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CESIFO WORKING PAPER NO. 5220
CATEGORY 13: BEHAVIOURAL ECONOMICS
FEBRUARY 2015

ISSN 2364-1428

CESifo
Center for Economic Studies & Ifo Institute

CESifo *Working Paper No. 5220*

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Abstract

We introduce a simple, easy to implement instrument for jointly eliciting risk and ambiguity attitudes. Using this instrument, we structurally estimate a two-parameter model of preferences. Our findings indicate that ambiguity aversion is significantly overstated when risk neutrality is assumed. This highlights the interplay between risk and ambiguity attitudes as well as the importance of joint estimation. In addition, over our stakes levels we find no difference in the estimated parameters when incentives are real or hypothetical, raising the possibility that a simple hypothetical question can provide insights into an individuals preferences over ambiguity in such economic environments.

JEL-Code: D010, D030, D810.

Keywords: ambiguity aversion, experiments, estimation.

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February 10, 2015
We thank Michael Kuhn and Pietro Ortoleva for invaluable input and useful comments. We also thank seminar participants at UC San Diego and University of Chicago for helpful feedback.

1 Introduction

Individuals face uncertainty daily. People must evaluate the likelihood of uncertain future outcomes, such as whether a business venture will succeed or fail, the future performance of a stock, or whether their vacation will be ruined by rain. In cases where the outcomes are not accompanied by objective probabilities, the normative approach of Subjective Expected Utility (SEU) theory introduced by (Savage, 1954) has traditionally been used. In this framework, an individual behaves as though she holds a single (subjective) prior over all states of the world and maximizes the expected value of utility given this prior.

Ellsberg (1961), however, proposed that most individuals treat ambiguous uncertainty differently than objective risk.[1] In particular, he argued that people exhibit a significant degree of ambiguity aversion, placing a premium on outcomes for which probabilities are known. This general result has been replicated broadly and has broad and important implications for the economics of optimal contracting, investment choices, and mechanism design.

Several lines of research have attempted to model attitudes towards both objective and subjective uncertainty in a way that is consistent with ambiguity-averse behavior. Gilboa and Schmeidler (1989) developed a model of maxmin expected utility (MEU) in which an individual can have multiple priors and her expected utility from an outcome is taken as the minimum given this set of priors. In this framework an individual can be seen as pessimistic in the way that she evaluates the likelihood of an ambiguous outcome.

The model of α-maxmin expected utility (α-MEU) proposed by Ghirardato, Maccheroni and Marinacci (2004) generalized MEU to represent the utility of an outcome as the convex combination of the expected utilities given the set of priors the individual holds. Models of recursive expected utility (REU) posit that individuals have a subjective second order probability distribution over a set of first order priors on the likelihood of possible outcomes, and maximize expected utility over both first and second order lotteries (Ahn, 2008; Halevy and Feltkamp, 2005; Klibanoff, Marinacci and Mukerji, 2005). In these models, the degree

[1] Take for example two urns, Urn A and Urn B. Each urn is filled with 100 red and/or black balls. Urn A has 50 red balls and 50 black balls, while Urn B has an unknown distribution of red and black balls. An individual is offered the following bet: first choose a color, red or black, and then an urn from which to draw a ball. If the ball drawn matches the chosen color, then you win; otherwise you lose. In this context, ambiguity aversion implies that the individual will have a strict preference for drawing from Urn A, where the probability of drawing a particular color is known. Notice, however, that such a preference is inconsistent with SEU. For any given single prior, if the individual believes that there are more black balls than red in Urn B, then she should choose black and draw from Urn B; if she believes that there are more red balls, then she should choose red and draw from Urn B. At most, under SEU the individual can be indifferent between the urns, but the theory cannot rationalize a strict preference for Urn A. Nevertheless, such ambiguity aversion has been established as a robust empirical phenomenon across a variety of contexts (see Charness and Gneezy (2010) and references therein).

of ambiguity aversion is determined by the relative concavities of the two utility functions.

Given the ubiquity of ambiguity in economic decision making and the large theoretical literature on the subject, it is important to have a viable and robust experimental method to empirically characterize ambiguity aversion both in lab and field settings. Previous experimental literature on the subject has mostly focused on finding the presence of ambiguity aversion rather than the extent to which it exists (Becker and Brownson, 1964; Slovic and Tversky, 1974). Given the extent to which ambiguity aversion has been explored theoretically, it would be desirable for an experimental method to yield data rich enough to estimate levels of ambiguity.

In addition, since models of ambiguity are typically characterized by two parameters – coefficients of risk and ambiguity aversion – it is important that the experimental method jointly measures ambiguity and risk attitudes and makes minimal assumptions and restrictions on the coefficients (e.g. risk neutrality).[2] Lastly, a viable experimental method for studying ambiguity aversion should be simple enough to be utilized in the field, where access to computers is low and subjects may not understand complex instructions.

In this paper, we propose a simple, easy to use method designed to generate choice data rich enough for the study of ambiguity attitudes both in reduced form as well as structural estimation. Using a double multiple price list (DMPL) format we jointly elicit risk and ambiguity attitudes by having individuals make a series of decisions in contexts with both subjective and objective uncertainty (see Andersen *et al.* (2008) for use of DMPL to jointly elicit time and risk preferences). We then use the data to estimate parameters r and α of the α-MEU model, where the parameter r is the risk aversion coefficient and α reflects ambiguity aversion.

