Under Partial Ambiguity, Are Women More Risk Averse Than Men?

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Abstract

This paper investigates people's attitude towards partial ambiguity. In a laboratory setting, we study three symmetric variants of the ambiguous urn in Ellsberg's 2-urn paradox by varying the possible compositions of red and green tokens in a 50-token bag. Subjects value betting on the bag with a greater payoff even smaller set of possible compositions exists. The valuation of lotteries with only two possible compositions decreases in the degree of spread except for a reversal when it approaches the extreme case of either all red or all green. This paper also discusses and compares our findings for existing models and the possible implication of decision making under different genders. The uncertainties in various settings lead to different results.

1. Introduction

Partial ambiguity has long been a typical study in experimental economics. Few studies, if not none, focus on the comparison of gender difference between the cases with partial ambiguity, where the information about the nature of uncertainty is only partially known. Motivated by the classical 2-color and 3-color examples, we study experimentally several variants of partial ambiguity in a laboratory setting, and examine the implications of the observed behavior according to the gender difference. In the experimental study, we follow a multiple price list procedures to elicit the certainty equivalents for bets on different bags of 50 tokens of which each token may be red or green. When the composition of tokens is not fully known, we refer to this situation as involving partial ambiguity. Our experiment consists of three parts. In Part I of our experiment, we consider interval partial ambiguity where subjects can choose whether to accept a fixed amount of payoff or to bet on the occurrence of red tokens. In interval ambiguity, denoted by [n, 50-n], the number of red tokens can range anywhere from n to 50-n with the rest of the tokens green.

In part II of our experiment, the possible number of red tokens can range from 0 to n and from 50-n to 50 under the disjoint variants. We also test the third symmetric variant called two-point ambiguity, the number of red tokens is limited to either n or 50-n. For both interval and disjoint ambiguity, subjects tend to value betting on a bag with a smaller set of ambiguous states more. For two-point ambiguity, subjects exhibit greater aversion as n goes from 25 (no ambiguity) to B1.

Finally, we discuss the findings and the implications of our findings for gender differences of decision makings under uncertainty in the literature. Subsequent to the experiment, we analyze the result between men and female subjects. We study the likelihood that male or female decides to bet in the game to see if male subjects are more aggressive and less risk aversion than female subjects. This may have some implications for their decision making in the reality.

2. Related Literature

The classical 2-color urn thought experiment of Keynes (1921, 75) and Ellsberg (1961) suggests that people generally favor betting on an urn with a known composition of 50 black and 50 white balls over betting on another urn with an unknown number of black or white balls which add to 100. Models that can account for ambiguity aversion, including maximin expected utility (Gilboa and Schmeidler 1989), smooth ambiguity preference (Kilbanoff, Marinacci and Mukerji 2005, Seo 2009), source preference (Smith 1969, Tversky and Kahneman 1992, Chew and Sagi 2008), and the like. They all focus on comparing between the case of risk with complete knowledge about the probability distribution and the case of ‘full ambiguity’ with minimal knowledge about the nature of the uncertainty. As for partial ambiguity, where the information about the nature of uncertainty is partially known, has less been explored.

There have been many academic studies investigating gender differences. Our laboratory experiments also stress the gender differences in decision making and indicate that women are less risk seeking under the condition of partial ambiguity to a large extent. The result rebuts several experiments, such as the dictator game (Bolton and Katok, 1995), the threshold public game (Cadsby and Maynes, 1998) as well as the duopoly game (Mason et al, 1991) which show no obvious difference in performances between female and male groups.

Instead, many researchers agree that women are more risk averse than men. For example, Byrnes, Miller and Schafer (1999) conclude that females responders are more risk averse than their male counterparts after analyzing 150 studies from 1967 to 1997. Our paper reinforces the conclusion of the predecessors and contributes to an inspiration of women are actually more risk averse when they are under a more uncertain condition, particularly in the symmetric interval condition. Instead of continuing the bet, they prefer receiving the fixed amount. On the contrary, in the other test such as two-point and disjoint circumstances, women tend to be more risk bearing than men. Male subjects tend to seek for a safer position, which has discrepancies between our findings and the traditional view. However, this exceptional situation can be explained by the imbalance proportion of male and female subjects. This may generate a less credible result from the traditional view.

3. Experimental Design

We use {n} find to denote an unambiguous deck with a known composition of n red tokens and 50-n tokens. A fully ambiguous deck is denoted by [0; 50]:

Let A denote the set of possible compositions in terms of the possible number of red cards in the 50 tokens deck. In total there are five sets of ambiguity.

Consider the following three symmetric variants of full ambiguity described: **symmetric interval ambiguity** denoted by [n, 50-n], **symmetric two point ambiguity** denoted by {n, 100-n}, and **symmetric disjoint ambiguity** denoted by [0,n]U[50-n,100]; and two asymmetric variants of full ambiguity described: **asymmetric interval ambiguity(low to high)** denoted by [0, n]. **Asymmetric interval ambiguity (high to low)** denoted by [50,n]

Three benchmark treatments are set up: B0={25,25} , B1= {0,50} , B2= [0,50]. Here, B1 appears to admit some ambiguity in interpretation. Being either all red or all black may give it a semblance of a 50:50 lottery. B2, The two point ambiguous is intended to be interpreted parallel to the B1. It admits an alternative description as follows. Firstly it can be described as comprising 25 cards which are either all red or all green while the composition of the other 25 cards remains unknown. This process can be applied to the latter 10 cards to arrive at a further division into 5 cards which are either all red or all black while the composition of the remaining

5 cards remains unknown. Doing this ad infinitum gives rise to a dyadic decomposition of

[0; 50] into subintervals which are individually either all red or all green.

f our study is based on the following 5 groups of six treatments. In each treatment, subjects choose their own color to bet on.

1) **Symmetric two point ambiguity.** This involves 6 lotteries with symmetric two point ambiguity:

   B0 = {25,25} ; P1 ={20,30}; P2 ={15,30}; P3 = {10,40}; P4 = {5,45}; B1 ={0,50} :

2) **Symmetric interval ambiguity.** This involves 6 lotteries with symmetric interval ambiguity:

B0 = {25,25} ; S1 =[20,30]; S2 =[15,35]; S3 = [10,40] S4 = [5,45]; B2 =[0,50] :

3) **Symmetric disjoint ambiguity.** This involves 6 lotteries with symmetric disjoint ambiguity.

B1 = {0,50} ; D1 =[0,5]U[45,50] ; D2 =[0,10]U[40,50] ; D3 = [0,15]U[35,50],

D4 =[0,20]U[30,50]; B2 =[0,50] :

4) **Asymmetric interval ambiguity (low to high).** This involves 6 lotteries with symmetric asymmetric interval ambiguity with the number of red tokens always begin from 0 and upper limit varies depending in the case.

