage of hedgers among all subjects. As it happens, the percentage is identical across treatments. The bottom graph shows the percentage of hedgers among subjects who are strictly ambiguity averse and have color-symmetric beliefs. Again, the difference across treatments is small and not significant (Fisher exact test, $p = .66$).¹⁶

Fig. 3 also sheds light on the question whether subjects try to hedge away ambiguity. Looking at the top of Fig. 3, there does not seem to be a strong preference for hedging, as slightly less than 50% of subjects choose to hedge. Strictly speaking, Hypotheses 2 and 3 only apply to subjects who are ambiguity averse and have color-symmetric beliefs. However, even for this subgroup of subjects, there does not seem to exist a strong preference for hedging (see lower part of Fig. 3). In DecDrawFlipReveal ($n = 48$), the percentage of hedgers is 58.3%, and in DecFlipRevealDraw ($n = 36$) the percentage is 52.8%. Neither is significantly different from 50% according to a binomial test ($p = .31$ and $p = .86$, two-sided, respectively). If subjects were indifferent we might expect them to choose randomly and produce a 50:50 split. This suggests that subjects, at the least, do not have a strict preference for hedging and supports the finding of Dominiak and Schnedler (2011).¹⁷ Of course, some people may still be intentionally hedging, but it would appear that these people are not in the majority even when the opportunity to hedge is as obvious as in our investigation.¹⁸

4.1. Results of the alternative specification

The treatments in the alternative specification arguably provide the cleanest test of the Reversal of Order axiom since subjects in this treatments had to make just one decision. It also allows us to test the procedure recommended by Baillon

¹⁵ All tests in this paper are two-sided tests.

¹⁶ The percentage of subjects with color-symmetric beliefs was somewhat different across the main treatments (57% vs. 43%). Although this difference is not significant (Fisher exact test, $p = .103$), it is worthwhile to consider hedging rates for the subgroup of ambiguity averse subjects with color-symmetric beliefs. The logit regression in Appendix A also shows that the RoO axiom holds even when controlling for color-symmetric beliefs.

¹⁷ Dominiak and Schnedler (2011) elicited the willingness to pay for various bets. Their “chameleon ticket” is comparable to our “by” bet in our DecFlipRevealDraw treatment. However, Dominiak and Schnedler (2011) did not vary the timing of the coin toss and the draw from the urn.

¹⁸ We find marginal evidence of higher hedging rates among ambiguity averse subjects with color symmetric beliefs compared with remaining subjects. This result is presented using logit regressions in Appendix A.

Table 3
Classification of subjects in main treatments.

Ambiguity averse	69.2%
Symmetric beliefs	50.4%
Asymmetric beliefs	39.7%
Symmetric beliefs & ambiguity averse	35.9%

Note: $n = 234$.

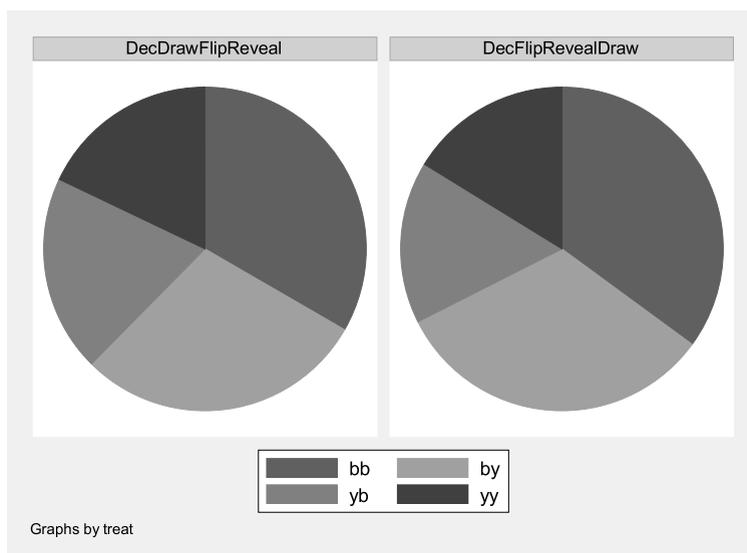


Fig. 2. Relative frequencies of choices in Part 1 of the main experiment.

et al. (2014), namely that the coin is flipped before but revealed only after the decision (AFlipDecRevealDraw). On the other hand, these treatments do not allow us to test Hypotheses II and III since we cannot identify subjects who are ambiguity averse and have symmetric beliefs.

Fig. 4 shows the percentage of hedgers in those three treatments. Again, the RoO axiom seems to hold as there is no significant difference in the percentage of hedgers between any of the treatments, either jointly among all three treatments (Fisher exact tests, $p = .46$), or using pairwise Fisher exact tests ($p > .32$). When the coin is flipped before the decision, as in treatment AFlipDecRevealDraw, we find a slightly lower percentage of hedgers, but this difference is not significant.

When we compare the alternative specification with the main treatment, we see that hedging rates are somewhat lower in the alternative specification. However, the only pairwise differences that are significant at the 5% level are those between AFlipDecRevealDraw and the two main treatments (Fisher exact tests). There may be a number of reasons why the hedging rates are lower in the alternative specifications, which we cannot identify due to a number of design changes. However, in any case, hedging rates below 50% are surprisingly low.