Since our participants are largely risk averse, estimates of ambiguity aversion are much greater when risk neutrality is assumed than if ambiguity and risk parameters are estimated jointly. We use our instrument to study whether the calculated estimates differ depending on whether the stakes used to elicit them are real or hypothetical. We do not find a significant difference between the parameters elicited using the two methods over our stakes levels.[3]

Some of the earlier efforts to measure levels of ambiguity aversion elicited individuals' willingness to pay for a bet with an ambiguous likelihood of success. Fox and Tversky (1995)

[2] Andersen, Harrison, Lau and Rutström (2008) show that estimating time discounting parameters under the assumption of risk neutrality yields significantly higher discount rates than when time and risk parameters are jointly estimated. The authors emphasize the importance of taking risk preferences into account in order to more accurately characterize individual time preferences.

[3] Holt and Laury (2002) found that increasing real incentives 20x led to greater risk aversion estimates. In our comparison, the stakes were either real or hypothetical, but we did not differ the real stakes sizes.

compared participants hypothetical willingness to pay for a bet based on a draw from an urn with an ambiguous distribution of balls to a bet on an urn with a known distribution. Halevy (2007) measured ambiguity aversion in a similar way but used the incentive compatible BDM (Becker, Degroot and Marschak, 1964) mechanism to elicit willingness to pay. Using a multiple price list format, Moore and Eckel (2003) studied ambiguity aversion by eliciting the smallest amount individuals would be willing to accept for a gamble with ambiguous chances of winning. These methods, while qualitatively capturing ambiguity attitudes, do not jointly measure risk attitudes and hence may overstate the degree of actual ambiguity aversion.

In work that most closely resembles the current paper, Ahn, Choi, Gale and Kariv (2014) estimate the structural parameters of the α-MEU model through a computerized portfolio choice experiment. In their study, participants were endowed with a linear budget set and chose how much of their endowment to allocate between three assets – one with a $\frac{1}{3}$ objective probability of success and two that succeeded with probabilities that added up to $\frac{2}{3}$ (the success probability of each of the two assets was unknown). Individuals could minimize their exposure to ambiguity by investing an equal amount in each of the ambiguous assets. From a series of such choices, the authors jointly estimated the ambiguity and risk parameters of the α-MEU model assuming von Neumann-Morgenstern utility with constant absolute risk aversion (CARA). The results suggested a significant degree of heterogeneity in ambiguity attitudes, with the majority of subjects behaving as SEU maximizers – a finding that is not consistent with previous empirical work that demonstrates more prevalent ambiguity aversion.[4]

The remainder of our note is organized as follows. In the next section we present a detailed overview of our instrument and estimation techniques. We then discuss the empirical results and conclude with a discussion of the research implications.

[4]The use of a linear budget set, however, did not allow the analysis to distinguish between risk- or ambiguity-loving in one case and risk- or ambiguity-averse in another. As a consequence, the authors made restrictions on the parameters to be risk and ambiguity averse. This significantly limited the capacity of the analysis to capture the full range of preferences over ambiguity. Our instrument does not make such restrictions, allowing for the estimation of parameters that reflect both risk/ambiguity loving and averse preferences. In addition, the paper-and-pencil nature of our method makes it more viable as a resource for field research on ambiguity and risk attitudes.

2 A Simple Method

2.1 Procedure

We asked individuals to first make decisions over gambles where the probabilities of each outcome were objective, and then make decisions where the probabilities of some gambles were known while others were ambiguous. Choices between gambles were presented in a format known as a multiple price list (MPL). The MPL method has been used by researchers to elicit prices for commodities (Kahneman, Knetsch and Thaler, 1990), discount rates (Andersen *et al.*, 2008; Coller and Williams, 1999) and risk preferences (Holt and Laury, 2002).

We recruited 164 students at the University of California, San Diego and presented them with two multiple price lists. To elicit risk attitudes, we used an MPL derived from Holt and Laury (2002). Participants were presented with 10 decisions between pairs of gambles with objective probabilities over outcomes (see Appendix: Task H). Participants were informed that the outcome of a gamble would be realized using a fair 10-sided die.

Decisions are stacked in rows, each involving a choice between a gamble Option A in the left column and a gamble Option B in the right column. The payoffs for Options A and B remain constant for each decision, but the probability of obtaining the higher payoff in each gamble increases as one moves down the rows. By decision 10, the choice is between $2 and $3.85 – both with certainty. Barring extreme risk seeking, this implies a pattern of choice where the individual begins by choosing Option A for the first decision and then switches over to Option B at some point before the last row. The point where this switch is made, the "switch point," is used to characterize the individual's risk attitude.

In order to elicit ambiguity attitudes, we used a separate MLP that presented individuals with a series of decisions between gambles with known and unknown probabilities (see Appendix: Task T). Participants were presented with two urns. Urn A contained 50 red balls and 50 black balls; Urn B contained 100 red and black balls, but the distribution of colors was not known. They were asked to choose a color, red or black, which would act as their success color, and then make a series of 20 decisions between drawing a ball from Urn A or Urn B. If the color of the ball drawn from the chosen urn matched their success color, then they would win the prize corresponding to that decision. If the drawn color did not, then they would win nothing. Similar to the risk elicitation MPL, decisions are stacked in rows, with each being a choice of a draw from Urn A or Urn B. The payoffs for Urn A remain constant in each decision, but the payoffs for Urn B increase as one moves down the decision rows. Payoffs were designed such that unless the individual was very ambiguity loving, participants would start out with draws from Urn A in the first decision, and switch over to drawing from Urn B by the last decision. This switch point characterized the individual's ambiguity attitude.

