Review of Socio-Economic Perspectives **Wada, R. pp. 160-193**
Vol. 2, No: 1 /June 2017

DOI: 10.19275/RSEP014

Received: *16.03.2017*
Accepted: *02.06.2017*

DOES HAPPINESS AFFECT ATTITUDE TOWARDS AMBIGUITY? : AN EXPERIMENTAL APPROACH TO DISTINGUISH BETWEEN SUBJECTIVE PRIOR AND ACT UNDER AMBIGUITY

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Abstract

In the choice experiments under ambiguous information, there is no consensus about how to create ambiguous information. This paper shows that the way ambiguous information is given to subjects affects the decision making of them. In order to measure the degree of pessimism or optimism about ungiven probabilities, I create randomness with subject interactions through transparent procedure. By using this methodology, I found that individuals who held pessimistic prior invest less into ambiguous securities. In addition, I found that the happiness of an individual affects their decision making of investment into ambiguous securities.

Key words : Ambiguity aversion, SEU, MEU, α-MEU, Experimental economics

JEL Classification : D89, C91, G02

Citation :

Wada, R. (2017). Does Happiness Affect Attitude Towards Ambiguity?: An Experimental Approach to Distinguish Between Subjective Prior and Act Under Ambiguity. Review of Socio-Economic Perspectives, Vol 2(1), pp. 160-193 DOI: 10.19275/RSEP014

Introduction

This paper attempts to make clear the effect of happiness on decision making with ambiguous information. To do so, firstly I observe how happiness affects the distribution of subjective probabilities. Secondly, I ask subjects to select a sure amount of money or an ambiguous lottery. Possible future outcomes not given probabilities are called ambiguous situations. There are different models that explain individual decision making in ambiguous situations. The most famous models are Maxmin model, alpha-Maxmin model and smooth ambiguity model. Experimental studies attempt to make clear which model gives the best description of observed selection. Most previous studies reveal the subjects preferences for ambiguity without emphasizing the method used to create ambiguous information. Subjects are simply told "probabilities for outcomes are unknown". The two representative studies by Bossaerts et al. and Ahn et al. (2010) that study portfolio selection between ambiguous securities and risky securities in the context of Ellesberg paradox apply this simple instruction. Contrast to these studies, in Carbone, Dong and Hey（2016), subjects guess the approximate probabilities of three states of outcomes made by three colors using Bingo Juggler. Hayashi and Wada (2010) is the first study to test which theory is the best description of how individuals make their subjective probabilities under ambiguity by giving imprecise information. This study uses dice to generate imprecise information. Presently, there is no standard procedures to create ambiguous information. In the case that the methodology of giving ambiguous information is not transparent to the subjects, the relationships between subjects and experimenter may affect the subjects' priors. For example, suppose an experimenter tells the subjects "the probabilities are randomized by computer program", this can be manipulated by experimenter. Because subjects may suspect the experimenter wants to avoid paying out larger rewards, the subjects may show stronger ambiguous aversion.

In the experiments by Bossaerts et al. (2010) and Ahn et al. (2010), subjects are given three Allow securities in the context of Ellsberg Paradox; the probability of one security is known to be one third (1/3) and the probabilities of the other securities are not given, while the sum of the probabilities of these two securities is known to be the remaining two thirds (2/3). Therefore, subjects know neither the dense function of probability nor distribution of probabilities of each ambiguous security. Theoretically, in this case subjects could imagine any distribution of probabilities; uniform distribution, normal distribution, Gaussian distribution, Poisson distribution. In addition to these distribution, a distribution could have two bump. In the latter case, subjects would have more difficulty to guess probabilities than when distribution of probabilities has only one bump.

Based on the above points, this study proposes a novel methodology to produce ambiguous securities through a transparent procedure using human randomness. The experimenter places five subjects in a group. Each group member sets the security probability of another randomly selected group member. Until the end of the experiment, the correspondence between members is unknown. Each subject now confronts the unknown distribution of their security probability, selects a distribution of probability, and predicts one probability to decide a corresponding security for each member. The subjects can not know the distribution of probabilities but can guess to some extent. This procedure makes it possible to measure the degree of pessimistic or optimistic feelings when subjects are given ambiguous securities and provide subjective distribution of probabilities.

Usually the model to describe behaviors under ambiguity is entangled with observation of selected securities and it is impossible to disentangle the priors and acts in experiments. My study disentangles priors and acts. Whether a subject is pessimistic or optimistic is independent of their bet on ambiguous securities can be observed.

This study investigates whether happy feelings directly or indirectly affect attitudes toward ambiguous securities. Happy feelings can first affect optimism or pessimism of distribution of probabilities of ambiguous securities and then these subjective priors can affect decision making toward ambiguity. To make the association I set the experimental procedure which observes whether subjects are pessimistic or optimistic beside their bet on ambiguous securities.

1. Literature Review

There are several prominent previous studies to test which model can explain decision making under ambiguity. Ahn et al. (2010) tested models among maxmin expected utility (MEU), coquet expected utility (CEU), recursive expected utility (REU) model using Ellsberg paradox context; the subjects made their portfolio choice between one risky security and two ambiguous securities. In these studies, the probability of the wining state of a risky security is set to be one third and the sum of the probabilities of the wining states of ambiguous securities is two third. Especially, in Ahn et al. (2010), subjects made fifty choices under various budget constraints. However, it is not clear how the ambiguity is created. Bossaerts et al. (2010) uses the same settings and by observing the ratio of demand of risky securities per ambiguous securities. This study concludes that individuals' beliefs are not reflected in the ambiguous securities because some of investors do not have ambiguous security at all. This study found that some of subjects behaviors are explained by α max-min utility model rather than smooth ambiguity model by Klibanoff (2005) because they held their portfolio so as to keep constant the ratio of ambiguous securities per risky security. In contrast, Carbone, Dong and Hey（2016）create ambiguous securities with three states objectively using Bingo Juggler, so that the ambiguity is similar to error from true probability. They found that α—MEU explain observed behavior better than MV theory, and the behaviors of half of subjects are better explained by SEU. From the results of previous studies taken together, it seems that the individual's behaviors are explained by SEU model and α- MEU when we take heterogeneity of individuals into account.

