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Ambiguity and loss aversion: The effect of the endowment and windfall losses on the willingness to pay for insurance*

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Abstract

In a conventional experimental design for insurance purchase, we incorporate low and high degrees of variances of loss-occurrence probabilities under no-loss and loss treatments and create three treatment groups: NA (a treatment group with known probabilities of an unlucky event occurring), LA, and HA (treatment groups with low/high variances of loss-occurrence probabilities). Then, we conclude that the aversion behaviors in NA and HA are consistent with the existing economic theories such as the ambiguity aversion model and prospect theory; on the contrary, those in LA cannot be solved by them even if we combine them.

Keywords: Ambiguity aversion; Loss aversion; Reference point;

JEL Classification Code: C61, F41, H23

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1 Introduction

A seminal study by Ellsberg (1961) finds that individuals value bets with known probabilities higher than those with unknown probabilities. In sum, people dislike ambiguity and adjust their behavior in favor of known-probability risk (i.e., ambiguity aversion). As a natural consequence, insurers ask for higher premiums under ambiguous situations than under non-ambiguous ones, and insured people are willing to pay more to be insured against an ambiguous risk than a non-ambiguous one (e.g., Hogarth and Kunreuther, 1989; Kunreuther et al., 1995).

There is a vast body of literature in both theoretical and experimental economics examining how ambiguous-averse people make decisions about insurance demand. However, there is little research evidence on the following two points. First, when people experience a large-scale disaster, they lose their money and property, meaning that they must be in a loss state, not a no-loss state. Against the plausible argumentation, as mentioned in Alary et al. (2013), almost all studies implicitly suppose that the ambiguity is concentrated in a no-loss state, even if individuals suffer a loss. In other words, they do not consider that outcomes are expressed as changes with respect to the status quo, or a *reference point.* Considering that the framing effect may change individuals' perception of the ambiguous risk they face and hence, they may react to a particular choice in different ways depending on a no-loss (that is, positive frame) or loss state (that is, negative frame), an investigation into the framing effects is important.

Second, many decisions in our natural environment have to be made on the basis of imprecise information about potential losses, whereas scientists today are able to predict the natural disasters that stalk us more accurately owing to the development of science. Because accurate prediction allows us to forecast the arrival of a hurricane or a possible flood, we can consider insurance purchase under a lower variance of loss-occurrence probability. Alternatively, because earthquake predictions are more uncertain and less constrained than hurricane and flood predictions, they include a higher variance of loss-occurrence probability. An example of the probability statement about the likelihood of an earthquake is that the probability of a major earthquake occurring in an area is 10−20% over the next 30 years, which is a very high variance of loss-occurrence probability. The point which we should argue is that the variance of the occurrence probability of disasters such as major floods and hurricanes in many areas of world is smaller than that of loss occurrence by earthquake on the average. Consequently, the variance in the loss-occurrence probabilities exists "to a greater or lesser degree," and the variances of the probabilities are not uniform for all types of disasters.

Based on the abovementioned two points, we confirm people's insurance purchase response in no-loss and loss treatments with different variances of loss occurrence probabilities. In this situation, our primary questions are: is all we have to do just apply either the loss averse or ambiguity aversion propensity? Or, not independent of each other, do we need to consider a mixture of the two aversion propensities? To summarize, our data is inconsistent with the existing ambiguity theories even if they are mixed, which is theoretically supported.

In this study, we make use of a conventional experimental design for insurance purchase (e.g., Slovic et al., 1997; Laury et al., 2009). While the detailed description is given later, the important departure from this conventional experimental design is to incorporate a situation where participants perceive the variance of the event occurring vaguely into both no-loss and loss states. Let us look at two situations with different degrees of ambiguity expressed by $\theta =$"High" and "Low." We now define the probability of the event occurring by $p_\theta \equiv \bar{p} + \epsilon_\theta$ where $\bar{p}$ is a baseline probability and ϵ_θ shows a random variable from its baseline probability with mean zero. Then, if the random variables are equally likely to take on each of all possible values, it holds that $\text{Var}(\epsilon_{\text{High}}) > \text{Var}(\epsilon_{\text{Low}})$. We examine if people tend to buy full insurance for the situation with $\text{Var}(\epsilon_{\text{High}})$ more than that with $\text{Var}(\epsilon_{\text{Low}})$ in no-loss and loss states. We name the treatment groups with ϵ_{High} and ϵ_{Low} as HA (high ambiguity treatment) and LA (low ambiguity treatment), as well as the control group as NA (no ambiguity treatment) with $\epsilon_\theta = 0$.

Our study is strongly related to the following studies. First, recent studies such as Baillon and Bleichrodt (2015), Abdellaoui et al. (2016), and Kocher et al. (2018) examine the ambiguity effect in the loss and/or no-loss (i.e., gain) domains. Baillon and Bleichrodt (2015) use the Dutch AEX index and the Indian SENSEX index in a controlled lab experiment, and confirm the switching points of bets. Consequently, they show that their data is most consistent with prospect theory. Abdellaoui et al. (2016) measure the loss aversion in unambiguous and ambiguous situations. In detail, in the unambiguous situation, the outcome of a prospect is determined by drawing a ball from an urn containing five red balls and five black balls; whereas, in the ambiguous one, the proportion between black and red balls is unknown. Then, they investigate the utility curvature, concluding that the utility in no-loss and loss domains has the same form under risk and ambiguity by finding the participants' indifference value. Making use of Ellsberg's (1961) two-color design, Kocher et al. (2018) conclude that the ambiguity propensity is not always confirmed. When confirming the switching of their favor from the unknown situation to the known situation, they find that ambiguity attitudes depend on the outcome domain and likelihood range.

Whereas our study and the above literature are the same in the point that both no-loss and loss states are incorporated under ambiguous environments, our experiments have the following characteristics.[1] At first, in the studies above, participants did not know the variance of loss-occurrence probabilities, whereas we provide for LA and HA which differ by the degrees of their variance. Second, to compare aversion behaviors between unambiguous and ambiguous environments, we incorporate NA. As a result, we can confirm the loss- and ambiguity-averse propensities clearly. For instance, the comparison of the loss and no-loss treatments in NA allows us to mention the loss-averse preferences in a risk environment without any ambiguity, and the comparison between NA and LA (HA) allows us to see the ambiguity-averse preferences in the no-loss and loss states. Finally, by comparing LA with HA, we can see the variance-averse decisions of people under low and high variances of loss-occurrence probability. Owing to a richer preparation of qualitatively different treatments, one of our main findings is that people may have different perceptions of a potential loss even when they are in the loss state and do not change states from loss to no-loss. This implies that prospect theory cannot explain our findings because the loss aversion weight is fixed in the loss state. This is different from Baillon and Bleichrodt's (2015) conclusion that their data is most consistent with prospect theory.