It should be noted that we designed our instrument such that individuals made only one actual choice on each MPL: at which decision row they would like to switch from Option A (Urn A) to Option B (Urn B). Allowing individuals to switch freely between the options for each decision row has been shown to produce a significant number of inconsistent decisions, where participants switch more than once or make "backward" choices (Charness and Viceisza, 2015; Dave, Eckel, Johnson and Rojas, 2010; Jacobson and Petrie, 2009). Since such data are difficult to interpret with any standard model of preferences, it tends to be excluded from the analysis. This leads to significant amount of data lost. Condensing the MPL to a single choice of where to switch circumvents this issue. Andersen, Harrison, Lau and Rutström (2006) demonstrate that enforcing a single switch point does not significantly affect the elicited parameters, and this technique has been used by Tanaka, Camerer and Nguyen (2010) to elicit time and risk preferences from Vietnamese villages.

In order to insure incentive compatibility, participants were paid according to the realization of only one decision across both MPLs. Particularly, at the end of the experiment a coin would be flipped. If the outcome was Heads, the risk elicitation MPL would be used (Task H); if Tails, the ambiguity elicitation MPL would be used (Task T). Either a 10- or 20- sided die would then be rolled to determine what decision row to use for the participant's choice. This insured that our procedure avoided the procedural confounds outlined by Azrieli, Chambers and Healy (2012).

Of the 164 students who participated, 87 chose from gambles with real monetary stakes and 77 chose from hypothetical gambles. The outcome of each gamble was presented in experimental tokens. When real incentives were used, at the end of the experiment tokens were converted to dollars at a rate of 20 tokens = \$1.

2.2 Estimation

2.2.1 Model Specification

In order to estimate ambiguity and risk attitudes, we use the α-MEU model with fixed priors (Ghirardato *et al.*, 2004). Assuming von Neumann-Morgenstern utility with constant relative risk aversion (CRRA), our specification can be written as

$$V_i(x;\alpha,r) = \alpha_i \frac{x_{min}^{1-r_i}}{1-r_i} + (1-\alpha_i)\frac{x_{max}^{1-r_i}}{1-r_i} \quad (1)$$

where α_i reflects the ambiguity attitude of individual i, and r_i is her coefficient of risk aversion.[5] Note that in our specification x_{min} corresponds to the lower outcome in a binary gamble, and x_{max} corresponds to the greater outcome. For example, when drawing from Urn B, x_{max} = # of tokens for a successful draw and $x_{min} = 0$ tokens for an unsuccessful draw. Since we imposed no restrictions on the distribution of balls in Urn B, we assume that each individual knew that the number of balls matching her success color lay between 0 and 100, such that in the best case she would be guaranteed to receive x_{max} and in the worst case she would have no chance of receiving it.

In our specification, as well as in the class of models typically considered, the parameter α_i cannot be identified separately from the set of priors. Hence, following Ghirardato *et al.* (2004) and Ahn *et al.* (2014), we fix the set of priors and allow α_i to vary.

2.2.2 Econometric Estimation

In order to obtain structural estimates of i, and r_i we derive the likelihood function for the choices made by the participants. First, we specify the contribution to the likelihood of the choices made on the risk attitude MPL (Task H). Given that there are two possible outcomes for each gamble, let the utility from a gamble take the following form:

$$V_i(y;r) = \sum_{j=1,2} p(x_j)u_i(x_j;r) \tag{2}$$

where x_j is one of the two outcomes, $p(x_j)$ is the probability of that outcome, and y is a gamble from the set Y. In our context individuals always face a decision between two gambles, Option A and Option B, so $Y = \{y_A, y_B\}$ where y_A is Option A and y_B is Option B for that decision.

In addition, we assume individuals maximize the following random utility model:

$$U_i(y;r) = V_i(y;r) + \varepsilon_{iy} \tag{3}$$

where ε_{iy} is *i.i.d.* Type 1 Extreme Value distributed. Individuals maximize utility in the presence of uncertainty such that although they may deviate from the optimal choice in a deterministic setting, they choose the gamble that generates a higher utility with greater probability. Particularly, individuals choose y^* such that $U_i(y^*;\cdot) \geq U_i(y;\cdot)$ for all $y \in Y$. For all y in Y, the distribution of ε_{iy} leads to multinomial logit choice probabilities of choosing

[5]See Ahn *et al.* (2014) for illustration of how this specification can be generated from a variety of different models of preferences such as MEU, α-MEU and CEU.

a particular gamble y that can be expressed in the following form:

$$Pr^{Risk}(y) = \frac{e^{U_i(y;r)}}{\sum_{k=A,B} e^{U_i(y_k;r)}} \tag{4}$$

Next, to specify the contribution to the likelihood from the ambiguity MPL (Task T), let the utility of drawing a ball from an Urn A take the following form:

$$V_i(z^A; r) = \sum_{j=1,2} p(x_j) u_i(x_j; r) \tag{5}$$

where x_j is one of the two outcomes, $p(x_j)$ is the probability of that outcome, and z^A corresponds to Urn A. In our setting, $\{x_1, x_2\} = \{200, 0\}$ and $p(x_j) = .5$ for both $j = 1, 2$. We specify the utility of drawing a ball from Urn B as:

$$V_i(z_B; \alpha, r) = \alpha_i u_i(x_{min}; r) + (1 - \alpha_i) u_i(x_{max}; r) \tag{6}$$

where the parameters are defined as in (1). We also assume individuals maximize a random utility model as in (3). Hence, defining $Z = \{z_A, z_B\}$, the probability of choosing to draw from urn z can be expressed as:

$$Pr^{Amb}(z) = \frac{e^{U_i(z;r,\alpha)}}{\sum_{k=A,B} e^{U_i(z_k;r,\alpha)}} \tag{7}$$

The joint likelihood of risk and ambiguity attitude responses can then be expressed as:

$$\ln L = \ln Pr^{Risk} + \ln Pr^{Amb} \tag{8}$$

We employ the Broyden-Fletcher-Goldfarb-Shanno optimization algorithm to maximize the likelihood function and estimate the ambiguity and risk parameters.