K1 =[0,10]; K2 =[0,20]; K3= [0,30] K4 = [0,40]; B2 =[0,50] :

5) **Asymmetric interval ambiguity (high to low).** This involves 6 lotteries with symmetric asymmetric interval ambiguity with the upper limit number of red tokens always begin from 50 and lower limit varies depending in the case.

G1 =[50,40]; G2 =[50,30]; G3= [50,20] G4 = [50,10]; B2 =[0,50] :

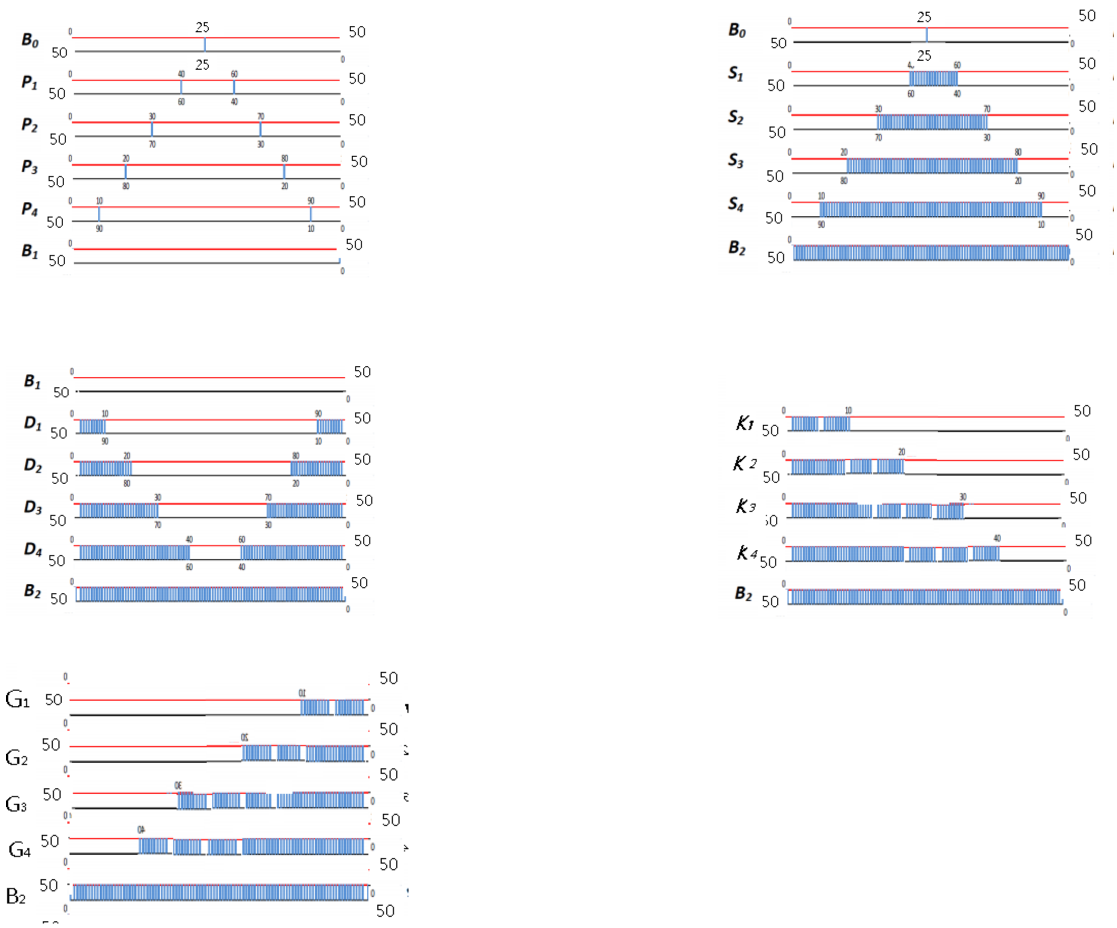

Figure 1. Illustration of 28 treatments in 5 groups

The lotteries delivers either a wining outcome of $35 or nothing. A price list design (e.g., Miller, Meyer, and Lanzetta, 1969; Holt and Laury, 2002) is used to find the CE of a lottery.

Subjects are asked to choose between betting on the red tokens drawn and getting some certain amount of money. For each lottery, subjects have 10 binary choices corresponding to 10 certain amounts ranging from S$3 to S$21. Each subject is required to complete 2 out of 6 set of ambiguity. The order of appearance of the 12 lotteries is randomized for each subject who each makes 120 choices in all. At the end of the experiment, in addition to a S$20 show-up fee, each subjects is paid based on his/her randomly selected decisions in the experiment. One out of 120 choices is randomly chosen using random formula from excel.

We recruited 47 undergraduate students from City University of Hong Kong as participants using advertisement posted on Canvas system and recruiting email sent to student's School mail box. The experiment consisted of 3 sessions with 10 to 15 subjects for each session. It was conducted by total of 6 authors of the experiment. After arriving at the experimental venue, subjects were given a subject ID. To study the effect of gender difference in the experiment. Male subjects were given subject ID with ODD number and female with EVEN number in the circumstance unknown by the subjects to avoid they make judgment aware of their gender. Subsequently, general instructions were read to the subjects followed by our demonstration of several example of possible compositions of the deck before subjects began making decisions. Most subjects completed the decision making tasks in both parts within 30minutes. At the end of the experiment, subjects received payment based on a randomly selected decision made in addition to a S20 show-up fee. The payment stage took up about 15 minutes.

4. Theoretical Prediction

There have been many academic studies investigating gender differences. Many researchers agree that women are more risk averse than men. For instance, Byrnes, Miller and Schafer (1999) conclude that the females responders are more risk averse than their male counterparts after analyzing 150 studies from 1967 to 1997. Does this phenomenon also exist in financial markets? Powell and Ansic (1997) find that men are more inclined to take different investments trategies which increase the portfolios' risk variations. Their laboratory experiments indicate that women are less risk seeking than the men irrespective of the familiarity, framing, costs and ambiguity 1. Similarly, others find that professional women in financial fields perform a more conservatively .De Goeij and Smedts (2008) conclude that male analysts are more likely to issue extreme positive stock recommendations than female analysts. Furthermore, in a study of America n professional mutual fund managers, Niessen and Ruenzi (2007) show that female managers invest in a more risk averse way than male managers.