The purpose of this study is different from these previous studies. This study focuses on the relationship between happiness and decision making under ambiguity because it is possible that happiness affects priors in view of behavioral economics. Arkes et al. (1988) is the only previous experimental study focusing on happiness and risk preference. This study reports that the half of subjects who were given candies inside a precious box gained a positive mood and evaluate risky lotteries higher and purchased insurances more than the other subjects who were not given candy. However, this results can be occurred by income effect of candy box. Therefore, in this paper, happiness is measured by survey.

2. The experiment

The suggested models for ambiguity in the previous studies are different between experiments. Not only the settings but procedures of experiments are possible to affect ambiguous preferences. When subjects are not informed how the ambiguous box are made, they can possibly suspect that the experimenter could manipulate the probability that the subjects are rewarded. Furthermore, in the case that subjects are told “probability is made by random function”, the more random numbers are created, the closer the distribution of randomized numbers became uniform distribution. From this viewpoint, this study create ambiguous securities thought a transparent and replicable procedure. Specific procedure of this experiment enables the experimenter to elicit pessimistic or optimistic priors when each subject makes a decision.

One hypothesis of this study is that the predictions of distribution of probabilities are affected by degree of happiness. The similar idea is shown by Epstein and Schneider (2008). They suppose that individuals become pessimistic when they receive ambiguous news in the market, such as when the variations of ambiguous securities are not given one value but given with some range. Even though this supposition has a crucial role in the conclusion of their study, there is no proof of this supposition. This study do not suppose all individuals have pessimistic priors under ambiguous information. Rather, I investigate a hypothesis that the degrees of pessimistic or optimistic priors are affected by individuals' degrees of happiness.

3. Procedure

Basic procedure is as below.

In the first stage, the subjects are asked to split 20 balls into green or yellow as they wish under some constraints. Subjects do not know the purposes for these questions.

Q1. Please enter 20 balls comprising of green or yellow as you like into box A.

How many green balls do you want to enter ?

➡ I enter [ ] green balls.

Q2. There are 5 green balls inside the box. Please enter another 15 balls comprising of green or yellow.

How many green balls do you want to enter?

➡ I enter [ ] green balls.

Q3. There are 10 balls inside the box of either color. Please enter another 10 balls comprising of green or yellow.

How many green balls do you want to enter?

➞ I enter [ ] green balls.

In the second stage, the experimenter makes groups comprising five subjects at random. This procedure is done in front of subjects. The papers subjects' numbers are written and sealed. All sealed papers are mingled and each five papers are selected to make one group. Neither experimenter nor subjects know who the members of their respective groups are until the end of the experiment.

In the third stage, the subjects are told that one member in their respective groups has been selected and the number they wrote down in the first stage has been randomly selected for betting. The subjects are told that a "ball will be drawn from the box chosen in the previous step and that they should state whether they prefer to bet or to receive a sure income of X dollars. X varies from 100 yen (approximately 80 dollars when 1 dollars values 120 yen) to 1000 yen to know certainty equivalent (CE) value of the ambiguous box. If a yellow ball is drawn from their box, subjects acquire 2000 and if a green ball is drawn, they acquire nothing.

Two ambiguous boxes corresponding to each subject are made in the end of experiment. The procedure to decide rewards took at least five minutes per person.

4. The measurement of happiness level

In an experimental environment it is very difficult to create happy or unhappy feelings. Although it is possible to give subjects feelings of fear or humor by some vertical experiment, these are temporal movement of feelings and different from sustained happiness or unhappiness. In addition, the methodology to give subjects long lasting unhappy feelings is ethically problematic. Therefore, I measured the subjects happy and unhappy feelings at that time they participated in the experiment by self-report. All subjects are students of Keio University and using this constraint I selected topics which are important to students.

The academic definition of subjective well-being by phycologists is “the emotional and cognitive evaluations of life”. This evaluation asks subjects how satisfied they are with their life events such as marriage, professions they engage in, and enrichment of all of life since birth. (Diener, Oishi and Lucus (2003).)

Based on the above definition, I asked subjects their level of happiness with regard to their (1) Familial Relationships (2) Academic studies (3) Relationship with their boyfriend or girlfriend (4) Monetary Situation (5) Relationship with Friends (6) Activities such as volunteering and hobbies (7) Total happiness. A scale of seven answers are listed. 1. Very happy / satisfied 2. Happy / Satisfied 3. Somewhat happy / satisfied 4. Normal 5. Somewhat unhappy / unsatisfied 6. Unhappy /Unsatisfied 7. Very unhappy / unsatisfied.

Subjects were asked to fill out the survey before the reward amount is decided. When the subjects answered the entire questionnaire, they were rewarded 1000 yen. These contents are private information, therefore, I carefully explained that their the data would anonymized using a subject number and I received a consent form from the subjects.

5．The distribution of dependent variable and independent variables

5-1．The difference of certainty equivalence (CE) between boxes

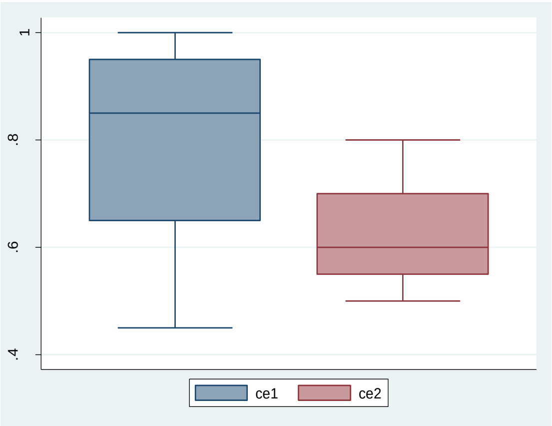

Figure 1 CE of Box A and Box B

(note1) The numbers of the vertical axis are CE/1000

(note2) CE2 shows the CE for box B, and CE3 shows the CE for box C, CE4 shows the CE for box D.