In what follows, the characteristics of our study are closely related to Borghans et al. (2009) and Schade et al. (2012). Making use of Halevy's (2007) version of Ellsberg's measure of ambiguity aversion, Borghans et al. (2009) examine the link of the valuations of bets to cognitive and noncognitive personality traits, finding that men reduce their valuation of

[1]When focusing on the loss domain alone, Xu et al. (2018) compare ambiguity attitudes for oneself and for others; however, our experiments do not incorporate social interaction.

ambiguous urns more than women. Furthermore, they conclude that psychological traits, including the Big five, are strongly associated with ambiguity aversion. Schade et al. (2012) confirm the strong effect of neuroticism on ambiguity aversion, but they do not use the other characteristics. In our study, the personal traits revealed by the Big five test affect the willingness-to-pay (WTP) for full insurance, which differs clearly in loss and no-loss states. In particular, the personal traits of neuroticism and extraversion have different roles in determining the level of the WTP for insurance against a potential loss between the no-loss and the loss treatments.

The remainder of this paper is organized as follows. In the next section, we present the set-up of our experiment. Section 3 shows our results. Section 4 shows the economic implication from the viewpoint of the theoretical framework in our experiment. Section 5 concludes.

2 Experimental design

2.1 The procedure

Our participants were undergraduate students at the Kansai University in Japan. There were 278 participants, comprising 142 males and 136 females (1 session consisted of approximately 20 participants), with each participant participating only once. We conducted 12 experimental sessions in total in July and November 2016 at the experimental laboratory of the Center for Experimental Economics (CEE) of the university. Average earnings, including the 1,000 JPY show-up fee, were 2,290 JPY (approximately 23 USD). Upon recruitment, participants were informed that the 1,000 JPY show-up fee portion of their experimental earning was not at risk. The sessions lasted 80 minutes on average, and the experiment was programmed using z-Tree (Fischbacher, 2007). Please see Figure 1 for the experimental procedure overall.

[Figure 1 around here.]

Participants were seated in isolated cubicles in front of computer terminals at the beginning of the experiment and signed a consent form for the abovementioned earnings and experiment time and so forth. Participants were informed of three tasks: the real-effort, insurance-purchase, and lottery tasks. However, they were not given any information regarding the insurance-purchase and lottery tasks until the completion of the real-effort task.[2]

Participants were informed that they would make use of experimental points, not JPY, and that 1 point corresponded to 1 JPY. We used a point-money exchange system so that participants would consider their show-up fee separately from their experimental earnings from the perspective that they could only use the points to purchase insurance in the insurance-purchase task.

In order to lessen the found-money effect and to make a potential loss more realistic for participants, they earned their endowment points in the first task of the experiment (i.e., the real-effort task) by adding up 50 two-digit numbers (Niederle and Vesterlund, 2007; Xu et al., 2018) before they faced the insurance-purchase decisions. To keep them motivated to do the calculation, they were told that if the number of miscalculations was large, they might not obtain any points in this task. Because each participants' accuracy rate for the 50 calculation questions was over at least 90 percent, they all earned a fixed payment of 1,000 points, which served as the endowment for potential losses in the insurance-purchase task. Please notice again that participants were not informed about the details of the following two tasks.

In the following insurance-purchase task, we employed a 2 (No-loss and Loss) $\times$ 3 (NA, LA, and HA) between-participants experimental design where NA stands for no ambiguity treatment (i.e., a risk treatment with known probabilities of an unlucky event), whereas LA and HA stand for low and high ambiguity treatments, respectively (i.e., risk treatments with ambiguous probabilities of an unlucky event). We detail the treatments later. Although we grasped the merits of the within-participants designs that have often been employed to measure the parameters of utility functions directly (e.g., Abdellaoui, Bleichrodt, and Paraschiv, 2007; Tanaka, Camerer, and Nguyen 2010 for prospect theory), we used a between-participants design in our experiment. The first reason is based on our presumption that the existing economic theories do not explain aversion preferences under our lab situation with the framing effects under ambiguous environments.[3] Therefore, considering that there may

[2]The translation of the experimental instructions is given in Appendix A.

[3]For instance, when only the existing ambiguous-averse theories are applied, Baillon and Bleichrodt (2015) find that their data, which are similar to our situation as described in the Introduction, are most consistent with prospect theory; however, as mentioned later, prospect theory cannot explain our data.

be no economic theories that are consistent with our data, we could not focus on specific economic theories to measure the degrees of aversion attitudes through switching analysis. Second, we wanted to avoid participants' confusion because 2 $\times$ 3 treatments would make within-participants designs more complicated.

Participants were either assigned to the "no-loss" or "loss" treatment. In the no-loss treatment (N = 136(male = 76)), after the participants were told that there would be a gain of an extra 1,000 points windfall, they were also told that there was a low probability that they would lose the windfalls where the endowments were kept. By contrast, in the loss treatment (N = 142(male = 79)), the participants were not told about any windfalls and were told that there was a low probability of a potential unlucky event where they would lose all their endowment points. Hereafter, the former loss is called as *the windfall loss* and the latter *the endowment loss*.

Participants were told the occurrence probabilities of a potential loss by showing them the numbers of black and white balls (explained later for more details). After that, they were offered insurance protection against each potential loss, and were asked to expose their maximum WTP for the full insurance that would completely protect against the potential loss. They were simultaneously informed that they could only buy the insurance when their WTP level was greater than the selling price of the insurance where the actually realized selling price of the insurance would be given at the beginning of the lottery task. They revealed their WTP for each occurrence probability of the unlucky events seven times where they were told that only one of these choices was relevant to the lottery task at random. Because participants did not know which one was relevant in advance, they had to decide for each probability as if it were relevant. After completing a WTP decision, they were not able to review or revise any previously-viewed decision.

This task has two properties. First, the endowment points of the participants in the no-loss treatment were not exposed to risk, whereas those in the loss treatment were. Therefore, if a reference point might be set on the endowment 1,000 points obtained in the real-effort task, the insurance decisions in the no-loss treatment would be made in the no-loss domain and those in the loss treatment would be made in the loss domain.[4] Second, the sizes of

[4]A possible candidate of the reference point is the 1,000 points plus the show-up fee; however, we do not focus on this case because participants were informed that they could use the points for the purchase of the

the endowment and windfall losses were the same. Therefore, based on the abovementioned properties, we can easily apply the loss-aversion statement that the endowment loss has a much stronger negative effect than an equivalent windfall loss. The differences among NA, LA, and HA will be given in the following subsection.