2.3 Results

For our analysis, we pool the data and estimate (1) with errors clustered at the individual level. Results are reported in Table 1 below.

The parameter estimates of r suggest substantial risk aversion in the population. Previous studies employing a similar MPL method to measure risk attitudes have found comparable estimates of the coefficient (Andreoni, Kuhn and Sprenger, 2014; Holt and Laury, 2002; Tanaka *et al.*, 2010).

Participants in our study display a significant amount of ambiguity aversion regardless

Table 1.
Aggregate Utility Estimates

	α	r
Real Incentives	0.55	0.48
Joint Estimate	(.01)	(.01)
Real Incentives	0.60	-
Assume Risk Neutrality	(.01)	
Hypothetical Incentives	0.54	0.50
Joint Estimate	(.01)	(.02)
Hypothetical Incentives	0.60	-
Assume Risk Neutrality	(.01)	

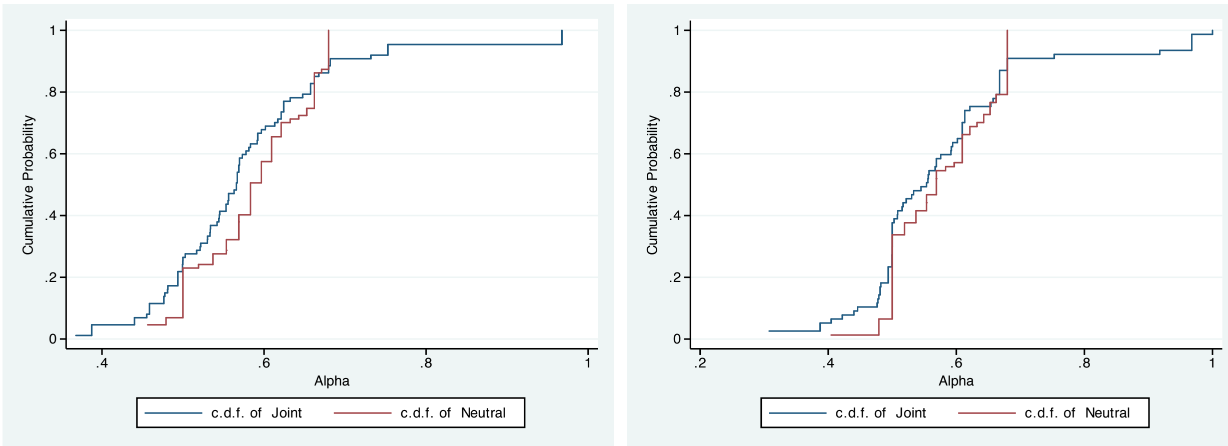
† Results from analysis with clustered standard errors in parentheses.

of the specification or incentive scheme used. Particularly, estimated values of α were significantly greater than the ambiguity neutral value of 0.5 ($p < .001$ for all four specifications listed in Table 1).

In addition, assuming risk neutrality generated significantly greater estimates of α than when risk and ambiguity attitudes were estimated jointly. This was the case when incentives were real ($\chi^2(1) = 1331.7$, $p < .001$) and hypothetical ($\chi^2(1) = 717.6$, $p < .001$). Figure 1 compares empirical cumulative distribution functions of estimated α parameters when risk and ambiguity are estimated jointly versus when risk neutrality is assumed.

In the case of both real and hypothetical incentives, the distribution of α when risk neutrality is assumed lies to the right of the distribution with joint estimates. A two-sample Kolmogorov-Smirnov test for equality of distributions rejected the null hypothesis in both the real ($D = .22$, $p = .02$) and hypothetical incentive case ($D = .23$, $p = .02$). This suggests that eliciting ambiguity attitudes without taking risk aversion into account may overestimate the level of ambiguity aversion, which highlights the importance of joint estimation.[6]

[6]We also examined the effects of background risk and ambiguity on the estimated parameters using a similar paradigm as Harrison, List and Towe (2007). Similar to Harrison *et al.* (2007), we found that endowing participants with background risk significantly affected the estimated risk aversion parameter, but had no affect on the ambiguity aversion parameter. Endowing participants with background ambiguity did not affect estimates of either parameter. For more on measurement of risk in the field see the applications discussed in Harrison and List (2004).



(a) **Real Incentives** (b) **Hypothetical Incentives**

Figure 1. Empirical CDF

We do not find a significant difference when comparing parameter estimates elicited using real or hypothetical incentives: the estimates of α and r did not differ based on incentive scheme ($\chi^2(1) = .35$, $p = .55$ for α; $\chi^2(1) = .72$, $p = .72$ for r). This implies that using hypothetical incentives may not necessarily produce different measures of ambiguity than when real monetary incentives are used, at least when stakes are relatively low.[7]

3 Discussion and Conclusion

We introduced a simple method of jointly eliciting ambiguity and risk attitudes. This paper-and-pencil instrument was used to elicit choices over gambles in contexts where uncertainty over outcomes was both objective and subjective. Individuals' decisions were then used to structurally estimate a two-parameter model of preferences over risk and ambiguity. Our results showed that jointly estimating risk and ambiguity attitudes generated parameter values reflecting significantly less ambiguity aversion than under the assumption of risk neutrality. In addition, estimates elicited using hypothetical incentives did not differ from those elicited using real monetary stakes in either of the specifications used.