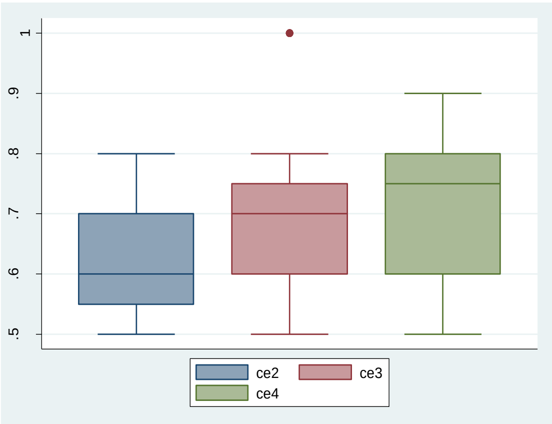

Figure 2 CE of BoxB, Box C and Box D.

(note1) The numbers of the vertical axis are CE/1000

(note2) CE2 shows the CE for box B, and CE3 shows the CE for box C, CE4 shows the CE for box D.

【Box B vs. Box A】 By Wilcoxson **rank sum test,** Box B is significantly larger than Box C (**z =4.51**). Because Box A is risky box. the evaluation of Risk has larger variation than ambiguity.

CE of B is expressed by this equation,

$$\mathrm{CE(B)} = \left\{w_0 \frac{0}{20} + w_1 \frac{1}{20} + \cdots + w_{20} \frac{20}{20}\right\} \mathrm{u(2000yen)}$$

If subjects apply uniform distribution of green balls in Box B, $w_0 = w_1 = \cdots . = w_{20} = \overline{w}$, Therefore, $\mathrm{CE}(B) = 21\overline{w} * u(2000) = \frac{1}{2} u(2000)$ = CE(A)

In the case that possible subjective probabilities of green balls in Box B have a unique focal point with a symmetric distribution,

$$\mathrm{CE(B)} = \left\{w_0 \frac{0}{20} + w_1 \frac{1}{20} + \cdots w_{10} \frac{10}{20} + \cdots w_{19} \frac{19}{20} + w_{20} \frac{20}{20}\right\} \mathrm{u(2000yen)}$$

Assuming that $w_{20-x} = w_{0+x}$,

$$\mathrm{CE(B)} = \{\tfrac{1}{2} w_{10} + w_{11} + \cdots + w_{20}\} \mathrm{u(2000)} \qquad = \left\{w_{10} \frac{10}{20}\right\} \mathrm{u(2000yen)} = \frac{1}{2} u(2000)$$

,

In both cases, CE (B) is considered to be equivalent to CE(A).

If a subject holds asymmetric distribution, and they are pessimistic, the CE of Box B is low as observed. In the experiment, 20 subjects out of 49 were CE(A) = CE(B). Twelve subjects were risk neutral.

【**Box B vs. Box C**】 **By** Wilcoxson **rank sum test,** Box B is significantly larger than Box C (z=2.685). This is surprising result when it is considered that Box C already contains five green balls that bring a losing state. This result comes from the ambiguity averse because Box B’ s ambiguity is larger than Box C.

【**Box B vs. Box D**】 The CE of Box D is significantly larger than Box B (z =4.51). The significant difference between these Boxes comes from the size of ambiguity because, Box D contains at least one green ball and average of green balls of box D is 5.5 because the number of green ball is decided by uniform distribution.

【Box C vs. Box D】 Even though the ambiguity of Box D is smaller than Box C, the difference between Box C and Box D is not significant. The fact that CE of Box D has a larger range reflects that Box D is mixed box of risk (Box A) and ambiguity (Box B)

5-2．The distribution of priors of green balls

In this subsection, I show the actual distribution of priors of green balls and the degree of pessimism for each box.

In the first stage of this experiment, subjects wrote down the number of green balls without being informed of the purpose. In the second stage, subjects are informed how the numbers are utilized. The experimenter makes groups comprised of five subjects chosen randomly in front of the subjects. Subjects are informed that another member of their group has been selected to determine their security probability. Subjects are asked to predict all five member's numbers and asked to mark a circle for their own number and mark triangle for the number who decide restrictive balls.

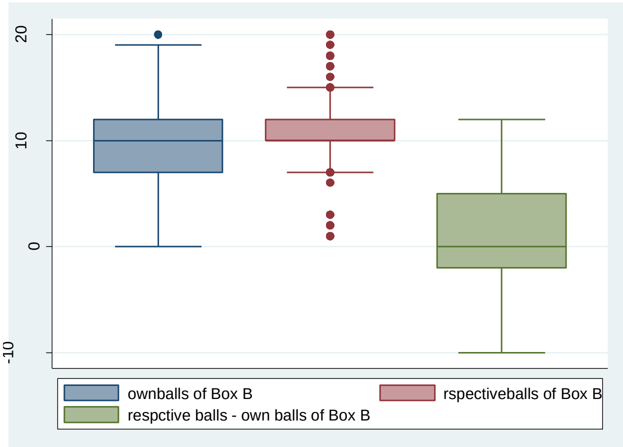

Figure 3 The degree of pessimism of Box B

(note) The blue bar shows the number of green ball a subject wrote down in the first stage. The red bar shows the predicted number of green balls chosen for them. The green bar shows the degree of pessimism

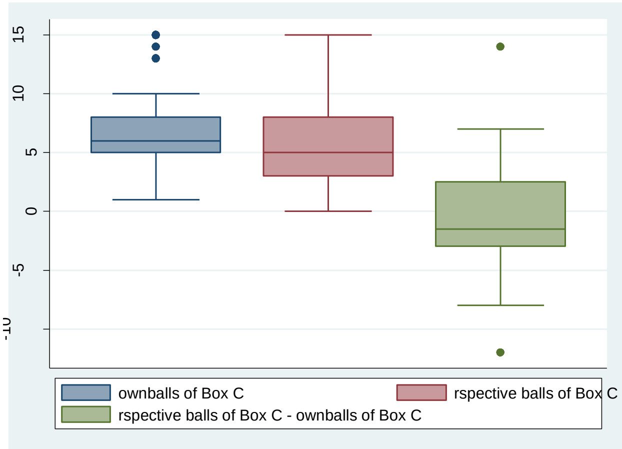

Figure 4 The degree of pessimism of Box B

(note) The blue bar shows the number of green ball a subject wrote down in the first stage. The red bar shows the predicted number of green balls chosen for them. The green bar shows the degree of pessimism