However, there are still several researchers who argue against the “women risk aversion” theory and consider it to be a stereotype. Differences between women and men in their responses to risk are well documented. Studies have found differences between women and men in the perceptions of the risk attached to alcohol and drug use (Spigner, Hawkins, and Loren, 1993); the catastrophic potential of nuclear war, technology, radioactive waste, industrial hazards, and environmental degradation (Flynn, Slovic, and Mertz, 1994); and the perceived riskiness of various recreational and social activities (Boverie, Scheuffele, and Raymond, 1995). Evidence also indicates men are more likely to engage in risky behavior such as gambling (Levin, Snyder, and Chapman, 1988); "direct risk" health behavior (Kristiansen, 1990); and unsafe sex (Swanson, Dibble, and Trocki, 1995). Women are found to have less risky asset portfolios than men (Jianakoplos and Bernasek, 1998), they report lower risk propensity towards financial risk than men (Brasky et al., 1997), and are more risk averse towards gambles than men (Levin, et al., 1998). In an experiment designed to mimic investment behavior, Powell and Ansic (1998) find that women choose less risky alternatives. Levy, Elron and Cohen (1999) conduct an investment experiment over several weeks, and find that women's lower willingness to take on financial risks obviously lowers their earnings relative to men.

Several theories have been put forward to explain ambiguity aversion, but none has yet gained general acceptance (Camerer, 1995, pp. 644–649; Camerer & Weber, 1992; Curley, Yates, & Abrams, 1986; Keren & Gerritsen, 1999). We believe that ambiguity aversion is driven by loss of decision confidence arising from pessimism in response to uncertainty. Our *uncertainty intolerance* hypothesis is based partly on the reasonable assumption that people are motivated to feel confident about their judgments and decisions, and partly on clear evidence that uncertainty undermines confidence (Becker & Brownson, 1964; Dugas, Gosselin, & Ladouceur, 2001; Ghosh & Ray, 1997) and induces a psychological state that most people find disturbing or aversive (Freeston, Rhéaume, Letarte, Dugas, & Ladouceur, 1994). Freeston et al. proposed that ambiguous situations activate an uncertainty schema that makes people worry and feel more anxious. Similarly, Ghosh and Ray (1997) demonstrated that the presence of ambiguity accentuates people's perceptions of risk, and that decision maker who are less risk averse, and have more tolerance for ambiguity, display greater confidence in their choice. Thus, we argue that the tendency of decision makers to prefer known-risk to ambiguous options arises because most people tend to become more anxious and less confident in the face of uncertainty, and ambiguous options, almost by definition, involve greater uncertainty than risky options.

5. Results

The summary statistics in is presented in Table 1. We apply the Friedman test to test whether the CEs of the 25 tokens come from a single distribution. We reject the null hypothesis that the CEs come from the same distribution ($p < 0.001$).

As expected, CE of {25} (no control) is obviously higher than that of [0; 50] (paired Wilcoxon Signed-rank test, $p=0.048 < 0.05$). Also, our subjects have distinct attitudes towards different types of ambiguity.

Specifically, for the comparison between {25} and [0; 50], 21% of the subjects exhibit ambiguity aversion, 32% of the subjects exhibit ambiguity neutrality, and 47% of the subjects are risk-seeking in ambiguity in general. For female, 28% of the subjects are exhibit ambiguity risk-aversion, 36% of the subjects exhibit ambiguity neutrality and 36% of the subjects are risk-seeking in ambiguity. For male, we found that 12.5% of the subjects exhibit ambiguity aversion, 25% of the subjects exhibit ambiguity neutrality and 62.5% of the subjects are risk-seeking in ambiguity. It matches with our prediction, which states that female exhibit more risk-aversion than male do. In the literature "Ambiguity Measurement", the ambiguity level (N) measurement is using the 4 times the variance of probability of picking the red token.

$$CE = 7.053585 - 1.399048\,N \qquad (N = ambiguity\ level)$$
$$[Using\ the\ result\ of\ B0, P1, P2, P3, P4, B1, S1, S2, S3, S4, B2, D1, D2, D3, D4]$$

(P<0.05)

Regression for symmetric interval, two point and disjoint ambiguity

(see E-View Result 1 in Appendix A)

$$CE = 4.840653 + 5.165835\,N \qquad (N = ambiguity\ level)$$
$$[Using\ the\ result\ B2, K1, K2, K3, K4, G1, G2, G3, G4]$$

Regression for asymmetric ambiguity (from high to low and from low to high)

(see E-View Result 2 in Appendix A)

The above regressions show that the p-value of both regressions are significant

Two point						
	General	SE	Male	Female	N (Male)	N (Female)
B0	7.79	2.532	8.375	7.36	8	11
P1	7.77	3.140	5.5	7	4	9
P2	6.08	3.427	5.5	6.33	4	9
P3	5.77	2.833	5.5	5.89	4	9
P4	5.57	2.876	5	5.78	4	9
B1	6.46	3.307	6	6.67	4	9

Symmetric Interval						
	General	SE	Male	Female	N (Male)	N (Female)
B0	7.79	2.532	8.375	7.36	8	11
S1	7.42	1.702	8	7	8	11
S2	6.32	1.826	6.875	5.91	8	11
S3	7.16	1.481	6.875	7.36	8	11
S4	6.58	1.127	6.75	6.45	8	11
B2	5.23	2.121	6	4.89	8	11

Symmetric Disjoint						
	General	SE	Male	Female	N (Male)	N (Female)
B1	6.46	3.307	6	6.67	4	9
D1	5.31	2.983	3.5	6.11	4	9
D2	5.38	3.355	4.25	5.89	4	9
D3	6.54	3.711	7.75	6	4	9
D4	6.77	3.898	8	6.22	4	9
B2	5.23	2.121	6	4.89	4	11

Asymmetric Interval (From high to low)						
	General	SE	Male	Female	N (Male)	N (Female)

G1	6.53	1.548	6.375	6.71	8	7
G2	6.36	1.494	5.86	6.86	8	7
G3	6.2	1.787	5.88	6.57	8	7
G4	5.73	3.023	5.38	6.14	8	7
B2	5.23	2.121	6	4.89	8	11

Asymmetric Interval (From low to high)						
	General	SE	Male	Female	N (Male)	N (Female)
K1	3.33	2.066	3.25	3.43	8	7
K2	4.33	2.434	4.75	3.86	8	7
K3	4.73	1.750	4.66	4.83	8	7
K4	5.6	2.410	5.125	6.14	8	7
B2	5.23	2.121	6	4.89	8	11

Table 1. Summary statistics of switching point for the lotteries

The Spearman correlations between pairs of CEs for the 23 lotteries, ranging between -64.15% to 97.73%, show that some of them are negatively correlated and some of them are positively correlated. (see Table S1 in Appendix A). The Spearman correlations for male ranges from -97.8% to 90.4% while the Spearman correlations for female ranges from -93.31% to 96.38%. (see Table S2 and S3 in Appendix A). The correlations between risk attitude measure by the CEs for B0 = (25,25) and ambiguity attitude, measured by the difference in CEs between that of B0 and those of the other 22 ambiguous bets shows that risk attitude is mostly correlated positively with ambiguity attitude. The Spearman correlation of risk attitude and ambiguity attitudes range from -27.4% to 69.9%. (see Table S4 in Appendix A).