Given our findings, we believe that the simplicity of the instrument along with its capacity of generating data viable for structural estimation makes it an ideal tool for measuring ambiguity attitudes in the field. Although several studies have looked at risk attitudes across various populations (Charness and Viceisza, 2015; Jacobson and Petrie, 2009; Tanaka *et al.*,

[7] In Holt and Laury (2002), estimates of risk aversion were indeed greater when larger monetary stakes were used. The stakes, however, were magnitudes greater than the ones employed here.

2010), few have examined attitudes towards ambiguity. Given the ubiquity of ambiguity in decision making, a portable method capable of producing a precise characterization of ambiguity aversion would be a valuable instrument for economic research.

Additionally, our finding that the incentive scheme did not affect the estimated parameters contributes to the debate of whether monetary incentives are a necessary condition for eliciting "true" preferences. In many experimental contexts, particularly when the experiment may require participants to experience a loss, having real monetary stakes may be infeasible or unrealistic. Although Holt and Laury (2002) found that the size of incentives did affect the elicited preferences, in a review of the time preference literature Frederick, Loewenstein and O'Donoghue (2002) suggest that the evidence is mixed. Our results imply that further research is needed to specify the situations when incentive compatibility is necessary for preference elicitation, and when hypothetical incentive schemes would yield similar, if not more "accurate" results.

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Appendix

Instructions for Task H (Real)

In addition to the Instructions, this envelope contains a Decision Sheet. Please look on to your Decision Sheet as you read these Instructions to ensure that you understand the procedure of the experiment. If you have a question at any point, please raise your hand.

The Decision Sheet contains 10 separate Decisions numbering 1 through 10. Each of these Decisions is a choice between "Option A" and "Option B". One of these decisions will be randomly selected to determine your earnings. A ten-sided die will be used to determine the payoffs. After you have made your choice, this die will be rolled twice: once to select one of the 10 Decisions to be used, and then again to determine your payoff for the Option associated with that decision, either A or B, given your choice at that decision.

To choose an Option for each decision, you will make one choice in the "Switch" column on the right. This choice indicates that you would like to switch from Option A to Option B, and will signify whether Option A or Option B is used to determine your earnings for each of the 10 decisions. For each decision **before** your choice, Option A will be used for payment. For each decision **after** your choice, including the decision where the choice was made, Option B will be used.

For example, if the die roll outcome is 6, Decision No. 6 will determine payment.

1. If your "Switch" number is **after** Decision No. 6, then Option A will be used to determine your payoff. You will have a 6/10 chance of earning 200 tokens, and a 4/10 chance of earning 160 tokens.
2. If your "Switch" number is **before or at** Decision No. 6, then Option B will be used to determine your payoff. You will have a 6/10 chance of earning 385 tokens, and a 4/10 chance of earning 10 tokens.

Namely, once we select a decision to determine your earnings, if that decision came **before** your choice to switch, Option A will be used. If that decision came **after** or **at** your choice, Option B will be used.

Please look at Decision 3 at the top of the Decision Sheet. Option A pays 200 tokens with a chance of 3/10, and 160 tokens with a chance of 7/10. Since each side of a ten-sided die has an equal chance of being the outcome in a throw, this corresponds to Option A paying 200 tokens if the throw of the die is 1, 2 or 3, and 160 tokens if the throw of the die is any other number (4 through 10). Option B pays 385 tokens if the throw of the die is 1, 2 or 3, and 10 tokens if the throw of the die is any other number (4 through 10). The other Decisions are similar, except that as you go down the table, the chances of the higher payoff for each Option increase. For Decision 10 in the bottom row, no die will be needed since each Option pays the highest payoff for sure. Your choice there is between 200 tokens and 385 tokens.

Once you are done with both tasks H and T, you will proceed to another room where an experimenter will flip a coin. If the outcome is Heads, the experimenter will throw a ten-sided die to select which of the ten Decisions will be used. The die will then be thrown again to determine your earnings for the Option you chose for the selected Decision. Earnings in tokens will be converted to dollars such that 20 tokens = $1, so if your payoff was 200 tokens you would earn $10. This will be added to your previous earnings, and you will be paid in cash when finished.

Please raise your hand if you have any questions. If you do not have any questions, please proceed to the Decision Sheet and mark your choices.

Decision Sheet

This is your Decision Sheet. Please indicate at which decision you would like to switch from Option A to Option B by putting a check mark in the box of the Switch column. When you are finished, you should have 1 check mark. For any decisions before this check mark, Option A will be used to determine payment. For any decisions after and including the check mark, Option B will be used.