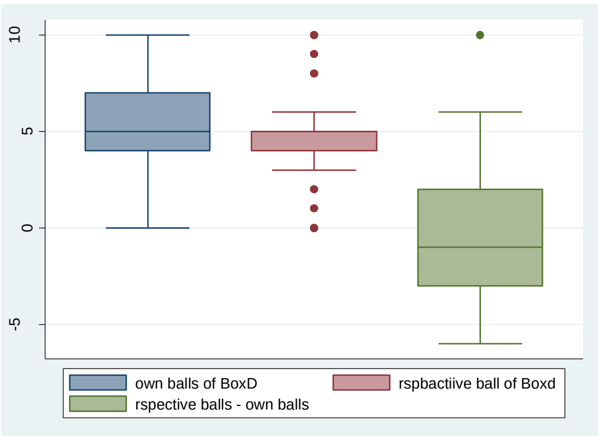

Figure 5 The degree of pessimism of Box D

(note) The blue bar shows the number of green ball a subject wrote down in the first stage. The red bar shows the predicted number of green balls chosen for them. The green bar shows the degree of pessimism

6．Empirical Analysis

6-1．Models

To explain CEs for each box, consider the models below

1) Model 1: The demand of ambiguous box is decided by happiness indirectly though pessimistic / optimistic prior.

In this model, demand of B.(C,D) is dependent of degree of pessimism / optimism

for prior of green balls. Demand is expressed by CE of each box (lottery) and/or the each bet for a box. The pessimism / optimism for prior of green balls is the decided degree of happiness.

CE of ambiguous Box = const. + a_1 (degree of risk averse)

+ a_2 (degree of pessimism)

$$\text{The degree of pessimism} = \text{const.} + b_1 \text{(happiness of familial)} + b_2 \text{(happiness of love)} + b_3 \text{(happiness of friendships)} + b_4 \text{(happiness of monetary situation)} + b_5 \text{(happiness of studies)}$$

2) Model 2-1: The demand of ambiguous Box is decided depending on the degree of risk aversion and /or ambiguity aversion

In this model, the risk aversion is measured by demand for Risky Box A

The ambiguity aversion is measured by relative demand for Ambiguous Box B per se Risky Box A

$$\text{CE of box B} = \text{const.} + a_1 \text{(degree of risk aversion)} + b_1 \text{(happiness of familial)} + b_2 \text{(happiness of love)} + b_3 \text{(happiness of friendships)} + b_4 \text{(happiness of monetary situation)} + b_5 \text{(happiness of studies)}$$

CE of Box C, D = const. + a_1 (ambiguity preference)

+ b_1 (happiness of familial)

+ b_2 (happiness of love)

+ b_3 (happiness of friendships)

+ b_4 (happiness of monetary situation)

+ b_5 (happiness of studies)

3) Model 2-2 : The bet on Box is explained by both risk preferences or ambiguity preference degree of happiness.

In this model, the risk aversion is measured by demand for Risky Box A. The ambiguity aversion is measured by relative demand for Ambiguous Box B per se Risky Box A

Bet on box B = const. + a_1 (degree of risk aversion)

+ b_1 (happiness of familial)

+ b_2 (happiness of love)

+ b_3 (happiness of friendships)

+ b_4 (happiness of monetary situation)

+ b_5 (happiness of studies)

Bet on Box C, D = const. + a_1 (ambiguity preference)

$+ \ b_1$ (happiness of familial)

$+ \ b_2$ (happiness of love)

$+ \ b_3$ (happiness of friendships)

$+ \ b_4$ (happiness of monetary situation)

$+ \ b_5$ (happiness of studies)

【Dependent Variables】

A) In both models CE of each box is measured as below. In the multiple questionnaires to ask subjects whether they bet for a risky/ambiguous box that rewards 2000 yen in its wining state rather than receive a sure x yen (1) , the choice of "bet" will change to "not bet" on the threshold for each subject. The switching point is between x yen to x+100 yen. Therefore, the CE of this box is defined as x + 50 yen. The CE of a subject who selects "bet" for any x is supposed to be 1000 yen, the CE of a subject who selects "not bet" is supposed to be 0 yen.

I standardize the CE to 0 to 1 by divided by 1000 yen,

B) The act of bet for a yellow ball is drawn from each subject's box is 1 and "not bet " is 0.

【Independent Variables】

C) To measure the risk degree of aversion of subjects, I applied Coefficient of Rational Risk Aversion. The calculation of CRRA is measured by application of cumulative utility $u(c) = \frac{c^{1-\gamma}}{1-\gamma}$. The calculation of Coefficient of Absolute Risk Aversion is calculated by application of $u(c) = -\frac{1}{\alpha} e^{-\alpha c}$ I I selected γ as a proxy because explanation power was stronger than CARA.

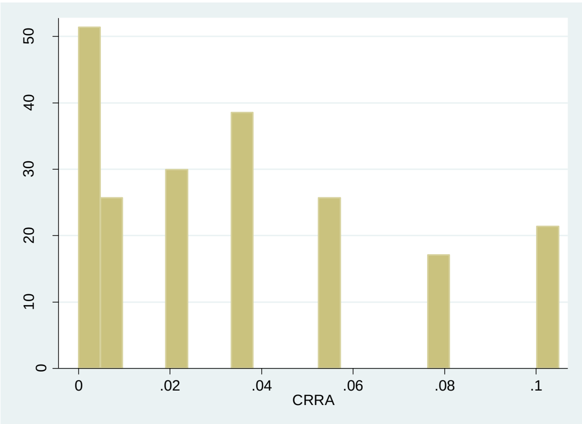

Fig. 23 The distribution of CRRA measured by Risky Box A

7 . The results of empirical analysis

7-1 . CE explained by degree of pessimistic feelings

7-1-1 . Estimated by Ordinary Least Square

By using OLS, it is investigated whether the differences of CE of B, C and D between subjects are explained by degree of pessimism for each box. The null hypothesis that distribution of pessimistic degrees were heterogeneous

dispersion is not rejected, therefore, the result after revised heterogeneous dispersion. In addition, I tested the result using Generalized Least Squared

Estimation. Pessimistic Degree explains CE of all Boxes significantly when GLS is used.