The results of the two Spearman correlations indicate that some of them are negatively correlated and some of them are positively correlated for both female and male. The variation of the Spearman correlations for female is slightly greater than that of male.

Observation 1 (symmetric interval ambiguity)

For lotteries related to interval ambiguity, B0, S_1, S_2, S_3, S_4 and B_2, there is a statistically obvious decreasing trend in CEs as size of ambiguity increase in general. Under different gender view, male and female have the same result of obviously decreasing trend in CEs as the size of ambiguity increase. In task B_0, S_1, S_2 and S_4, female have lower CEs than male. While task S_3 and B_2, male have higher CEs than female. The difference of CEs in task B_2 between male and female is not obvious.

Moreover, we count the number of individuals exhibiting specific patterns in Observation 1. For the 6 symmetric interval ambiguity lotteries, 31.6% of the subjects have the same CEs, 5.3% of the subjects have increasing CEs, 31.6% of the subjects have decreasing CEs, and 21.1% of the subjects have non-increasing CEs until S_4 (5:45) with an increase at B_2 (5:50).

Between B_0 and B_2, 31.6% of the subjects have the same CEs, 21.1% of the subjects display a higher CE for B_2 than that for B_0; and 47.4% of the subjects exhibit the reverse.

Between B_2 and S_4, 31.6% of the subjects have the same CEs, 31.6% of the subjects have a higher CE for S_4 than for B_1, and 36.8% of the subjects exhibit the reverse.

In gender view, 28.6% and 40% of the males and female shave the same CEs, 14.3% and 0% of the males and females have increasing CEs, 42.9% and 30% of the males and females have decreasing CEs, and 14.3% and 30% of the males and females have non-increasing CEs until S_4 with an increase at B_2. 36.4% of the female and 25% of the male subjects have same CEs between B_0 and $B_{2.}$ 27.3% of female and 12.5% of male subjects have a higher CE for B_2 than that for B_0 while 36.4% of female and

62.5% of the male subjects exhibit the reverse. 27.3% of female and 37.5% of the male subjects have same CEs between B_2 and S_4. 45.5% of female and 25% of the male subjects have a higher CE for S_4 than for B_2 while 27.3% of the female and 37.5% of the male subjects exhibit the reverse.

As such, we can conclude that female subjects are more risk-seeking than male subjects under this symmetric interval ambiguity at individual level, astonishingly, which is not consistent with the theoretical prediction.

Observation 2 (symmetric disjoint ambiguity)

Interestingly, for lotteries related to interval ambiguity, B_1, D_1, D_2, D_3, D_4, B_2 there is a statistically obvious increasing trend in CEs as size of ambiguity increase in general. Under difference gender view, males have an obvious result of increasing trend in CEs as the size of ambiguity increase. While female do not have obvious difference in CEs as the size of ambiguity increase. In task D_3, D_4, female have lower CEs than male. While in task B_1, D_1, and D_2, male have higher CEs than female. The difference of CEs in task B_2 between male and female is not obvious.

At the individual level, for the 6 symmetric interval ambiguity lotteries, 23.1% of the subjects have the same CEs, none of the subject has increasing CEs, 38.5% of the subjects have decreasing CEs, and 30.8% of the subjects have non-decreasing CEs until D_4 with a decrease at B_2.

Between B_1 and B_2, 30.8% of the subjects have the same CEs, none of the subjects display a higher CE for B_2 than that for B_1; and 69.2% of the subjects exhibit the reverse.

Between B_2 and D_4, 38.5% of the subjects have the same CEs, 7.7% of the subjects have a higher CE for B_2 than that of D_4, and 53.8% of the subjects exhibit the reverse.

In gender view, 0% and 33.3% of the males and female shave the same CEs, none of the males and females have increasing CEs, 25% and 44.4% of the males and females have decreasing CEs, and 50% and 50% of the males and females have non-decreasing CEs until D_4 with an increase at B_2. 22.2% of the female and 50% of the male subjects have the same CEs between B_1 and B_2. None of the female nor male subjects have a higher CE for B_2 than that for B_1 while 77.8% of the female and 50% of the male subjects exhibit the reverse.

33.3% of the female and 50% of the male subjects have the same CEs between B_2 and D_4. 11.1% of the female and 0% of the male subjects have a higher CE for B_2 than that of D_4 while 55.6% of the female and male subjects have a higher CE for D_4 than for B_2.

Therefore, we can conclude that women are more risk-aversion under this treatment (disjoint ambiguity) at individual level as more female subjects have a higher CE for B_1 than that of B_2, which is what we expected in the theoretical prediction.

<u>Observation 3 (2-point ambiguity):</u>

For lotteries related to two-point ambiguity, B_0; P_1; P_2; P_3; P_4; and B_1, there is a obvious non-increasing trend in the CEs from $B_0 = \{25\}$ to $P_4 = \{5,45\}$. Male subjects have an obvious result of decreasing trend in CEs as the size of ambiguity increases until P_4. Female subjects also have obvious difference in CEs as the size of ambiguity increases until P_4.Interestingly, CE of B_1 reverses this trend and is obviously higher than the CE of P_4. Moreover, the CE of B_1 is obviously different from that of B_0.

At the individual level, for the 6 two-point ambiguity lotteries, 15.4% of the subjects have the same CEs, 0% of the subjects have increasing CEs and 15.4% of the subjects have non-increasing CEs and 7.7% of the subjects have non-increasing CEs until {5;45} with an increase at B_1.

Between B_0 and B_1, 38.5% of the subjects have the same CEs, 46.2% of the subjects display a higher CE for B_0 than that for B_1; and 15.4% of the subjects exhibit the reverse. Between B1 and {5;45}, 30.8% of the subjects have the same CEs, 38.5% of the subjects have a higher CE for B_1 than for {5;45}, and 30.8% of the subjects exhibit the reverse.

For the results with accordance to gender difference, 22.2% of female subjects and 0% of male subjects have the same CEs. 11.1% of female subjects and 25% of male subjects have decreasing CEs. No female and male subjects have increasing CEs. 11.1% of female subjects and 0% of male subjects have decreasing CEs until {5;45}. Between B_0 and B_1, 44.4% of female subjects and 25% male subjects have the same CEs. 55.6% of female subjects and 50% of male subjects have a higher CE for B_0 than that for B_1 while 11.1% of female subjects and 25% male subjects exhibit the reverse. Between B_1 and {5;45}, 22.2% of female subjects and 50% of male subjects have the same CEs. 44.4% of female subjects and 50% of male subjects have a higher CE for B_0 than that for {5;45} while 33.3% of female subjects and 25% of male subjects exhibit the reverse.