No.	**Option A**	**Option B**	**Switch**
1	1/10 chance of 200 tokens 9/10 chance of 160 tokens	1/10 chance of 385 tokens 9/10 of 10 tokens	
2	2/10 chance of 200 tokens 8/10 chance of 160 tokens	2/10 chance of 385 tokens 8/10 of 10 tokens	
3	3/10 chance of 200 tokens 7/10 chance of 160 tokens	3/10 chance of 385 tokens 7/10 of 10 tokens	
4	4/10 chance of 200 tokens 6/10 chance of 160 tokens	4/10 chance of 385 tokens 6/10 of 10 tokens	
5	5/10 chance of 200 tokens 5/10 chance of 160 tokens	5/10 chance of 385 tokens 5/10 of 10 tokens	
6	6/10 chance of 200 tokens 4/10 chance of 160 tokens	6/10 chance of 385 tokens 4/10 of 10 tokens	
7	7/10 chance of 200 tokens 3/10 chance of 160 tokens	7/10 chance of 385 tokens 3/10 of 10 tokens	
8	8/10 chance of 200 tokens 2/10 chance of 160 tokens	8/10 chance of 385 tokens 2/10 of 10 tokens	
9	9/10 chance of 200 tokens 1/10 chance of 160 tokens	9/10 chance of 385 tokens 1/10 of 10 tokens	
10	10/10 chance of 200 tokens 0/10 chance of 160 tokens	10/10 chance of 385 tokens 0/10 of 10 tokens	

Instructions for Task T (Real)

In addition to the Instructions, this envelope contains a Decision Sheet. Please look on to your Decision Sheet as you read these Instructions to ensure that you understand the procedure of the experiment. If you have a question at any point, please raise your hand.

The Decision Sheet contains 18 separate Decisions numbering 1 through 18. Each of these Decisions is a choice between drawing a ball from “Urn A” or “Urn B”. One of these decisions will be randomly selected, depending on a roll of three dice, to determine your earnings. You will select a color, Red or Black, and this will be your **Success Color**. Once a decision is selected, your earnings will be determined by whether the ball drawn from the Urn matches your Success Color.

You will make one choice in the “Switch” column on the right. This choice indicates that you would like to switch from drawing a ball out of Urn A to drawing out of Urn B. Making a choice to switch means that every decision **before** your choice, a ball will be drawn from Urn A. For each decision **after** your choice, including the decision where the choice was made, a ball will be drawn from Urn B.

For example, if the dice roll outcome is 9, Decision No. 9 will determine payment.

3. If your “Switch” number is higher than 9, a ball will be drawn from Urn A, and if the color of the ball matches the chosen Success Color, then you will 200 tokens. If it does not match, you will earn 0 tokens.
4. If your “Switch” number is 9 or lower, a ball will be drawn from Urn B, and if the color of the ball matches the chosen Success Color, then you will 228 tokens. If it does not match, you will earn 0 tokens.

Namely, once we select a decision to determine your earnings, if that decision came **before** your choice to switch, a ball will be drawn from Urn A. If that decision came **after** or **at** your choice, a ball will be drawn from Urn B.

In each of the 18 decisions, Urn A has 50 Red balls and 50 Black balls, and pays 200 tokens if the ball drawn from Urn A matches your Success Color, and 0 tokens if it does not match. Since each color has a 1/2 chance of being drawn, this means that drawing from Urn A pays 200 tokens with a chance of 1/2, and pays 0 with a chance of 1/2.

Urn B, on the other hand, has an unknown number of Red and Black balls (with a total of 100 balls). It pays a positive amount if the ball drawn from Urn B matches your Success Color, and 0 tokens if it does not match. Since the chance of each color being drawn is unknown, the chance of Urn B paying a positive number of tokens is unknown as well. The only difference between the 18 options is the amount paid when a ball matching your Success Color is drawn from Urn B.

When you have made your choice to switch, please place these instructions and your Decision Sheet back into the envelope marked T. Once you are done with both tasks H and T, you will proceed to another room where an experimenter will flip a coin. If the outcome is Tails, the experimenter will throw three six-sided dice to select which of the 18 decisions will be used. The experimenter will then draw a ball from the Urn you had selected for that Decision to determine the payoff. Earnings in tokens will be converted to dollars such that 20 tokens = $1, so if your payoff was 200 tokens you would earn $10. You will then be paid in cash.

If you do not have any questions, please proceed to the Decision Sheet and mark your choices.

Decision Sheet

My Success Color is (please circle one): **Red** **Black**

Please indicate at which decision you would like to switch from Urn A to Urn B by putting a check mark in the box of the Switch column. When you are finished, you should have 1 check mark. For any decisions before this check mark, a ball will be drawn from Urn A. For any decisions after and including the check mark, a ball will be drawn from Urn B.

	Urn A	**Urn B**	
No.	**50 Red balls, 50 Black balls**	**? Red balls, ? Black balls**	**Switch**
1	200 tokens if Chosen Color 0 tokens if not	164 tokens if Chosen Color 0 tokens if not	
2	200 tokens if Chosen Color 0 tokens if not	172 tokens if Chosen Color 0 tokens if not	
3	200 tokens if Chosen Color 0 tokens if not	180 tokens if Chosen Color 0 tokens if not	
4	200 tokens if Chosen Color 0 tokens if not	188 tokens if Chosen Color 0 tokens if not	
5	200 tokens if Chosen Color 0 tokens if not	196 tokens if Chosen Color 0 tokens if not	
6	200 tokens if Chosen Color 0 tokens if not	204 tokens if Chosen Color 0 tokens if not	
7	200 tokens if Chosen Color 0 tokens if not	212 tokens if Chosen Color 0 tokens if not	
8	200 tokens if Chosen Color 0 tokens if not	220 tokens if Chosen Color 0 tokens if not	
9	200 tokens if Chosen Color 0 tokens if not	228 tokens if Chosen Color 0 tokens if not	
10	200 tokens if Chosen Color 0 tokens if not	236 tokens if Chosen Color 0 tokens if not	
11	200 tokens if Chosen Color 0 tokens if not	244 tokens if Chosen Color 0 tokens if not	
12	200 tokens if Chosen Color 0 tokens if not	252 tokens if Chosen Color 0 tokens if not	
13	200 tokens if Chosen Color 0 tokens if not	260 tokens if Chosen Color 0 tokens if not	
14	200 tokens if Chosen Color 0 tokens if not	268 tokens if Chosen Color 0 tokens if not	
15	200 tokens if Chosen Color 0 tokens if not	276 tokens if Chosen Color 0 tokens if not	
16	200 tokens if Chosen Color 0 tokens if not	284 tokens if Chosen Color 0 tokens if not	
17	200 tokens if Chosen Color 0 tokens if not	292 tokens if Chosen Color 0 tokens if not	
18	200 tokens if Chosen Color 0 tokens if not	300 tokens if Chosen Color 0 tokens if not	
19	200 tokens if Chosen Color 0 tokens if not	308 tokens if Chosen Color 0 tokens if not	
20	200 tokens if Chosen Color 0 tokens if not	316 tokens if Chosen Color 0 tokens if not	