After participants were informed of the insurance selling price at the beginning of the lottery task, each computer monitor showed whether they could buy the insurance or not. Thereafter, one of the seven questions in the insurance-purchase task was selected at random (common to all participants in each session). Furthermore, in LA and HA, one of five numbers was randomly selected (see the following subsection for more details) to determine the occurrence probability of the unlucky event. After that, the proportion between black and white balls was determined where we used 1,000 balls in total. For instance, when the randomly selected probability of a loss occurrence was 2%, we placed 20 black and 980 white small balls into a sealed box where all participants in each session confirmed the view of putting balls on a main screen at the front of the experiment room. After each participant picked a small ball from the sealed box, an experimenter confirmed the color of the drawn ball and returned it to the sealed box. The final earnings were determined.

Let us consider three types of earnings in the no-loss treatment (See Table 1). We denote the finally earned experimental *points* by Y, which does not include the show-up fee (JPY). First, if the participant draws white, he/she keeps all the points and $Y = 1,000$(the real-effort task)$+1,000$(the windfall). Second, if he/she draws black, which corresponds to the occurrence of the windfall loss, there are two types of earnings. Denoting the insurance selling price with I, we can see that $Y = 1,000$(the real-effort task)$+1,000$(the windfall)$-I$ if $WTP \geq I$ because the participants can buy insurance, and that $Y = 1,000$(the real-effort task) if $WTP < I$.[5] Because there is only no windfall in the loss treatment, unlike in the no-loss treatment, the final points in the loss treatment can be easily calculated as in Table 1. The important difference between the no-loss and loss treatments is given by "Change" in Table 1. The "Change" column shows the change from the endowment points. In other words, because the participants in the no-loss treatment always kept the endowment points,

insurance, but not the show-up fee (JPY).

[5] All the insurance prices were fixed at 50 points but the participants were not aware of this in the insurance-purchase task.

three types of points in “Change” have non-negative signs, which means that if the reference point might be set on the endowment point, they were in the no-loss state. Conversely, in the loss treatment, three types of points in “Change” have non-positive signs and hence, they might be in the loss state.

[Table 1 around here.]

After the main experiment, participants were asked to answer the post-experimental questionnaire. To measure personality traits (see Table 2 for more details.), we used the Japanese version of the Ten-Item Personality Inventory (Oshio et al. 2012, 2013), which is a measure of the Big Five (extraversion, agreeableness, conscientiousness, neuroticism, and openness) personality dimensions (Gosling, Rentfrow, and Swann, 2003).[6] Each dimension was rated with one positively keyed item and one negatively keyed item, and each item was scored on a seven-point scale ranging from 1(strongly disagree) to 7 (strongly agree). We used the Big-five test because if participants might have different perceptions between the no-loss and loss treatments, the measurement of the personality traits may be the key element in explaining their aversion behaviors, based on Borghans et al. (2009) and Schade et al. (2012) who investigate the relationship between personality traits and economic preferences such as ambiguity and risk aversion. The average scores (the standard deviation) of our participants were 4.075 (1.515) in extraversion, 2.933 (1.199) in agreeableness, 3.535 (1.319) in conscientiousness, 4.329 (1.282) in neuroticism, and 4.231 (1.399) in openness. In addition, the participants were asked to calculate the expected value to confirm their math performance which requires a particular kind of cognitive ability. In detail, the hypothetical question was as follows: *Suppose that you can receive some amount of money according to the number of a die-throw. You receive 300 yen if 1 comes up, 500 yen if 2, 900 yen if 3, 1000 yen if 4, 1300 yen if 5, and 1700 yen if 6. What is the expected value of the amount of money you receive when you roll this die?* When the right and wrong answers were given by 1 and 0, respectively, we confirm 0.389 on average and its standard deviation was given by 0.488.

[6] We average ratings of the related two items which generate the score of the personality traits in each dimension. For instance, the score of extraversion is calculated based on the scores of questions A and F in Table 2 where, because the content in question A is completely the opposite of that in question F, the score given in question F is arranged in an opposite direction.

[Table 2 around here.]

2.2 The treatment for ambiguity

Our participants were assigned to one of the NA, LA, and HA groups. Then, we notice again that our experiment has six kinds of treatments in total: the loss and no-loss treatments in each of the NA, LA, and HA groups. In NA, the numbers of black balls, which indicated the probabilities of the potential loss occurring, were 20(=2%), 30, 50, 75, 100, 150 and 200(=20%).

In what follows, we created LA and HA based on NA. For instance, LA and HA based on the 20 black balls in NA were created by:

$$\text{The number of black balls in LA}=10,\ 15,\ 20,\ 25,\ 30. \tag{1a}$$

$$\text{The number of black balls in HA}=0,\ 10,\ 20,\ 30,\ 40. \tag{1b}$$

Using the pattern of 20 black balls in NA and (1a) in LA and (1b) in HA, we explain five characteristics with respect to NA, LA, and HA (see Table 3 for NA, LA, and HA in all cases). First, the participants in NA determined the WTP for insurance based on the specific number of black balls (that is, 20 black balls). On the contrary, the numbers of black balls in LA and HA were not specific as in (1a) and (1b): more concretely, the participants in LA an HA knew that the actual number of black balls used was randomly selected from five candidates in (1a) or (1b). Second, each median in LA and HA corresponded to the number of black balls in NA. In (1a) and (1b), both medians are 20 black balls which correspond to 20 black balls in NA. In other words, the median *probability* of loss occurrence in LA and HA was the same as the specifically given probability in NA. Third, HA was mean-preserving spreads of LA. Specifically, noticing that the number of black balls in NA was the same as the median in LA and HA, we arranged for the number of black balls in LA to be incremented by 5 as in (1a), and those in HA by zero, .5, 1.5, and 2 times the median as in (1b). Fourth, the values of the expected loss in LA and HA could not be calculated in the point that the probability that the event occurs was not specific; however, if the probabilities were equally likely for five possible outcomes to occur, the values of the expected loss in NA, LA, and HA would be the same. Finally, the patterns of the number of black balls in LA and HA were the same in the no-loss and loss treatments.

[Table 3 around here.]