Thus, we can conclude that women exhibit more risk-aversion under this treatment (two-point ambiguity) at individual level as more female subjects have a higher CE for B_0 than that of B_1, which is what we expected in the theoretical prediction.

Observation 4 (asymmetric ambiguity—from high to low):

For lotteries related to asymmetric (from high to low) ambiguity, G_1;G_2;G_3;G_4 and B_2, there is an obvious non-increasing trend in the CEs from G_1 = {50:40} to B_2 = {50:10} as 33.3% of the subjects have the decreasing CEs from G_1 to B_2 whereas only 20% of the subjects have the increasing CEs and 6.7% of them have the same CEs from G_1 to B_2. Interestingly, 26.7% of the subjects have a higher CE in B_2 than that of G_1 in general. Male subjects have a generally obvious result of decreasing trend in CEs as the size of ambiguity increases until G_4. Female subjects also have obvious difference in CEs as the size of ambiguity increases. The difference of CEs in task B_2 between male and female is obvious.

At the individual level, for the asymmetric (from high to low) ambiguity lotteries, 6.7% of the subjects have the same CEs and 33.3% of the subjects have non-increasing CEs.

For the results according to gender, 57.1% of the female subjects and 25% of the male subjects have decreasing CEs while 28.6% of the female subjects and 25% of the male subjects have the increasing CEs and 0% of the female subjects and 12.5% of the male subjects have the same CEs from G_1 to B_2. No any female or male subjects have decreasing CEs until {50:10} with an increase in B2({50:0}). 0% of the female subjects and 25% of the male subjects have the same CEs between G_1 and B_2. 71.4% of the female subjects and 50% of the male subjects have a higher CE for G_1 than that of B_2 while 28.6% of the female subjects and 37.5% of the male subjects exhibit the reverse. 57.1% of the female subjects and 62.5% of the male subjects have the same CE for B_2 between B_2 and G_4. None of the female or male subjects have a higher CE for B_2 than that for G_4 while 42.9 of the female subjects and 37.5 of the male subjects exhibit the reverse.

Thus, we can conclude that women are more risk-aversion under this treatment asymmetric interval ambiguity (from high to low) at individual level as more female subjects have a higher CE for G_1 than that of B_2, which matches with our theoretical prediction.

Observation 5 (asymmetric ambiguity—from low to high)

For lotteries related to asymmetric ambiguity—from low to high, K_1;K_2;K_3;K_4 and B_2, there is an obvious increasing trend in the CEs from K_1={0:10} to K_4 = {0:40}. Interestingly, CE of B_1 reverses this trend and is obviously lower than the CE of K_4.

Male subjects have a generally obvious result of increasing trend in CEs as the size of ambiguity increases. Female subjects also have obvious difference in CEs as the size of ambiguity increases until K_4. The difference of CEs in task B_2 between male and female is obvious.

At the individual level, for the asymmetric (from high to low) ambiguity lotteries, 6.7% of the subjects have the same CEs and 20% of the subjects have increasing CEs in general.

For the result with reference to gender, 14.3% of the female subjects and 25% of the male subjects have the increasing CEs while 14.3 of the female subjects and 12.5% of male subjects have decreasing CEs and 0% of female subjects and 12.5% of male subjects have the same CEs from K_1 to B_2. 42.9% of female subjects and 12.5% of male subjects have the increasing CEs until K_4 ({0:40}) with a drop in the CE in B_2 ({0;50}). 28.6% of female subjects and 50% of male subjects have the same CEs between B_2 and K_4. 14.3% of female subjects and 12.5% of male subjects have a higher CE for B_2 than K_4 whereas 57.1% of female subjects and 37.5% of male subjects exhibit the reverse.

As such, we can conclude that women are more risk-seeking under this treatment (asymmetric interval ambiguity (from low to high)) at individual level as more female subjects have a higher CE for K_4 than that of B_2, astonishingly, which is inconsistent with our theoretical prediction.

A little conclusion is drawn that women exhibit more risk-aversion under disjoint ambiguity, two-point ambiguity and asymmetric interval ambiguity (from high to low) and they are more risk-seeking under symmetric interval ambiguity and asymmetric interval ambiguity (from low to high).

<u>Observation 6 (Across group)</u>

The mean CEs of the two-point ambiguity lotteries, P_1, P_2, P_3, P_4, and B_1, smaller than that of the corresponding symmetric interval ambiguity lotteries, B_0, S_1, S_2, S_3, and S_4, and B_2. The mean CEs of the symmetric interval ambiguity lotteries, B_0, S_1, S_2, S_3, and S_4, exceeds that of the corresponding disjoint ambiguity lotteries, B_1, D_1, D_2, D_3, D_4, even though each pair of S_i and D_i have the same size of ambiguity. The mean CEs of the symmetric interval ambiguity lotteries, B_0, S_1, S_2, S_3, and S_4, exceeds that of the corresponding asymmetric interval ambiguity lotteries (from low to high and from high to low), K_1, K_2, K_3, K_4, G_1, G_2, G_3, G_4, and B_2.

For the results with accordance to gender difference, both male and female subjects have the same mean CEs for the two-point ambiguity lotteries, P_1, P_2, P_3, P_4, and B_1, smaller than that of the corresponding symmetric interval ambiguity lotteries, B_0, S_1, S_2, S_3, and S_4, and B_2. And both group have the same result on the mean CEs of the symmetric interval ambiguity lotteries, B_0, S_1, S_2, S_3, and S_4, exceeds that of the corresponding disjoint ambiguity lotteries, B_1, D_1, D_2, D_3, D_4, even though each pair of S_i and D_i have the same size of ambiguity.

6. Implication

Refer to the Ellsberg two urns paradox from Keynes (1962), it concluded that people is favourable for the risk with a known source of uncertainty over another source with less know or have the same distribution, in other words, if the subjects know more about the uncertainty or the ambiguity, they are willing to bear more risk.

The CE can reflect the level of risk about the subject decision, in the CE is high, that mean the subjects is willing to take a guarantee amount, it implied that the subject willing to take more risk. So that CE is positively related to the level of risk willing to bear.

Now, the conclusion of the Ellsberg two urns paradox can be rephrase to “when the level of ambiguity is higher, the CE should be lower”, that mean the level of ambiguity should be negatively related to CE.

For the two point ambiguity: Under B0 = [25, 25], which is the clearest ambiguity condition as, so it has the highest CE in general, male and female parts. The CE of general, male and female in two point ambiguity is decreasing when the level of ambiguity increase from P_1 to P_4. It is consist to the concept that taking more risk when people know more about the uncertainty.