5. Conclusion

The Random-Lottery Incentive System (RLIS) was designed to prevent spillovers from one decision in an experiment to another. For ambiguity experiments, several papers (Oechssler and Roomets, 2014; Bade, 2015; Kuzmics, 2017) have argued that this may not be fully successful. Potentially, the typical Ellsberg urn experiment allows subject to hedge away ambiguity if they combine several decisions. This may or may not depend on the order in which the “horse race” (draw from ambiguous urn) and the “roulette wheel” (risky coin toss) are performed. For the latter question, the empirical validity of Anscombe and Aumann’s (1963) Reversal of Order axiom is crucial.

In this paper, we addressed two questions using an experiment. (1) Does the order of coin toss, urn draw, and decision matter at all in experiments? To our knowledge this is the first experimental test of the reversal of order axiom. (2) Do subjects actually hedge by combining several decisions in an experiment?

We found that (1) the Reversal of Order axiom seems to hold. Subjects were not significantly influenced by the order of coin flip, urn draw, and decision. And (2) most subjects do not seem to have a strict preference for hedging, even when the opportunity was presented to them on a silver platter. Thus it seems that, from a practical standpoint, experimenters do not need to worry too much about potential hedging opportunities. On the other hand, from a theoretical standpoint, given the results of Azrieli et al. (2018), the success of the Reversal of Order axiom suggests that, even with careful timing, monotonicity fails in many ambiguity experiments, calling into question incentive compatibility. However, the theoretical interpretation is clouded somewhat by the relatively low levels of hedging by ambiguity averse subjects with color-symmetric

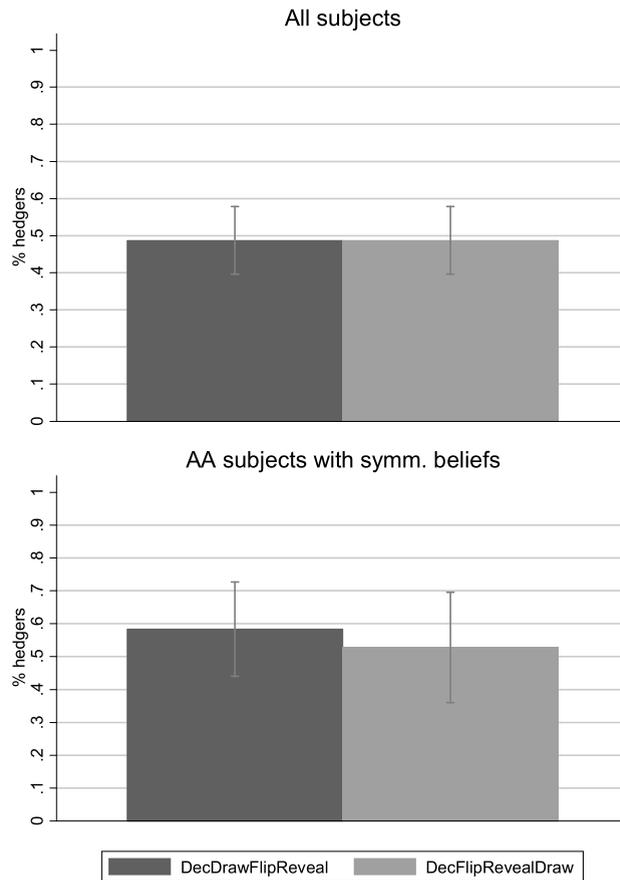


Fig. 3. Percentage of hedgers by treatment.

Note: Error bars show 95% confidence intervals based on binomial distributions. Subjects are counted as hedgers if they chose bets "by" or "yb". Top panel is based on 117 observations for each treatment. Bottom panel is based on 48 for DecDrawFlipReveal and 36 for DecFlipRevealDraw.

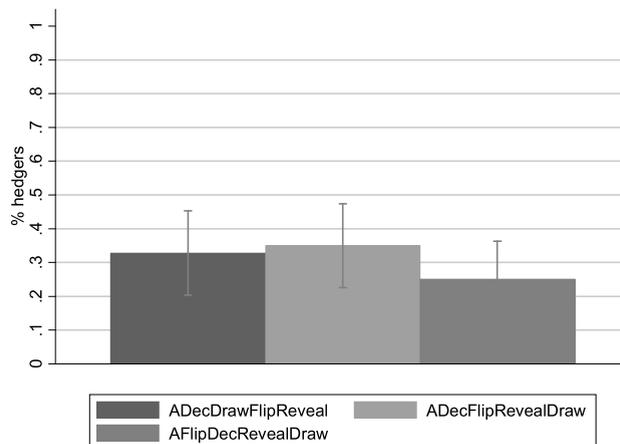


Fig. 4. Percentage of hedgers in the alternative specification by treatment (all subjects).

Note: Error bars show 95% confidence intervals based on binomial distributions. Subjects are counted as hedgers if they chose bets "by" or "yb".

beliefs. Theory predicts such subjects should hedge consistently so long as the coin flip comes last and/or the Reversal of Order axiom holds. Thus, future research should focus more on theories that do not combine ambiguity aversion with a preference for randomization.

Appendix A. Supplementary material

Supplementary material related to this article can be found online at <https://doi.org/10.1016/j.geb.2019.07.007>.

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