3 Results

3.1 Loss and ambiguous aversion preferences

Table 4 represents the mean WTP levels according to each occurrence probability. The "Probability" column is the probability of incurring the windfall/endowment losses in NA and the median probabilities of loss occurrences in LA and HA. First of all, the commonly observed finding is that the higher the value of the probability is, the higher the mean WTP level is (See Table 4A(a) and 4B(a)). For instance, in both no-loss and loss treatments, we can see that the mean WTP level is the highest at the 20% probability in all NA, LA, and HA cases.

[Table 4 around here.]

Second, we confirm the loss aversion preferences in Table 4A(a) and 4B(a). Because NA does not include ambiguity, the comparison of WTP in NA between the no-loss and loss treatments reveals the loss-aversion preferences. The NA columns in Table 4A(a) and 4B(a) show that the WTP in the loss treatment is greater than that in the no-loss treatment, leading to the conclusion that participants prefer avoiding the endowment loss over avoiding the windfall loss. Moreover, this propensity is consistently seen in HA; that is, when the loss occurrence is ambiguous and the variance of the occurrence probability is large, participants dislike the endowment loss and therefore, their WTP in the loss treatment was greater than their WTP in the no-loss treatment. See column HA in Tables 4A(a) and 4B(a). However, the findings obtained in NA and HA cannot be seen in LA. That is, under the low variance of the loss-occurrence probabilities, the "LA" column shows that participants might be loss-averse or loss-seeking. In that regard, Table 4C helps our understanding, in that it shows the difference in the mean WTP between the no-loss and loss treatments. All differences in the mean WTP in NA and HA have positive signs (i.e., loss-aversion preferences) and some of these are statistically significant at the 5% level; on the contrary, those in LA have positive (loss aversion) and negative signs (loss seeking).

Turning to the ambiguity-aversion preferences, we call the ambiguity-aversion (-seeking) preferences when WTP determined in the ambiguous environment is larger (lower) than in the unambiguous one. Let us compare the WTP in NA with that in LA or HA. The "NA vs HA" columns in Tables 4A(b) and 4B(b) show positive values regardless of treatment. In summary, because the WTP in HA was greater than that in NA on average, it can be said that participants were ambiguity-averse under the large variance of ambiguous risk. In what follows, the "NA vs LA" columns have positive values in Table 4A(b) but negative values in Table 4B(b), showing that participants were ambiguity-averse in the no-loss treatment; however, they were ambiguity-seeking in the loss treatment.

Then, our finding can be summarized as follows.

Proposition 1 *In NA and HA, the participants' preferences were ambiguity- and loss-averse for the endowment and windfall losses. In LA, their preferences were loss-averse or loss-seeking, and were ambiguity-seeking for the endowment loss and ambiguity-averse for the windfall loss.*

The findings in Proposition 1 are interesting in the following two aspects. First, the results observed in the endowment losses of LA may follow the paradoxical-insurance decision that people under-insure against disasters such as hurricanes and floods, not earthquakes. The reason is that people suppose they are in a loss state when spending the disaster insurance (i.e., the endowment loss), and that the loss-occurrence probabilities of hurricanes and floods have low variances (i.e., LA). Then, Proposition 1 shows that participants were ambiguity-seeking for the endowment loss, that is, they put weight on the smaller probability of the endowment loss.

Second, the different paradoxical decisions of people are widely reported in this field, showing that insurance rates for low probability and significant loss are lower than those for high probability and small loss (e.g., see Slovic et al., 1977; Laury et al., 2009) However, the experiments in Slovic et al. (1977) and Laury et al. (2009) were performed in an unambiguous environment.[7] Then, they argue that *low-probability events* lead to the misperception or

[7]Another difference is that Slovic et al. (1977) and Laury et al. (2009) not only change the probability of loss occurrence but also, the size of the loss to keep the size of the expected loss the same; on the contrary, our experiment is simpler in the regard that all participants faced the same loss size.

optimism of probabilities. This argument may be applied to the inconsistent results in LA (see Proposition 1); however, our finding can be applied to not only *low-probability* but also *high-probability* events. In other words, the important point apart from Slovic et al. (1977) and Laury et al. (2009) is that people may be optimistic and misperceive the loss-occurrence events even if *the occurrence probability is very high.* The key element in causing the misperception or optimism of probabilities in a wider range is the low variance of the loss-occurrence probabilities. For instance, even when the loss occurrence probability is 20% in LA, Tables 4A(a) and 4B(a) show that the WTP for the windfall loss was greater than that for the endowment loss, and Table 4B(b) that participants were ambiguity-seeking. Because of the paradoxical behavior of LA observed in Proposition 1, we can conclude that optimism or the misperception of low variance leads to the statistically significant difference of the WTP in the case of the endowment loss in the loss treatment (see "LA vs HA" in Table 4(b)).

Finally, we consider that the qualitatively different perception of the ambiguity in LA and HA leads to a complicated formation of loss aversion preference according to the degrees of ambiguity. This can be supported by the theoretical finding in the next section.

3.2 Regression results

We conduct regression analysis in order to examine factors affecting insurance purchase decisions by using the data collected from the experiment and post-experimental questionnaire in Table 5 (the no-loss treatment) and 6 (the loss treatment). In detail, we set the level of the WTP for insurance as the regressand, and include several key factors as regressors; risk probability dummies (the median probability in LA and HA), dummy variables of the ambiguity treatment groups (NA, LA and HA), a gender dummy (Male=1), calculation correctness (Correct=1), and the individual-average score of each participant's personality traits. Because 11.5% of the participants revealed zero WTP, we employ the two-part hurdle model for the estimation. See the results from the OLS model in Tables 5(1), 5(4), 6(1), and 6(4), as a reference of the two-part model.

In the loss treatment, we can see that except for the low probabilities, the risk probability dummies are positively correlated with the WTP level at statistically significant levels (See Table 6(2), 6(3), 6(5) and 6(6)). In sum, the higher probabilities of loss occurrence increase the WTP level in the loss treatment. Turning back to Table 5, the no-loss treatment shows that a similar relationship can be seen, but the effects of the risk probability dummies get weaker. For instance, the risk probability dummies do not affect the selections between zero and positive WTP in the no-loss treatment (See Tables 5(2) and 5(5)). The result that the risk probabilities have stronger effects in the loss treatment coincides with a straightforward economic intuition based on the loss averse statement.