For the symmetric interval ambiguity: When the n increased, only the CE of male decreased. There is a slightly increase in female’s CE after S_3 and S_4. This change in female’s CE make the general CE have the same trend as there are more female subject in this treatment. In this treatment, only the male’s part is consist with the conclusion of Ellsberg two urns paradox.

For the asymmetric interval ambiguity: Based on the regression analysis in result section, the relationship between the level of ambiguity and CEs is positive related. It may contradict the conclusion of Ellsberg two urns paradox.

The reason of this result is that the level of ambiguity is closely related to the probability of winning the coin betting game. From K1 to K4, the level of ambiguity increases, at the same time, the probability to draw a red coins also increases. In this case, subjects may not only consider the level of ambiguity, but also the expected value of the game. This decision can also be explained as a speculative activity.

For the disjoint ambiguity: From D_1 to D_4, the level of ambiguity is decreasing. The general CE and the male's CE increase from D_1 to D_4, CE is negatively related to the level of ambiguity. The female's CE decreases from D_1 to D_2, but it also has the increasing trend. The result from disjoint ambiguity is consist to the conclusion from Ellsberg two urns paradox.

According to the traditional view, the decision made by female subjects is more risk averse compared by the male decision.

Refer to the result, the CE of female in symmetric interval ambiguity is lower than the male's one, that means female tends to make a more secure choice with lower guarantee amount received. In this case, female is more risk averse than male about their decision making.

But for another treatment, such as two-point, asymmetric interval and symmetric disjoint treatment, generally the CE of female is higher than the male's CE, male play more safe, and risk averse in those treatment. There may be a conflict to the traditional view on gender difference as mentioned, but the experiment result is based on a small amount of subjects and imbalance gender of subjects in some treatments, it may make a biased result.

7. Conclusion

Our experiment has a small contribution to partial ambiguity by CHEW, MIAO and

ZHONG, the experiment examined the gender difference about the decision making under the ambiguity. There are five treatments to test the decision change under different ambiguity situation, including symmetric interval ambiguity, asymmetric interval ambiguity (from high to low and from low to high), two point ambiguity and disjoint ambiguity.

The result shows female subjects act more risk averse than male in symmetric interval ambiguity. Oppositely, male subjects act more risk averse in another four treatments. Not all treatments consist with the traditional view about gender difference.

About the analysis on the behaviour towards ambiguity, only two point ambiguity and the male subjects in symmetric interval ambiguity shows that the level of ambiguity is negatively related to the risk level of their decision. For the asymmetric interval ambiguity, it is believed that subjects also consider the expected utility of the coin betting. For the symmetric disjoint ambiguity, the implication also consists to the conclusion from Ellsberg two urns paradox.

The result may be have a great difference compared with other paper related to gender difference and ambiguity behaviour. There are some shortcoming for the experiment, which cause the error on the result and the implication. There are some suggestion about the experiment to tackle the shoutcoming:

The sample size is not larger enough, the power of generalization of the finding may be limited. It is appropriate to have a larger population size which is favourable for experiment result.

There is the gender imbalance problem about the subjects. The balanced gender should be found in order to increase the explanation power of the result.

Another suggestion is to increase the show-up fee. This is because there is a problem about the absent of subjects. In order to raise the attendance rate, the show-up fee should be increase to attract the subjects come to our lab experiment.

The final suggestion is to the subjects to have a two treatment in one session. Since the experience from the first experiment may affect the decision making in the second experiment, the result may be not accurate.

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Appendix A

1. Correlation Table

	B0	P1	P2	P3	P4	B1	S1	S2	S3	S4	B2	D1	D2	D3	D4	K1	K2	K3	K4	G1	G2	G3	G4
B0	1.0000																						
P1	0.4951	1.0000																					
P2	-0.3753	-0.0214	1.0000																				
P3	-0.0786	0.3401	0.4827	1.0000																			
P4	0.3716	-0.2158	-0.1991	-0.4131	1.0000																		
B1	-0.1539	-0.1494	0.3790	0.1191	-0.1860	1.0000																	
S1	-0.1487	0.3130	0.1758	0.2951	0.1218	-0.5352	1.0000																
S2	-0.4867	-0.1454	0.0266	0.1450	-0.1270	-0.3175	0.6991	1.0000															
S3	-0.4497	-0.2385	-0.0859	-0.2445	0.1641	-0.3469	0.2693	0.4030	1.0000														
S4	-0.3933	0.2211	0.1843	0.3495	-0.2117	0.3407	0.0335	0.0655	0.6213	1.0000													
B2	-0.2483	0.1251	0.2063	0.0832	0.0546	-0.2495	0.6383	0.4669	0.7428	0.3859	1.0000												
D1	-0.4117	-0.0808	-0.0433	-0.0501	0.0179	-0.1339	0.2500	0.0765	0.3977	0.4502	0.3292	1.0000											
D2	0.0943	-0.1728	0.2291	-0.0951	0.3741	0.4634	-0.1818	-0.3673	-0.1536	0.3239	0.0234	0.1204	1.0000										
D3	0.0218	0.1689	-0.1608	0.1793	0.0174	-0.2664	0.3846	0.2337	0.3850	0.5137	0.2011	0.5409	0.1025	1.0000									
D4	0.0864	0.2540	-0.1982	0.2212	0.0417	-0.2691	0.4280	0.2225	0.3854	0.5197	0.2419	0.5657	0.0392	0.9773	1.0000								
K1	0.2622	0.3033	-0.2535	0.3362	0.2136	-0.5272	0.1976	-0.0430	-0.1979	0.1375	-0.2537	0.1872	-0.1165	0.3612	0.3685	1.0000							
K2	0.2382	0.3179	0.0261	0.0986	0.2180	-0.1171	-0.0783	-0.5107	-0.3639	0.1496	-0.3267	0.2808	0.2968	0.2889	0.2737	0.6374	1.0000						
K3	0.0058	0.1225	0.6294	0.1861	0.4164	-0.0886	0.5060	0.0612	0.2446	0.0922	0.4631	0.1633	0.2772	0.1431	0.1841	-0.0580	0.1601	1.0000					
K4	0.1387	-0.0601	0.1630	0.1775	0.2053	0.2188	0.3655	0.4753	0.3551	0.2999	0.3583	-0.3754	0.2862	0.1125	0.1379	-0.2699	-0.4772	0.3250	1.0000				
G1	0.0147	-0.2070	-0.0677	-0.0585	0.5773	-0.2253	0.4212	0.3658	0.5254	-0.1071	0.4834	-0.0583	0.0234	0.2443	0.2751	-0.2136	-0.3256	0.4166	0.4596	1.0000			
G2	0.5001	0.5139	-0.1027	0.1363	0.1134	0.1038	0.0038	0.0086	-0.2763	-0.0149	-0.1273	-0.5094	-0.0921	-0.1376	-0.1299	0.2128	-0.0941	-0.1509	0.1815	0.0270	1.0000		
G3	-0.0964	0.1737	0.0921	0.1596	-0.4641	0.6293	-0.2776	-0.1318	-0.2037	0.6424	-0.1498	0.0481	0.5122	0.2562	0.1997	-0.2078	0.0184	-0.2641	0.2358	-0.3579	0.0936	1.0000	
G4	-0.4338	0.2856	0.3230	0.3652	-0.6415	0.0244	0.3039	0.2058	0.1737	0.6178	0.2766	0.3476	0.1460	0.3943	0.3362	0.0041	0.2124	0.0454	-0.0491	-0.3285	-0.3487	0.5596	1.0000