Instructions for Task H (Hypothetical)

In addition to the Instructions, you are also provided with a Decision Sheet. Please look on to your Decision Sheet as you read these Instructions to ensure that you understand the procedure of the experiment. If you have a question at any point, please raise your hand.

Please imagine the following hypothetical scenario.

The Decision Sheet contains 10 separate Decisions numbering 1 through 10. Each of these Decisions is a choice between “Option A” and “Option B”. One of these decisions would be randomly selected to determine your earnings in tokens. A ten-sided die would be used to determine the payoffs. After you have made your choice, this die would be rolled twice: once to select one of the 10 Decisions to be used, and then again to determine your payoff for the Option associated with that decision, either A or B, given your choice at that decision.

To choose an Option for each decision, you will make one choice in the “Switch” column on the right. This choice indicates that you would like to switch from Option A to Option B, and will signify whether Option A or Option B is used to determine your earnings for each of the 10 decisions. For each decision **before** your choice, Option A would be used for payment. For each decision **after** your choice, including the decision where the choice was made, Option B would be used.

For example, if the die roll outcome is 6, Decision No. 6 would determine payment.

5. If your “Switch” number is **after** Decision No. 6, then Option A would be used to determine your payoff. You would have a 6/10 chance of earning 200 tokens, and a 4/10 chance of earning 160 tokens.
6. If your “Switch” number is **before or at** Decision No. 6, then Option B would be used to determine your payoff. You would have a 6/10 chance of earning 385 tokens, and a 4/10 chance of earning 10 tokens.

Namely, once we select a decision to determine your earnings, if that decision came **before** your choice to switch, Option A would be used. If that decision came **after** or **at** your choice, Option B would be used.

Please look at Decision 3 at the top of the Decision Sheet. Option A pays 200 tokens with a chance of 3/10, and 160 tokens with a chance of 7/10. Since each side of a ten-sided die has an equal chance of being the outcome in a throw, this corresponds to Option A paying 200 tokens if the throw of the die is 1, 2 or 3, and 160 tokens if the throw of the die is any other number (4 through 10). Option B pays 385 tokens if the throw of the die is 1, 2 or 3, and 10 tokens if the throw of the die is any other number (4 through 10). The other Decisions are similar, except that as you go down the table, the chances of the higher payoff for each Option increase. For Decision 10 in the bottom row, no die will be needed since each Option pays the highest payoff for sure. Your choice there is between 200 tokens and 385 tokens.

When you have made your choice to switch, the experimenter would throw a ten-sided die to select which of the ten decisions would be used. The die will then be thrown again to determine your earnings for the Option you chose for the selected Decision.

Please turn over these instructions so that the experimenter knows that you are done.

If you do not have any questions, please proceed to the Decision Sheet and mark your choices.

Decision Sheet

This is your Decision Sheet. Please indicate at which decision you would like to switch from Option A to Option B by putting a check mark in the box of the Switch column. When you are finished, you should have 1 check mark. For any decisions before this check mark, Option A will be used to determine payment. For any decisions after and including the check mark, Option B will be used.

No.	**Option A**	**Option B**	**Switch**
1	1/10 chance of 200 tokens 9/10 chance of 160 tokens	1/10 chance of 385 tokens 9/10 of 10 tokens	
2	2/10 chance of 200 tokens 8/10 chance of 160 tokens	2/10 chance of 385 tokens 8/10 of 10 tokens	
3	3/10 chance of 200 tokens 7/10 chance of 160 tokens	3/10 chance of 385 tokens 7/10 of 10 tokens	
4	4/10 chance of 200 tokens 6/10 chance of 160 tokens	4/10 chance of 385 tokens 6/10 of 10 tokens	
5	5/10 chance of 200 tokens 5/10 chance of 160 tokens	5/10 chance of 385 tokens 5/10 of 10 tokens	
6	6/10 chance of 200 tokens 4/10 chance of 160 tokens	6/10 chance of 385 tokens 4/10 of 10 tokens	
7	7/10 chance of 200 tokens 3/10 chance of 160 tokens	7/10 chance of 385 tokens 3/10 of 10 tokens	
8	8/10 chance of 200 tokens 2/10 chance of 160 tokens	8/10 chance of 385 tokens 2/10 of 10 tokens	
9	9/10 chance of 200 tokens 1/10 chance of 160 tokens	9/10 chance of 385 tokens 1/10 of 10 tokens	
10	10/10 chance of 200 tokens 0/10 chance of 160 tokens	10/10 chance of 385 tokens 0/10 of 10 tokens	

Instructions for Task T (Hypothetical)

In addition to the Instructions, you are also provided with a Decision Sheet. Please look on to your Decision Sheet as you read these Instructions to ensure that you understand the procedure of the experiment. If you have a question at any point, please raise your hand.