In what follows, the dummies for NA and HA are significantly and positively correlated with the WTP level in Tables 6(3) and 6(6); whereas, the significant effects cannot be seen in Tables 5(3) and 5(6). In summary, when they participated in the loss treatment, the levels of WTP in NA and HA are higher than those in LA, seeming that the participants in NA and HA had a stronger inclination to pay for insurance than in LA. However, in the no-loss treatment, we do not find the difference between treatments significant.

As for the remaining variables, our findings can be summarized in three points: gender, the Big five traits, and the calculation test. First, let us confirm the role of the male dummy. In Tables 5(5) and 6(5), the male dummy is significant and negatively correlated with the selection between zero and positive WTP, which implies that men tend to select zero WTP, that is, they have a tendency not to buy insurance. Except for zero WTP, men are willing to pay a higher price for the windfall loss insurance in Table 5(6), but conversely, not for the endowment loss insurance in Table 6(6). That is, men tend to avoid the windfall loss compared with women; whereas, compared with men, women tend towards avoiding the endowment loss. As such, there is less consistent evidence for gender differences in the framing effects on aversion preferences as argued in Croson and Gneezy (2009).

Second, turning to the Big five, our specific interest is to examine the effects of neuroticism. The reason is based on Schade et al.'s (2012) conclusion that the higher the level of neuroticism (worry in their paper) is, the higher the WTP level is, and more importantly that neuroticism has a larger effect on WTP than the probability of the potential loss. Then, noting that their experiment is limited to a so-called no-loss treatment, we can see from Tables 5(5) and 5(6) that the qualitative effects of neuroticism on the WTP level are the same as those in Schade et al. (2012). That is, the participants who had higher neuroticism scores had the tendency to make a larger payment for the insurance purchase in the no-loss treatment. However, surprisingly, Tables 6(5) and 6(6) show that neuroticism has no effect on WTP. That is, people determine the level of WTP irrespective of their degree of neuroticism. Next, we are interested in the effect of extraversion, which is defined as the behavior of someone who tends to draw energy from being around others more than being alone. This is because all the signs of the extraversion variable are similar to those of the Male dummy; whereas, unlike the male dummy, extraversion does not have significant effects in some cases as in Tables 5(5) and 6(6). As for the personal traits, our findings can be summarized as follows.

Remark 1 *(i) As in Shade et al. (2012), neuroticism affects WTP for insurance against the windfall loss. However, the role of neuroticism is limited contrary to the argument in Schade et al. (2012), that is, neuroticism does not have any significant effect against the endowment loss. (ii) The commonly observed point between the male dummy and extraversion scores is that extroverted people and men make optimistic decisions when their states may be below the reference points; on the contrary, they make sound decisions when their states are guaranteed over the reference point.*

Third, Tables 5(5) and 6(5) show that the "Calculation" variable has a positive sign at a significant level and Tables 5(6) and 6(6) show that the higher the calculation score, the lower the WTP level. In other words, participants who achieved a high calculation score selected the positive WTP, not zero WTP, independently of the no-loss and loss treatments. Furthermore, they tend to spend even less on insurance than the others.

[Table 5 and 6 around here.]

4 Discussion

Proposition 1 shows the differences of the ambiguity- and loss-aversion preferences between LA and HA. Considering that the difference between LA and HA is only the variance of the loss-occurrence probability, we may need to think about a complicated preference according to the degrees of ambiguity. To explain the individuals' propensities in Proposition 1, we have some preference models: maxmin expected utility (Gilboa and Schmeidler, 1989), $\alpha-$maxmin expected utility (Ghiradato, Maccheroni, and Marinacci 2004), prospect theory (Kahneman and Tversky, 1979; Tversky and Kahneman, 1992), and the smooth ambiguity model (Klibanoff, Marinacci, and Mukerji, 2005). However, considering the differences in ambiguity behavior between the no-loss and loss treatments in Proposition 1, we do not consider the maxmin and $\alpha-$maxmin expected utility models. The reason is that the maxmin model predicts uniform ambiguity attitudes, which does not reflect the different ambiguity attitudes observed in Proposition 1. Furthermore, the $\alpha-$maxmin model provides different weights with respect to unlikely and likely events, but it cannot explain the loss-aversion preferences, thereby concluding that our data is not consistent with the predictions of the $\alpha-$maxmin model. As for this point, Baillon and Bleichrodt (2015) also mention that the maxmin model with uniform ambiguity attitudes and the $\alpha-$maxmin model with sign-independent aversion attitudes are inconsistent with their data obtained in the experiment.[8] Their conclusion is that their collected data is most consistent with prospect theory.

Then, we extend the theoretical model of smooth ambiguity aversion (e.g., Klibanoff et al., 2005; Gollier, 2011; Alary et al., 2013), by incorporating a reference point based on prospect theory. As mentioned in Kahneman and Tversky (1979) and Tversky and Kahneman (1992), the introduction of the reference point means that the value is measured in terms of changes from the status quo; furthermore, the effect of a loss is greater than the effect of a gain of the same magnitude (i.e., loss aversion). We consider an ambiguity- and loss-averse individual who has an opportunity to buy an insurance to avoid the unlucky event of incurring a loss. The probability, p_θ, of the event occurring is ambiguous and is represented by a positive stochastic variable. For instance, the probability may be represented by $p_\theta = \bar{p} + \epsilon_\theta$ where $\bar{p}$ is a baseline probability of loss occurrence. When E denotes the expectation operator over the random variable ϵ_θ, the stochastic variable ϵ_θ satisfies $E(\epsilon_\theta) = 0$ under the individual's belief. In our experiment, it holds that $\epsilon_{HA} > \epsilon_{LA}$ if the random variables are equally likely to take on each of all the possible values. Denoting the utility function by $u(\cdot)$, we assume that the utility function is increasing (that is, $u'(\cdot) > 0$). If the utility function is concave $u'' < 0$ (that is, the vNM utility function), then the individual is risk-averse; on the contrary, the utility function with $u'' = 0$ ($u'' > 0$) means that the individual is risk-neutral (risk-seeking).

Following Klibanoff et al. (2005), Gollier (2011), and Alary et al. (2013), we suppose

[8] Making use of two stock indices (the Dutch AEX index and the Indian SENSEX index), Baillon and Bleichrodt (2015) observe the uncertain bet of subjects in a controlled lab experiment.

that the individual maximizes the following utility function:

$$V(x) = \phi^{-1}\left[E_\theta \phi\left\{\pi(p_\theta)u_1(x) + \pi(1-p_\theta)u_2(x)\right\}\right], \tag{2}$$

where x shows the WTP for the insurance. In what follows, $\pi(\cdot)$ represents the probability weight function. Therefore, it does not always hold that $\pi(p_\theta) + \pi(1-p_\theta) = 1$. For example, Kahneman and Tversky (1979) assume that the probability weight function $\pi(\cdot)$ is overweight for low probabilities and underweight for moderate and high ones, thereby generating an inverse S-shaped probability weighting function.