	OLS			OLS robust		
Dependent variables	CE of Box B	CE of Box C	CE of Box D	CE of Box B	CE of Box C	CE of Box D
Constant (t-value) [P>|t|]t	0.5232 (137.08***) [0.000]	0.6045 (36.87***) [0.000]	0.6320 (30.04***) [0.000]	0.5253 (73.04***) [0.000]	0.6045 (36.69***) [0.000]	0.6320 (28.66***) [0.000]
Degree of pessimism	-0.003144 (-0.63) [0.535]	-0.06207 (-1.65) [0.107]	0.0113 (0.35) [0.728] -	-0.003144 (-0.62) [0.538]	-0.0620 (-1.60) [0.117]	0.0113 (0.37) [0.713]
CRRA	2.8902 (37.04***) [0.000]	2.1895 (6.50***) [0.000]	1.8783 (4.35***) [0.000]	2.9087 (31.62***) [0.000]	2.1895 (6.21***) [0.000]	1.8783 (4.35***) [0.000]
F-value (Prob. > F)	F(2,46)= 660.04 (0.0000)	F(2,46)= 21.59 (0 .0003)	F(2,46) = 9.85 (0.0003)	F(2,44) = 500.96 (0.0000)	F(2,46)= 19.34 (0.0000)	F(2,46)= 10.00 (0.0002)
R^2 Adjusted R^2	0.9677 0.966	0.4832 0.4607	0.3001 0.2697	0.9677	0.4832	0.3001

Root MSE	0.01841	0.0788	0.1011	0.01865	0.07881	0.10112

Table 1 Certainty Equivalent Value of Ambiguous Box and Degree of Pessimistic

(note1) the degree of pessimism = (the number of green balls chosen for a subjects – the number of green balls) / the range of possible green balls

(note2) the *** of t-value shows the independent variable is significant for 1 %.

the ** of t-value shows the independent variable is significant for 5 %

the * of t-value shows the independent variable is significant for 10 %

The squared residuals of the model of Box B with CRRA was explained 97 %. The subjects may have distributions of possible green balls in their box possibly similar to uniform distribution, therefore, the CE of B could explained by risk preferences enough.

GLS Robustness analysis	CE of Box B (t value) [P>|t|]	CE of BoxC (t-value) [P>|t|]	CE of Box D (t-value) [P>|t|]
Constant	0.5232 (447.40) [0.000]	0.6059731 (115.75***) [0.000]	0.6284632 (97.84***) [0.000]
Degree of pessimism	-0.007822 (-2.30**) [0.022]	-0.05856 （ -4.85*** ） [0.000]	-0.02653 (-1.92*) [0.055]
CRRA	2.890254 (120.88***) [0.000]	2.167632 (20.47***) [0.000]	1.8551 (14.32***) [0.000]
Wald chi2(2)	14612.21 Prob > chi2 = 0.0000	420.89 Prob > chi2 = 0.0000	216.63 Prob> chi2 = 0.0000
Log likelihood	1277.685	1162.073	431.4513

Table 2 the measurement of CE by degree of pessimism and degree of risk aversion

(note1) the degree of pessimism = (the number of green balls chosen for a subjects

– the number of green balls) / the range of possible green balls

(note2) the *** of t-value shows the independent variable is significant for 1 %.

the ** of t-value shows the independent variable is significant for 5 %

the * of t-value shows the independent variable is significant for 10 %

The CE of Box C and Box D were more weakly explained by risk preferences than Box B. It is possible that the prediction of distribution of green balls of box C was more complicated because of multiple focal points, therefore, subject did not apply uniform distributions. CE of Box C could be explained better by ambiguity aversion. Because the focal point of priors of Box D was only five, subjects could have priors similar to Box B, however, the CE of Box D was significantly explained by its pessimistic degree.

3-1-2. Logit Analysis and Probit Analysis

For each Box, I asked subjects whether they bet for a yellow ball (wining state ball) or receive a certain amount of money. We can consider that these are discrete "two-value problems". It is assumed that each subject decide "bet or not bet" for every questionnaire dependently, using logit model and probit model, we can observe casual relationships between decision making and subjective probability distribution, and happy feelings.

I made panel data for each subject × each lotteries (10 lotteries)

10 lotteries are x yen versus bet for ambiguous Box. In all models using logit and probit analysis, CRRA was 1 % significant. These results also shows that the more risk averse, the less evaluation of ambiguous box were low. Degree of pessimistic were not significant for Box D.

		Panel logit			Panel probit		
		Bet on Box B z-value P>|z|	Bet on Box C z-value P>|z|	Bet on Box D z-value P>|z|	Bet on Box B z-value P>|z|	Bet on Box C z-value P>|z|	Bet on Box D z-value P>|z|
Fixed Effect Part	Constant	-2.048474 (-3.46**) [0.001]	-2.6734 (-3.19**) [0.001]	-2.216 (-2.49**) [0.013]	-1.1450 (-3.47**) [0.001]	-1.4218 (-3.20**) [0.001]	-1.2146 (-2.48**) [0.013]
	Degree of Pessimism	-1.123946 (-2.09**) [0.036]	-0.9867 (-2.03**) [0.043]	-0.423 (-0.98) [0.327]	-0.6831 (-2.27***) [0.023]	-0.6073 (-2.17**) [0.030]	-0.2495 (-0.99) [0.321]
	CRRA	37.651 (8.42***) [0.000]	39.525 (7.42***) [0.000]	33.078 (6.75***) [0.000]	21.842 (8.86***) [0.000]	21.427 (7.79***) [0.000]	18.518 (7.10***) [0.000]
Wald χ^2		72.10	55.30	47.53	79.69	60.79	47.53
Log Likelihood		-215.81	-180.329	-183.829	-216.055	-182.074	183.829
Prob. $>\chi^2$		0.000	0.000	0.000	0.000	0.000	0.000
Random Effect Part	$\ln(\sigma^2)$ $\sigma_u = \sqrt{\hat{\psi}}$ P	1.092 1.727 0.4754	1.797 2.456 0.6470	1.938 2.636 0.6786	0.482 0.978 0.489	0.554 1.319 0.6351	0.757 1.460 0.6808
	Likelihood-ratio test of ρ=0 $\overline{\chi^2} = 0$ Prob. $>\overline{\chi^2}$	151.74 0.000	228.55 0.000	220.04 0.000	150.79 0.000	224.72 0.000	219.08 0.000

Table 1 The Logit/Probit models of Bets on ambiguous boxes with degree of pessimism and degree of risk aversion

(note1) the degree of pessimism = (the number of green balls chosen for a subjects – the number of green balls) / the range of possible green balls

(note2) the *** of t-value shows the independent variable is significant for 1 %.
the ** of t-value shows the independent variable is significant for 5 %

the * of t-value shows the independent variable is significant for 10 %

In the case that risk preferences are removed from the estimation of equations, only the pessimistic feeling mattered in Box B and Box D but did not matter in Box C. It is difficult to understand the reason why this occurred, however these results are consistent with the observation of the act similarly in Box B and D. The proxy of distribution of ambiguous Box explained significantly the CE of B and D. In addition, the ambiguity preferences are significantly important.