Table S1. Spearman correlation of CEs for lotteries

	B0	P1	P2	P3	P4	B1	S1	S2	S3	S4	B2	D1	D2	D3	D4	K1	K2	K3	K4	G1	G2	G3	G4
B0	1.000																						
P1	0.055	1.000																					
P2	0.019	-0.978	1.000																				
P3	-0.703	0.166	-0.348	1.000																			
P4	0.833	-0.381	0.366	-0.435	1.000																		
B1	0.346	0.316	-0.110	-0.788	-0.151	1.000																	
S1	0.164	0.400	-0.559	0.581	0.286	-0.632	1.000																
S2	0.164	0.400	-0.559	0.581	0.286	-0.632	0.346	1.000															
S3	0.588	-0.086	-0.030	0.107	0.821	-0.544	0.208	0.904	1.000														
S4	0.184	-0.405	0.235	0.392	0.643	-0.853	0.430	0.781	0.880	1.000													
B2	0.077	-0.141	-0.049	0.587	0.472	-0.894	0.539	0.579	0.686	0.868	1.000												
D1	-0.855	-0.447	0.312	0.743	-0.426	-0.707	0.000	0.000	-0.192	0.302	0.316	1.000											
D2	-0.271	0.923	-0.967	0.525	-0.554	0.000	0.513	0.513	-0.103	-0.254	0.048	-0.076	1.000										
D3	-0.332	0.311	-0.503	0.903	-0.108	-0.803	0.875	0.875	0.474	0.590	0.798	0.442	0.584	1.000									
D4	-0.326	0.217	-0.417	0.901	-0.052	-0.857	0.868	0.868	0.513	0.658	0.844	0.485	0.501	0.995	1.000								
K1	-0.700	0.135	-0.047	0.056	-0.900	0.426	0.144	0.307	0.041	0.017	-0.249	0.302	0.208	-0.324	-0.366	1.000							
K2	0.479	0.405	-0.518	0.280	0.514	-0.426	0.584	0.241	0.023	0.113	-0.078	-0.302	0.392	0.666	0.658	0.808	1.000						
K3	-0.494	-0.775	0.812	-0.107	-0.246	0.000	0.385	0.420	0.313	0.427	0.230	0.577	-0.662	-0.474	-0.420	0.305	0.268	1.000					
K4	-0.494	-0.775	0.812	-0.107	-0.246	0.000	0.385	0.420	0.313	0.427	0.230	0.577	-0.662	-0.474	-0.420	0.305	0.268	1.000	1.000				
G1	-0.071	-0.775	0.631	0.322	0.492	-0.816	0.338	-0.263	-0.076	0.327	0.436	0.577	-0.574	0.328	0.420	-0.511	-0.160	0.176	0.176	1.000			
G2	-0.692	-0.596	0.625	0.062	-0.497	0.000	-0.088	-0.130	-0.252	-0.016	-0.144	0.667	-0.433	-0.358	-0.323	0.475	0.188	0.602	0.602	0.142	1.000		
G3	0.261	-0.837	0.751	-0.050	0.741	-0.567	-0.254	-0.137	0.214	0.352	0.433	0.267	-0.777	0.034	0.130	-0.418	-0.378	-0.445	-0.445	0.445	-0.175	1.000	
G4	0.128	-0.826	0.715	0.104	0.651	-0.682	0.049	-0.123	0.148	0.446	0.390	0.402	-0.706	0.157	0.253	-0.228	-0.005	-0.174	-0.174	0.723	0.016	0.817	1.000

Table S2. Spearman correlation of CEs for lotteries (Male)

	B0	P1	P2	P3	P4	B1	S1	S2	S3	S4	B2	D1	D2	D3	D4	K1	K2	K3	K4	G1	G2	G3	G4
B0	1.0000																						
P1	0.2683	1.0000																					
P2	0.1724	0.2474	1.0000																				
P3	0.6524	0.3869	0.4982	1.0000																			
P4	0.0654	0.2114	0.8677	0.1657	1.0000																		
B1	0.0103	0.1483	0.2033	-0.1139	0.4802	1.0000																	
S1	-0.3481	-0.5601	-0.3292	-0.5802	-0.3223	-0.0959	1.0000																
S2	-0.4732	-0.1885	-0.5337	-0.6502	-0.5154	0.0229	0.7901	1.0000															
S3	-0.5078	-0.5547	-0.5560	-0.6105	-0.5477	-0.0389	0.4075	0.2758	1.0000														
S4	-0.2225	0.0923	0.1675	-0.5468	0.3758	0.1685	-0.1827	-0.3715	0.4906	1.0000													
B2	-0.1151	-0.3963	-0.3502	-0.3052	-0.4308	-0.0465	0.7348	0.4797	0.7902	0.1790	1.0000												
D1	-0.2016	-0.3475	0.0722	-0.1987	0.3804	0.3431	-0.3965	-0.4550	-0.2138	-0.0063	-0.5596	1.0000											
D2	0.0083	-0.1108	-0.3472	-0.1342	-0.2275	0.5177	0.0248	0.3749	0.4789	-0.4363	0.2559	0.2068	1.0000										
D3	-0.1285	-0.6211	-0.2084	-0.3909	0.1305	0.3921	-0.0177	-0.1429	0.1509	-0.0466	-0.1430	0.8714	0.4366	1.0000									
D4	0.0658	-0.4868	-0.0852	-0.2235	0.2401	0.4752	-0.1947	-0.3129	-0.0656	-0.0098	-0.2969	0.8810	0.3932	0.9638	1.0000								
K1	-0.2024	-0.8052	0.4997	-0.1794	0.4980	0.0000	0.2504	-0.2387	0.1100	0.1667	0.0060	0.5319	-0.1677	0.6705	0.5914	1.0000							
K2	0.6965	0.0355	0.4527	0.4279	0.4876	0.0911	-0.5137	-0.8903	-0.8621	0.2703	-0.6026	0.3450	-0.4869	0.2922	0.5395	0.2618	1.0000						
K3	0.0091	-0.4526	0.2929	0.3653	-0.0862	-0.2499	0.5652	0.1194	0.3364	-0.3823	0.6598	-0.4436	-0.2391	-0.3548	-0.4123	0.3215	-0.1691	1.0000					
K4	0.6617	-0.2737	-0.0248	0.4368	-0.0951	-0.4994	-0.3014	-0.7244	-0.5437	-0.1533	-0.3335	0.1793	-0.4900	0.2370	0.3782	0.1868	0.7924	0.0400	1.0000				
G1	-0.6248	-0.9331	-0.1774	-0.5387	-0.1139	-0.4163	0.4913	0.1930	0.5743	-0.0632	0.2362	0.4300	-0.0656	0.6220	0.3642	0.7264	-0.2561	0.2546	0.0097	1.0000			
G2	-0.0676	0.3934	-0.6830	-0.2788	-0.5069	-0.3367	0.0993	0.2146	-0.0412	0.2107	0.0606	-0.3586	-0.4195	-0.4218	-0.4518	-0.7024	-0.1424	-0.3027	0.0431	-0.2721	1.0000		
G3	0.0875	0.2232	0.3827	-0.4116	0.6859	0.4494	-0.0958	-0.0955	-0.3025	0.8542	-0.2997	0.2837	-0.0974	0.2752	0.3465	0.2396	0.3885	-0.5647	-0.0862	-0.1368	-0.1171	1.0000	
G4	0.4712	0.1855	0.6650	0.5723	0.6122	0.5849	-0.7758	-0.7243	-0.6708	-0.0837	-0.6981	0.5064	0.2849	0.3863	0.6268	0.2464	0.6107	-0.2055	0.2522	-0.3195	-0.6531	0.2743	1.0000