The novelty in model (2) is the introduction of the increasing function $\phi(\cdot)$ which captures the attitudes toward ambiguity. In particular, the concavity of $\phi(\cdot)$ represents ambiguity aversion (that is, $\phi'' < 0$), which shows an aversion to mean-preserving spreads in the random state probabilities p_θ. When $\phi(\cdot)$ is defined by a linear function (that is, $\phi'' = 0$), the individual's preference shows ambiguity neutrality, which is observationally equivalent to expected utility.

We now consider the case of the windfall loss. In sum, an individual can obtain an exogenous profit $\tilde{W}$ with the probability p_θ and nothing with the rest probability $1 - p_\theta$ (i.e., the windfall loss). Denoting the initial wealth by W, which corresponds to the 1,000 endowment points, we can show the functions $u_1(x)$ and $u_2(x)$ as follows:

$$u_1(x) = \underbrace{\int_0^x u(W + \tilde{W} - I)dF(I)}_{(\#G1)} + \underbrace{\int_x^W u(W + \tilde{W})dF(I)}_{(\#G2)}, \tag{3a}$$

$$u_2(x) = \underbrace{\int_0^x u(W + \tilde{W} - I)dF(I)}_{(\#G3)} + \underbrace{\int_x^W u(W)dF(I)}_{(\#G4)}, \tag{3b}$$

Notice that I is the selling price of an insurance, and $F(I)$ represents the cumulative distribution function with a probability density function $f(I)$ where we assume that $f(I)$ is uniformly distributed. Moreover, we assume that $\tilde{W} > I$ as in our experiment, that is, the selling price of the insurance, is less than the exogeneous profit. The function (3a) with the probability p_θ corresponds to the case in which the gain $\tilde{W}$ arises, which means that the individual draws a white ball from the sealed box in our experiment irrespective of the purchase of the insurance. On the contrary, the function (3b) shows that the individual incurs the windfall loss unless he buys the insurance. Next, the terms in ($\#G1$) and ($\#G3$) show that the WTP level selected by the individual is greater than the selling price of the insurance, and therefore he buys it. By contrast, the other terms in (#$G2$) and (#$G4$) mean that the WTP level is lower than the selling price of the insurance so that he cannot buy the insurance.

We now assume that the initial wealth W is the reference point of the individual, thereby supposing that $W = 0$. Then, (3a) and (3b) can be rewritten as:

$$u_1(x) = \int_0^x u(\tilde{W} - I)dF(I) + \int_x^W u(\tilde{W})dF(I), \tag{4a}$$

$$u_2(x) = \int_0^x u(\tilde{W} - I)dF(I), \tag{4b}$$

where we use $u(W) = u(0) = 0$ in the term (#$G4$). Notice that $(\tilde{W} - I)$ has a positive value.

Substituting (4a) and (4b) into (2) and making use of the Leibniz integral rule, we can derive the first-order condition of WTP as follows:

$$u(\tilde{W} - I)E_\theta\left(\phi'(U_\theta)\pi(p_\theta) + \phi'(U_\theta)\pi(1 - p_\theta)\right) = u(\tilde{W})E_\theta\left(\phi'(U_\theta)\pi(p_\theta)\right), \tag{5}$$

where $U_\theta \equiv \pi(p_\theta)u_1(x) + \pi(1 - p_\theta)u_2(x)$. The right-hand side in (5) shows the expected gain biased by the ambiguity function $\phi'(U_\theta)$, whereas the left-hand side in (5) means that the individual selects the optimal WTP level to equal the expected gain in the right-hand side. Finally, the equation (5) can be rewritten as:

$$\frac{u(\tilde{W} - x)}{u(\tilde{W})} = \frac{E_\theta\phi'(U_\theta)\pi(p_\theta)}{E_\theta\left(\phi'(U_\theta)\pi(p_\theta) + \phi'(U_\theta)\pi(1 - p_\theta)\right)}. \tag{6}$$

In what follows, we turn to the case of the endowment loss. Then, the individual faces an exogenous loss L with the probability p_θ (i.e., the endowment loss) and he does not suffer the loss with the rest probability. Making use of the utility function (2) again, we consider the functions $u_1(x)$ and $u_2(x)$ in the loss range as follows:

$$u_1(x) = \underbrace{\int_0^x u(W - I)dF(I)}_{(\#L1)} + \underbrace{\int_x^W u(W - L)dF(I)}_{(\#L2)}, \tag{7a}$$

$$u_2(x) = \underbrace{\int_0^x u(W - I)dF(I)}_{(\#L3)} + \underbrace{\int_x^W u(W)dF(I)}_{(\#L4)}. \tag{7b}$$

We suppose that $I < L$ as in our experiment, implying that the insurance selling price is less than the loss size. The function (7a) with the probability p_θ corresponds to the case that the loss L arises if the individual does not buy the insurance (the term (#$L1$)) and the loss L can be avoided if he buys the insurance (the term (#$L2$)). Applying this to our experiment, this case shows that the individual draws a black ball from the sealed box. Alternatively, the function (7b) shows that the individual does not suffer the loss regardless of whether he buys the insurance or not. Specifically, the term (#$L3$) means that the individual buys the insurance, and the other term (#$L4$) means that he does not. As in the gain range, when the initial wealth W is assumed to be the reference point (i.e., $W = 0$), the functions (7a) and (7b) are given by:

$$u_1(x) = \int_0^x u(-I)dF(I) + \int_x^W u(-L)dF(I), \tag{8a}$$

$$u_2(x) = \int_0^x u(-I)dF(I). \tag{8b}$$

where we use $u(W) = u(0) = 0$ in the term (#$L4$).