		Panel probit		Panel logit	
		Bet on Box C z 値 P>|z|	Box D z 値 P>|z|	Box C z 値 P>|z|	Box D z 値 P>|z|
Dependent Variables	Constant	-0.03517 (-0.17) [0.863]	0.03417 (0.07) [0.941]	-0.1955 (-0.55) [0.585]	0.006311 (0.01) [0.994]
	Degree of pessimism	-0.02468 (-2.02**) [0.043]	-0.0390 (-2.32***) [0.021]	-0.0361 (-1.86*) [0.063]	-0.06695 (-2.59**) [0.010]
	Ambiguity preferences $\frac{CE\ of\ Box\ B}{CE\ of\ box\ A}$	-0.6326 (-2.24**) [0.025]	-0.6297 (-3.72***) [0.000]	-0.9742 (-2.02**) [0.044]	-1.0708 (-3.88***) [0.000]
Wald χ^2		5.74	39.39	4.43	42.21
Log (Pesedo) Likelihood		-218.06	-205.86	-218.30	-205.96
Prob. $>\chi^2$		0.0566	0.000	0.1091	0.000
$\ln(\sigma^2)$ $\sigma_u = \sqrt{\hat{\psi}}$ ρ		0.1774 1.0928 0.54424	0.3743 1.2058 0.5925	1.3145 1.9300 0.5310	1.5240 2.1426 0.5825

Table 4 Panel Data Logit and Probit Analysis of bets on ambiguous box

3-2-1 Pessimistic prior and degree of happiness

From the result of Table 5, one of my hypothesis that there is a casual relationship between pessimistic prior and degree of happiness. In Table 5, risk neutral dummy is added.

	Panel Logit			Panel Probit		
Independent Variables (t-value) [P>|t|]	Degree of Pessimism Box B	Degree of Pessimism Box C	Degree of Pessimism Box D	Degree of Pessimism Box B	Degree of Pessimism Box C	Degree of Pessimism Box D
Constant	-2.502876 (-0.92) [0.362]	-2.544877 (-0.99) [0.327]	0.1868 (0.68) [0.501]	-3.3343 (-1.22) [0.231]	-2.9662 (-1.14) [0.261]	0.08944 (0.33) [0.740]
Familial （unhappiness）	-1.0029 （-1.88*） [0.067]	0.4149 (0.81) 0.1228	-0.07869 (-1.23) [0.226]	-1.2874 (-2.44**) [0.019]	0.27081 (0.48) [0.632]	-0.1120 (-1.75*) [0.087]
Love （unhappiness）	0.7469 （1.87*） [0.068]	-0.1123 (-0.23) [0.821]	0.07806 (1.69*) [0.098]	0.8554 (2.08**) [0.043]	-0.05736 (-0.11) [0.911]	0.09076 (1.96*) [0.057]
Friendship （unhappiness）	0.6636 （1.45） [0.154]	-0.03621 (-0.08) [0.934]	0.07868 (1.31) [0.196]	1.0406 (2.52**) [0.016]	0.1548 (0.33) [0.746]	0.1228 （ 2.16** ） [0.036]
Monetary situation （unhappiness）	0.7130317 (1.39) [0.172]	0.2888 (0.52) [0.606]	0.07679 (1.64) [0.108]	0.8798 (1.77*) [0.084]	0.3733 (0.70) [0.486]	0.09632 (1.99*) [0.053]
Grades （unhappiness）	-0.09575 (-0.21) [0.833]	0.1063 (0.23) [0.821]	-0.05473 (-1.27) [0.212]	0.01493 (0.03) [0.974]	0.1624 (0.34) [0.737]	-0.04177 (-0.98) [0.333]
Risk Neutral Dummy				-2.6136 (-1.80*) [0.079]	-1.3244 (-0.69) [0.492]	-0.3061 (-1.76*) [0.086]
F value	F(5, 43) = 1.37 Prob. > F = 0.2534	F(5, 43) = 0.51 Prob. > F = 0.7690	F(5, 43) = 2.25 Prob.>F = 0.0667	F(6, 42) = 2.31 Prob. > F = 0.0514	F(6, 42) = 0.71 Prob. > F = 0.6416	F(6, 42) = 3.27 Prob.>F = 0.0099
R^2	0.1197	0.0308	0.1330	0.1598	0.0422	0.1826
Root MSE	4.7454	4.7431	0.4961	4.6907	4.771	0.4874

Table 2 The degree of pessimism explained by happiness Indicators

(note1) the degree of pessimism = (the number of green balls chosen for a subjects – the number of green balls) / the range of possible green balls

(note2) the *** of t-value shows the independent variable is significant for 1 %.

the ** of t-value shows the independent variable is significant for 5 %

the * of t-value shows the independent variable is significant for 10 %

As for the risk neutral subjects, the demand for Box B and Box D were significantly explained by pessimistic degrees for each box, and subjects who feel happy about familial things were not pessimistic for the priors. Those who feel unhappy with lovers and friends were pessimistic for ambiguous Box B and D. There is a possibility happiness about friendship leads to trust with friends and making them not pessimistic. However, the predicted pessimistic degree did not explain the CE of box B and Box D.

Furthermore, Box C was not explained by any degree of happiness.
With these results integrated, the hypothesis that the pessimistic degree is causally affected by happy feelings is not strongly supported.