Table S3. Spearman correlation of CEs for lotteries (Female)

Ambiguity attitude	P1	P2	P3	P4	B1	S1	S2	S3	S4	B2	D1	D2	D3	D4	K1	K2	K3	K4	G1	G2	G3	G4
Risk attitude	-0.274	0.069	-0.013	0.115	0.521	-0.02	0.286	0.143	0.56	0.269	0.258	0.481	0.056	0.02	0.553	0.699	0.479	0.352	0.208	0.326	0.507	0.508

Table S4. Spearman correlation of risk attitude and ambiguity attitudes

Dependent Variable: CE
Method: Least Squares
Date: 05/20/15 Time: 21:22
Sample: 1 231
Included observations: 231

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	7.053585	0.260622	27.06442	0.0000
LEVEL_OF_AMBIGUITY	-1.399048	0.590882	-2.367727	0.0187

E-View Result 1: Regression for symmetric interval, two point and disjoint ambiguity

Dependent Variable: CE
Method: Least Squares
Date: 05/20/15 Time: 21:41
Sample: 1 139
Included observations: 139

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	4.840653	0.301972	16.03014	0.0000
LEVEL_OF_AMBIGUITY	5.165835	1.698964	3.040580	0.0028

E-View Result 2: Regression for asymmetric ambiguity (from high to low and from low to high)

2. Instructions

General Instructions

Welcome to our study on decision making. The descriptions of the study contained in this instrument will be implemented fully and faithfully.

Each participant will receive a $30 show up fee in addition to earnings based on how you make decisions. All information provided will be kept CONFIDENTIAL.

Information in the study will be used for research purposes only. Please do not discuss any aspect of the specific tasks of the study with any one.

1. The set of decision making tasks and the instructions for each task are the same for all participants
2. It is important to read the instructions CAREFULLY so that you understand the tasks in making your decisions.
3. At ANY TIME, if you have questions, please raise your hand.
4. PLEASE DO NOT communicate with others during the experiment.
5. Do take the time to go through the instructions carefully in making your decisions.
6. Cell phones and other electronic communication devices are not allowed.
7. Please fold the decision sheet after you have made your own decision so that others will not know your decision before the experiment process, including the people who run the experiment.

<u>Instruction for the experiment</u>

Each participant will be given 6 decision sheets for the decisions of task 1, task 2, task 3, task 4, task 5 and task 6. Each decision sheet is of the form illustrated below. You have to make 10 decisions in each of the tasks. You will make 60 decisions in total and your payoff will only depend on only one of the decisions. 2 sets of paper will be used to determine your payoff. One of which names the number of task and another will name the numbers of task.

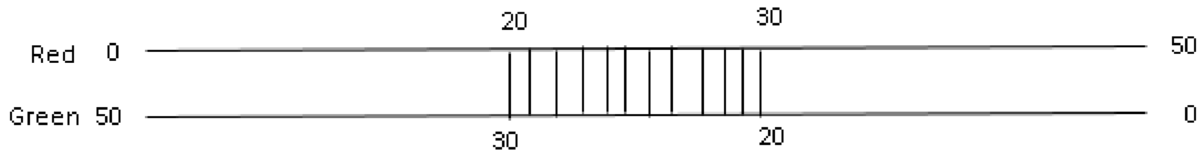
Number:	Option A	Option B	Decision (Circle your choice)
1	Betting on token	Receiving $3 for sure	A / B
2	Betting on token	Receiving $5 for sure	A / B
3	Betting on token	Receiving $7 for sure	A / B
4	Betting on token	Receiving $9 for sure	A / B
5	Betting on token	Receiving $11 for sure	A / B
6	Betting on token	Receiving $13 for sure	A / B
7	Betting on token	Receiving $15 for sure	A / B
8	Betting on token	Receiving $17 for sure	A / B
9	Betting on token	Receiving $19 for sure	A / B
10	Betting on token	Receiving $21 for sure	A / B

Each such table lists 10 choices to be made between an option A and option B.
If option A is chosen, the payoff is determined as follows.
Option A: subject needs to pick the red color of a token randomly drawn from a bag of 50 tokens with different compositions of red and green. If you pick up the red token correctly, you receive $35; otherwise you receive nothing.
Option B: subject will receive the specific amounts of money **for sure** no matter they

guess the colour of tokens accurately, and are arranged in an ascending manner in the amount of money.

For each row, you are asked to indicate your choice in the final decision coloum as you need to circle your choice, which is option A or B.
Each example involves you drawing a token randomly from a box of 50 tokens containing red and green tokens.

Example 1: There is a box containing 20 to 30 red tokens and the number of red tokens may be anywhere between 20 to 30 with the rest of the tokens green, as illustrated below



Example 2: There is a box containing 15 to 35 red tokens and the number of red tokens may be anywhere between 15 to 35 with the rest of the tokens green, as illustrated below