Using the loss aversion parameter, we can make the following assumption as many other studies do (e.g., Tversky and Kahneman, 1991, 1992; Benartzi and Thaler, 1995; Thaler, Tversky, Kahneman, and Schwartz, 1997; Tanaka et al., 2009):

$$u(-Y) = -\lambda u(Y), \quad \text{and} \quad u(-L) = -\lambda u(L). \tag{9}$$

Substituting (9) into (8a) and (8b), and moreover substituting these functions into (2), we can obtain the first-order condition of x:

$$u(x)E_\theta\left(\phi'(U_\theta)\pi(p_\theta) + \phi'(U_\theta)\pi(1-p_\theta)\right) = u(L)E_\theta\left(\phi'(U_\theta)\pi(p_\theta)\right). \tag{10}$$

Equation (10) means that the individual selects the optimal WTP level to meet the equality of the equation in (10) where the right-hand side shows the expected loss. Importantly, when the loss aversion weight λ is a constant parameter, the loss-aversion parameters are canceled out. To compare each first-order condition in the loss/no-loss ranges more easily, we can rewrite the equation (10) as follows:[9]

$$\frac{u(x)}{u(L)} = \frac{E_\theta\phi'(U_\theta)\pi(p_\theta)}{E_\theta\left(\phi'(U_\theta)\pi(p_\theta) + \phi'(U_\theta)\pi(1-p_\theta)\right)}. \tag{11}$$

[9]Making use of the CRRA (constant-relative-risk-aversion) function, we can rewrite (6) and (11) as follows:

$$(6):\ \left(1 - x/\tilde{W}\right)^{1-\gamma} = \frac{E_\theta\phi'(U_\theta)\pi(p_\theta)}{E_\theta\left(\phi'(U_\theta)\pi(p_\theta) + \phi'(U_\theta)\pi(1-p_\theta)\right)}.$$

$$(11):\ (x/L)^{1-\gamma} = \frac{E_\theta\phi'(U_\theta)\pi(p_\theta)}{E_\theta\left(\phi'(U_\theta)\pi(p_\theta) + \phi'(U_\theta)\pi(1-p_\theta)\right)}.$$

where γ shows the relative risk aversion parameter.

Then, the right-hand sides in (6) and (11) are the same because the functions $\phi(\cdot)$ and $\pi(\cdot)$ are symmetrically given between the loss and no-loss ranges. Furthermore, looking at the left-hand sides in (6) and (11), we can confirm that the function $u(\cdot)$ with the usual assumptions does not generate the essential difference of WTP in (6) and (11).

As in many studies, we have assumed that loss preferences are stable across decision contexts, which means that the same degree of loss aversion is applied for multiple ambiguous choices, even though the contexts of the decisions are different. However, we do not understand the empirical validity of the assumption of context-invariant loss preferences. Therefore, we now suppose that the loss aversion weight is affected by the ambiguous situation such as λ_θ. For instance, based on our findings in the experiment, we may assume that the loss aversion weight in HA is greater than in LA. In sum, loss-aversion individuals dislike a higher degree of variance that indicates the likelihood of the potential outcome. Then, the first-order condition (10) can be modified by:

$$u(x)E_\theta\left(\phi'(U_\theta)\pi(p_\theta)\lambda_\theta + \phi'(U_\theta)\pi(1-p_\theta)\lambda_\theta\right) = u(L)E_\theta\left(\phi'(U_\theta)\pi(p_\theta)\lambda_\theta\right). \tag{12}$$

Finally, as in (11), we can arrange for (12) as follows:

$$\frac{u(x)}{u(L)} = \frac{E_\theta\phi'(U_\theta)\pi(p_\theta)\lambda_\theta}{E_\theta\left(\phi'(U_\theta)\pi(p_\theta)\lambda_\theta + \phi'(U_\theta)\pi(1-p_\theta)\lambda_\theta\right)}. \tag{13}$$

Then, the right-hand side in (13) is clearly different from that in (6), implying that the loss aversion weight may play a pivotal role in the investigation of the difference in the WTP observed in Proposition 1.

5 Conclusion

Focusing on the degrees of the ambiguity in the no-loss and loss treatments, we summarize the main findings in the following two points. First, the preferences in NA and HA are ambiguity- and loss-averse for the endowment and windfall losses. By contrast, the preferences in LA do not follow those in NA and HA, showing that they are loss-averse or loss-seeking, and are ambiguity-seeking for the endowment loss and ambiguity-averse for the windfall loss. This result cannot be supported by the standard prospect theory and smooth ambiguity aversion model unless the loss aversion weight depends on the degree of ambiguity.

The vaguer information of event probabilities yields to the greater demand for the insurance; however, the smaller variance of loss-occurrence probability decreases the demand for the insurance because of the misperception or the optimism of the small variance. That is, this intuition predicts that owing to the development of science, the more accurate the catastrophe prediction is, the less the demand for the insurance that should protect our life is. This propensity can be seen in almost all the event probabilities based on our findings in the experiment.

References

[1] Abdellauoui, M., Bleichrodt, H., L'Haridon, O., and van Dolder, D., 2016, Measuring loss aversion under ambiguity: a method to make prospect theory completely observable, *Journal of Risk and Uncertainty* 52, 1–20.

[2] Abdellaoui, M., Bleichrodt, H., and Paraschiv, C., 2007, Loss aversion under prospect theory: A parameter-free measurement, *Management Science* 53(10), 1659–1674.

[3] Alary, D., Gollier, C., and Treich, N., 2013, The effect of ambiguity aversion on insurance and self-protection, *Economic Journal* 123, 1188–1202.

[4] Baillon A., and Bleichrodt, H., 2015, Testing ambiguity models through the measurement of probabilities for gains and losses, *American Economic Journal: Microeconomics* 7(2), 77–100.

[5] Benartzi, S., and Thaler, R. H., 1995, Myopic loss aversion and the equity premium puzzle, *Quarterly Journal of Economics* 110(1), 73–92.

[6] Borghans, L., Golsteyn B. H. H., Heckman, J, J., and Meijers, H., 2009, Gender differences in risk aversion and ambiguity aversion, *Journal of the European Economic Association* 7(2–3), 649–658.

[7] Croson, R., and Gneezy, U., 2009, Gender differences in preferences, *Journal of Economic Literature* 47(2), 448–474.

[8] Ellsberg, D., 1961, Risk, ambiguity and the savage axioms, *Quarterly Journal of Economics* 75(4), 643–669.

[9] Fischbacher, U., 2007, z-Tree: Zurich toolbox for ready-made economic experiments. *Experimental Economics,* 10(2), 171–178.

[10] Ghirardato, P., Maccheroni, F., and Marinacci, M., 2004, Differentiating ambiguity and ambiguity attitude, *Journal of Economic Theory* 118(2), 133–173.

[11] Gilboa, I., and Schumeidler, D., 1989, Maxmin expected utility with a non-unique prior, *Journal of Mathemetical Economics* 18(2), 141–153.