7-3．Direct relationship: CE of ambiguous Boxes and happiness

7-3-1．CE of All Box is explained happiness and risk / ambiguity preference

	OLS robust			
Dependent Variables	CE of Box A (t-value) [P>|t|]	CE of Box B (t-value) [P>|t|]	CE of Box C (t-value) [P>|t|]	CE of Box D (t-value) [P>|t|]
constant	0.5963 (6.89***) [0.000]	0.7339 (16.40***) [0.000]	0.7802 (16.39***) [0.000]	0.9156 (19.46***) [0.000]
Familial relationship （unhappiness）	-0.02607 (-0.93) [0.359]	0.01594 (1.05) [0.299]	-0.0032103 (-0.22) ［0.831］	0.004226 (0.26) [0.796]
Love （unhappiness）	0.002827 (0.15) [0.878]	-0.002464 (-0.25) [0.806]	-0.005395 (-0.45) ［0.658］	-0.002 (-0.17) [0.867]
Friendship （unhappiness）	0.04955 (2.65**) [0.011]	-0.02827 (-2.70*) [0.010]	-0.03185 (-3.18**) [0.003]	-0.04290 (-4.55***) [0.000]
Monetary situation （unhappiness）	0.02018 (1.04) [0.302]	-0.01173 (-1.14) [0.260]	-0.009546 (-0.91) [0.366]	-0.018549 (-1.51) [0.138]
Grades (unhappiness）	0.01913 (1.04) [0.303]	-0.01068 (-1.10) [0.278]	0.006593 (0.61) [0.548]	-0.01683 (-1.87*) [0.069]
Sex Dummy (Female＝1 Male＝0)	-0.005768 (-0.10) [0.920]	0.005024 (0.17) [0.867]	0.002114 (0.07) [0.947]	0.0003172 (0.01) [0.992]
F-value	F(6,42)= 2.26 Prob.>F = 0.0557	F(6,42)= 2.49 Prob. > F = 0.0377	F(6, 42) = 2.81 Prob.>F = 0.0216	F(6, 42) = 6.06 Prob.> F = 0.0001
R^2	0.1712	0.1940	0.1892	0.3406
Root MSE	0.18035	0.09603	0.1033	0.10272

Table 3 The certainty equivalent values of Boxes and degree of happiness

(note1) the degree of pessimism = (the number of green balls chosen for a subjects

– the number of green balls) / the range of possible green balls

(note2) the *** of t-value shows the independent variable is significant for 1 %.

the ** of t-value shows the independent variable is significant for 5 %

the * of t-value shows the independent variable is significant for 10 %

Table 6 shows the results of testing whether CE for all boxes are explained by happy feelings directly using OLS. The degrees of happiness start at 1 (very happy) and go to 7 (very unhappy). The degree of happiness becomes larger as subjects feel unhappy. The sign of coefficients becomes negative if happy individuals evaluate Box higher. I asked the subjects about their happiness in their hobbies and recruitment activity and their human relationship outside family, boyfriend, girlfriend, and friends. These happiness indicators are not significant in any models.

It is very interesting that the result of Box A cannot be explained by any happiness. CE of Box B, C, D was significantly higher for those who feel happier with friends. As for CE of Box D, the satisfaction of study (grades) feel more demand for Box D because Box D is mixture of box of uniform distribution and ambiguous box. The subjects who evaluate themselves to be cool bet Box D more.

In addition to the above test, CE of Box C and D were significantly explained by relative ambiguity preference made by CE of B divided by CE of A. Those who satisfy monetary situation evaluated Box B with CRRA. These result was not very robust but intuitive.

Dependent Variables	CE of Box B (t 値) [P>|t|]	CE of Box C (t 値) [P>|t|]	CE of Box D (t 値) [P>|t|]
Constant	0.5497 (53.08***) [0.000]	0.89033 (20.80***) [0.000]	0.9976 (20.41***) [0.000]
Familial relationship （unhappiness）	003155 (1.37) [0.180]	-0.01540 (-1.33) [0.192]	-0.004846 (-0.40) [0.690]
Love （unhappiness ）	-0.002613 (-1.36) [0.180]	-0.002548 (-0.31) [0.759]	0.0001194 (0.01) [0.990]
Friendship (unhappiness）	-0.003628 (-1.34) [0.189]	-0.01037 (-1.30) [0.199]	-0.02691 (-3.61**) [0.001]
Monetary situation （unhappiness）	-0.003255 (-1.80*) [0.080]	0.0003763 (0.05) [0.957]	-0.01116 (-1.04) [0.306]
Grades （unhappiness）	-0.001159 (-0.69) [0.494]	0.01476 (1.67) [0.103]	-0.01075 (-1.25) [0.217]
CRRA	2.8146 （ 29.82*** ） [0.000]		
Ambiguity preferences		-0.1496 (-5.55***) [0.000]	-0.1114 (-4.03***) [0.000]
Sex Dummy (Female ＝ 1 Male＝0)	0.001418 (0.31) [0.760]	0.0002874 (-0.01) [0.991]	-0.0014705 （-0.05） [0.959]
F-value	F(7,41) = 174.73 Prob. > F = 0.0000	F(7, 41) = 11.67 Prob. > F = 0.0000	F(7, 41) = 8.47 Prob. > F = 0.0000
R^2	0.9730	0.5731	0.5155
Root MSE	0.0178	0.07587	0.08911

Table 4 The certainty equivalent of ambiguous Boxes explained with degree of happiness and ambiguity preferences

(note1) the degree of pessimism = (the number of green balls chosen for a subjects

– the number of green balls) / the range of possible green balls

(note2) the *** of t-value shows the independent variable is significant for 1 %.

the ** of t-value shows the independent variable is significant for 5 %

the * of t-value shows the independent variable is significant for 10 %

7-3-2 . The logit and probit analysis of bet for each lottery

When it is supposed that subjects decide whether they bet the ambiguous box that gives a chance to receive 2000 yen when a yellow ball is drawn or not independently every times, the decision making bet or not bet can be described as a logit model or probit model.

Each subject decides to receive a certain amount of money or bet an ambiguous box. Because sure incomes varies from 100 yen to 1000, subjects face ten times decision making.