Please imagine the following hypothetical scenario.

The Decision Sheet contains 20 separate Decisions numbering 1 through 20. Each of these Decisions is a choice between drawing a ball from "Urn A" or "Urn B". One of these decisions would be randomly selected to determine your earnings in tokens. You will first select a color, Red or Black, and this will be your **Success Color**. Once a decision is selected, your earnings will be determined by whether the ball drawn from the Urn matches your Success Color.

You will make one choice in the "Switch" column on the right. This choice indicates that you would like to switch from drawing a ball out of Urn A to drawing out of Urn B. Making a choice to switch means that every decision **before** your choice, a ball will be drawn from Urn A. For each decision **after** your choice, including the decision where the choice was made, a ball will be drawn from Urn B.

For example, if the dice roll outcome is 9, Decision No. 9 would determine payment.

7. If your "Switch" number is higher than 9, a ball would be drawn from Urn A, and if the color of the ball matches the chosen Success Color, then you would earn 200 tokens. If it does not match, you would earn 0 tokens.
8. If your "Switch" number is 9 or lower, a ball would be drawn from Urn B, and if the color of the ball matches the chosen Success Color, then you would earn 228 tokens. If it does not match, you would earn 0 tokens.

Namely, once a decision is selected to determine your earnings, if that decision came **before** your choice to switch, a ball would be drawn from Urn A. If that decision came **after** or **at** your choice, a ball would be drawn from Urn B.

In each of the 20 decisions, Urn A has 50 Red balls and 50 Black balls, and pays 200 tokens if the ball drawn from Urn A matches your Success Color, and 0 tokens if it does not match. Since each color has a 1/2 chance of being drawn, this means that drawing from Urn A pays 200 tokens with a chance of 1/2, and pays 0 with a chance of 1/2.

Urn B, on the other hand, has an unknown number of Red and Black balls (with a total of 100 balls). It pays a positive amount if the ball drawn from Urn B matches your Success Color, and 0 tokens if it does not match. Since the chance of each color being drawn is unknown, the chance of Urn B paying a positive number of tokens is unknown as well. The only difference between the 20 options is the amount paid when a ball matching your Success Color is drawn from Urn B.

When you have made your choice to switch, an experimenter would throw one 20-sided die to select which of the 20 decisions would be used. The experimenter would then draw a ball from the Urn you had selected for that Decision to determine the payoff.

Please turn over these instructions so that the experimenter knows that you are done.

If you do not have any questions, please proceed to the Decision Sheet and mark your choices.

Decision Sheet

My Success Color is (please circle one): **Red** **Black**

Please indicate at which decision you would like to switch from Urn A to Urn B by putting a check mark in the box of the Switch column. When you are finished, you should have 1 check mark. For any decisions before this check mark, a ball will be drawn from Urn A. For any decisions after and including the check mark, a ball will be drawn from Urn B.

	Urn A	**Urn B**	
No.	**50 Red balls, 50 Black balls**	**? Red balls, ? Black balls**	**Switch**
1	200 tokens if Chosen Color 0 tokens if not	164 tokens if Chosen Color 0 tokens if not	
2	200 tokens if Chosen Color 0 tokens if not	172 tokens if Chosen Color 0 tokens if not	
3	200 tokens if Chosen Color 0 tokens if not	180 tokens if Chosen Color 0 tokens if not	
4	200 tokens if Chosen Color 0 tokens if not	188 tokens if Chosen Color 0 tokens if not	
5	200 tokens if Chosen Color 0 tokens if not	196 tokens if Chosen Color 0 tokens if not	
6	200 tokens if Chosen Color 0 tokens if not	204 tokens if Chosen Color 0 tokens if not	
7	200 tokens if Chosen Color 0 tokens if not	212 tokens if Chosen Color 0 tokens if not	
8	200 tokens if Chosen Color 0 tokens if not	220 tokens if Chosen Color 0 tokens if not	
9	200 tokens if Chosen Color 0 tokens if not	228 tokens if Chosen Color 0 tokens if not	
10	200 tokens if Chosen Color 0 tokens if not	236 tokens if Chosen Color 0 tokens if not	
11	200 tokens if Chosen Color 0 tokens if not	244 tokens if Chosen Color 0 tokens if not	
12	200 tokens if Chosen Color 0 tokens if not	252 tokens if Chosen Color 0 tokens if not	
13	200 tokens if Chosen Color 0 tokens if not	260 tokens if Chosen Color 0 tokens if not	
14	200 tokens if Chosen Color 0 tokens if not	268 tokens if Chosen Color 0 tokens if not	
15	200 tokens if Chosen Color 0 tokens if not	276 tokens if Chosen Color 0 tokens if not	
16	200 tokens if Chosen Color 0 tokens if not	284 tokens if Chosen Color 0 tokens if not	
17	200 tokens if Chosen Color 0 tokens if not	292 tokens if Chosen Color 0 tokens if not	
18	200 tokens if Chosen Color 0 tokens if not	300 tokens if Chosen Color 0 tokens if not	
19	200 tokens if Chosen Color 0 tokens if not	308 tokens if Chosen Color 0 tokens if not	
20	200 tokens if Chosen Color 0 tokens if not	316 tokens if Chosen Color 0 tokens if not	