The bet can be explained by degree of pessimistic and CRRA, and the results are in table 8. The subjects who were satisfied with their friendship and with monetary situation bet more. Although the subjects who satisfied with their study/grade select

		Bet on Box B	Bet on Box C	Bet on Box D	Bet on Box B	Bet on Box C	Bet on Box D
Fixed Effect Part	Const. (z-value) P>|z|	1.3595 (2.09**) [0.037]	0.5495 (0.66) [0.507]	3.2863 (3.17***) [0.002]	1.359 (3.66***) [0.000]	0.5495 (0.82) [0.413]	3.2863 (2.83**) [0.005]
	Familial Relationship	-0.06189 (-0.57) [0.571]	-0.05607 (-0.46) [0.644]	-0.02929 (-0.23) [0.820]	0.06188 (-1.16) [0.245]	-0.05607 (-0.73) [0.468]	-0.02923 (-0.21) [0.836]
	Love	0.07438 (0.89) [0.374]	-0.09443 (-1.01) [0.313]	0.09503 (0.97) [0.332]	0.07439 (1.71*) [0.088]	-0.09443 (-1.20) [0.230]	0.09502 (1.19) [0.235]
	Friend ship	-0.5688 (-4.73***) [0.000]	-0.5524 (-4.36***) [0.000]	-0.8708 (-5.78***) [0.000]	-0.5688 (-4.92***) [0.000]	-0.5524 (-3.35**) [0.001]	-0.8708 (-7.57***) [0.0

							00]
	Monetary Situation	-0.1441 (-1.67) [0.094]	-0.1378 (-1.45) [0.147]	0.3732 (-3.59***) [0.000]	-0.1441 (-1.93**) [0.054]	-0.1378 (-5.82***) [0.000]	-0.3732 (-5.66***) [0.000]
	Studies	-0.1167 - 1.48) [0.139]	0.10318 (1.17) [0.243]	-0.3560 (-3.69***) [0.000]	-0.1167 (-3.24**) [0.001]	0.1032 (3.99***) [0.000]	-0.3556 (-5.08***) [0.000]
Wald χ^2		28.76	26.28	54.05	32.67	104.74	133.91
Log Likelihood		0.70235	-208.019	-189.8328	-247.753	-208.019	-189.8329
Prob. >χ^2		0.000	0.0001	0.0000	0.0000	0.000	0.000
Random Effect Part	$\ln(\sigma^2)$ $\sigma_u = \sqrt{\hat{\psi}}$ P	0.7024 1.4207 0.3802	1.4307 2.0449 0.5597	1.9291 2.6237 0.6766	0.7024 1.4207 0.3802	1.4307 2.0449 0.5597	1.9291 2,6237 0,6766
	Likelihood ratio test of ρ=0 $\overline{\chi^2} = 0$ Prob. >$\overline{\chi^2}$	129.28 0.000	203.08 0.000	234.69 0.000			

Table 8 The bet on ambiguous Boxes and degree of happiness

(note1) the degree of pessimism = (the number of green balls chosen for a subjects – the number of green balls) / the range of possible green balls

(note2) the *** of t-value shows the independent variable is significant for 1 %.

the ** of t-value shows the independent variable is significant for 5 %

the * of t-value shows the independent variable is significant for 10 %

Even though we can link the bet to the ambiguous box to happiness, that satisfaction with friendship does affect ambiguous box bet frequency can be interpreted as subjects may have friends in their restrictive groups. To evade this criticism, I show that the bet to the ambiguous box was described by total happiness. Taking all results into consideration, I conclude that the happiness affect the bet on ambiguous securities.

		Panel logit		
		Bet on Box B	Bet on Box C	Bet on Box D
Fixed Effect Part	Content z-value P>|z|	-0.3066 (-0.72) [0.470]	-0.5157 (-0.94) [0.349]	0.3178 (0.37) [0.715]
	Total happiness	-0.1215 (-1.66*) [0.096]	-0.1919 (-3.02**) [0.003]	-0.4537 (-6.31***) [0.000]
Wald χ^2		0.0964	9.12	39.87
Log pseudoikelihood		-265.470	-222.690	-221.75
Prob. $>\chi^2$		0.0964	0.0025	0.0000
$\ln(\sigma^2)$ $\sigma_u = \sqrt{\hat{\psi}}$ ρ		0.54370 1.3124 0.3436	1.2998 1.9153 0.5272	1.6056 2.2318 0.6022

Table 9 The bet on ambiguous Boxes and degree of total happiness

(note1) the degree of pessimism = (the number of green balls chosen for a subjects – the number of green balls) / the range of possible green balls

(note2) the *** of t-value shows the independent variable is significant for 1 %.
the ** of t-value shows the independent variable is significant for 5 %
the * of t-value shows the independent variable is significant for 10 %

Conclusion

In this experiment I used human randomness to create ambiguous securities though a transparent procedure. Then I measured their degree of pessimism / optimism independently of their act. The subject's demand for ambiguous securities was explained by their measured degree of pessimistic feeling.

However, the degree of pessimism was not explained by the degree of happiness. Rather, the demand for ambiguous securities are directly explained by happiness. Specifically the happiness with friendships significantly explained more demand for ambiguous box. The most striking results is the certainty equivalent of ambiguous securities with a unique bump in the distribution of probabilities,

which was mostly explained by risk preferences. However, the ambiguous securities with multiple bumps in the distribution of probabilities are less explained by risk preferences. Therefore, I conclude that the method ambiguous information in an experiment is given to subjects may affect their decision making.

The results show that the more pessimistic subjects evade bets on ambiguous securities. However, the degrees of pessimism do not explain the degree of happiness of subjects with consistency. I cannot conclude that the pessimistic / optimistic degree on priors are not explained by happiness. However, this result shows that the subjects who are satisfied with friendship and monetary situation bet more on ambiguous boxes. As for box B and D, subjects who are satisfied with their studies at school bet more. I could say that happiness does matter in deciding to invest in ambiguous securities through some mechanism.

In this study, firstly I showed that the method used to give ambiguous information does affect the bet on ambiguous box. Secondly, I could define and measure the pessimistic / optimistic degree independently of their bet on ambiguous securities. Thirdly, I confirm that the degree of happiness of individuals directly affects decision making under ambiguity.

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