[12] Gollier, C., 2011, Portfolio choices and asset prices: The comparative statics of ambiguity aversion. *The Review of Economic Studies,* 78(4), 1329–1344.

[13] Gosling, S. D., Rentfrow, P. J., and Swann Jr, W. B., 2003, A very brief measure of the Big-Five personality domains, *Journal of Research in Personality,* 37(6), 504–528.

[14] Halevy, Y., 2007, Ellsberg revisited: an experimental study, *Econometrica* 75(2), 503–536.

[15] Hogarth, R.M., and Kunreuther, H., 1989, Risk, ambiguity, and insurance, *Journal of Risk and Uncertainty* 2, 5–35.

[16] Kahneman, D., and Tversky, A., 1979, Prospect theory: An analysis of decision under risk. *Econometrica* 47, 263–291.

[17] Klibanoff, P., Marinacci, M., and Mukerji, S., 2005. A smooth model of decision making under ambiguity. *Econometrica,* 73(6), 1849–1892.

[18] Kocher, M, G., Lahno, A. M., and Trautmann, S.T., 2018, Ambiguity aversion is not universal, *European Economic Review* 101, 268–283.

[19] Kunreuther, H., Meszaros, J., Hogarth, R.M., and Spranca, M., 1995, Ambiguity and underwriter decision processes, *Journal of Economic Behavior and Organization* 26(3), 337–352.

[20] Laury, S.K., Mclnnes, M.M., and Swarthout, J.T., 2009, Insurance decisions for low-probability losses, *Journal of Risk and Uncertainty* 39, 17–44.

[21] Niederle, M., and Vesterlund, L., 2007, Do women shy away from competition? Do men compete too much?, *The Quarterly Journal of Economics* 122, 1067–1101.

[22] Oshio, A., Abe, S., Cutrone, P., and Gosling, S. D., 2013. Big five content representation of the Japanese version of the Ten-Item Personality Inventory. *Psychology,* 4(12), 924–929.

[23] Oshio, A., Shingo, A. B. E., and Cutrone, P., 2012. Development, reliability, and validity of the Japanese version of ten item personality inventory (TIPI-J). *Japanese Journal of Personality,* 21(1), 40–52.

[24] Schade, C., Kunreuther, H., and Koellinger, P., 2012, Protecting against loss-probability disasters: The role of worry, *Journal of Behavioral Decision Making* 25, 534–543.

[25] Slovic, P., Fischhoff, B., Lichtenstein, S., Corrigan, B., and Combs, B., 1997, Preference for insuring against probable small losses: Insurance implications, *Journal of Risk and Insurance* 44, 237–258.

[26] Tanaka, T., Camerer, C. F., and Nguyen, Q., 2010, Risk and time preference: Linking Experimental and housing survey data from Vietnam, *American Economic Review* 100 (1), 557–571.

[27] Thaler, R.H., Tversky, A., Kahneman, D., and Schwartz, A., 1997, The effect of myopia and loss aversion on risk taking: an experimental test, *Quarterly Journal of Economics* 112 (2), 647–661

[28] Tversky, A., and Kahneman, D., 1991, Loss aversion in riskless choice: A reference-dependent model, *Quarterly Journal of Economics* 106(4), 1039–1061.

[29] Tversky, A., and Kahneman, D., 1992, Advances in prospect theory: Cumulative representation of uncertainty, *Journal of Risk and Uncertainty* 5, 297–323.

[30] Xu, Y., Xu, X., and Tucker, S., 2018, Ambiguity attitudes in the loss domain: Decisions for self versus others, *Economics Letters* 170, 100–103.

Appendix A.

Instruction (loss treatment)

Instruction for Task 1 (the real-effort task)

In Task 1, you will do a calculation task. Calculation questions (two-digit addition) will be displayed on the computer screen. Compute and enter the answer. You will face 50 calculation questions in total. Ten questions will be displayed per screen. You can use the blank paper at hand for your calculations. When you finish entering the answer, you earn 1,000 points and Task 1 ends. However, you may not obtain any points if there are many calculation errors in your answer. Task 1 continues until everyone is done.

Instruction for Task 2 (the insurance-purchase task)

In Task 2, you may purchase an insurance against the risk of losing 1,000 points. You can use your points from Task 1, to purchase the insurance. On the computer screen on your desk, the numbers of black balls in the box (that contains 1,000 balls in total) are displayed, indicating the probability of the occurrence of the potential loss. Please enter the maximum value of points you think you want to spend to buy the insurance for each number of black balls. (Please enter points in increments of 10. If you do not want to buy the insurance, enter 0.)

If your purchase price (in points) that you indicate is higher than the selling price (in points) of the insurance where the actual selling price of the insurance is displayed in Task 3, you can purchase the insurance at the selling price. Then, we will deduct the selling price from your 1,000 points obtained in Task 1. Hence, you will be protected even if the loss occurs. By contrast, if your purchase price is lower than the selling price, then you cannot buy the insurance. In this case, you will keep your 1,000 points.

Please see the following example.

- There are 10 black balls. (Because the box has 1,000 balls in total, there are 990 white balls.)
- Suppose that the maximum value of points you think you will pay to buy the insurance is 100 points.

- If the actual selling price of the insurance is 50 points, then you can purchase the insurance and the 50 points are deducted from your 1,000 points.
- If the actual selling price of the insurance is 150 points, then you cannot purchase the insurance and no points are deducted.

(LA, HA treatment only) In each purchase decision, we show the five possible outcomes of the number of black balls on your computer screen where the probability distribution of the outcomes is unknown. In Task 3, we are going to choose one of the five possible outcomes randomly. For example, if the five possible outcomes of the number of black balls are given by 5, 10, 15, 20, or 25 black balls, then the number of black balls that is actually in the box is one of these five outcomes. In detail, at the beginning of Task 3, one of the five balls with 5, 10, 15, 20, 25 written on it is chosen and the number of black balls written on it is put into the box.

Finally, you are asked reveal the amount you are willing to pay for the insurance multiple times, for each change in the pattern of the number of black balls. The actual pattern to be used is determined by Task 3.

Instruction for Task 3 (the lottery task)

First of all, the number of black balls actually used and the insurance price are displayed on the main screen at the front of the experiment room. In addition, whether you may purchase the insurance or not is decided based on your decision at Task 2.

Next, let us determine the number of black balls. One of the participants randomly chooses one of seven questions, by drawing a middle-sized ball from the sealed box.

(LA, HA treatment only) Furthermore, another participant randomly chooses one of the five balls which correspond to the selected pattern of black balls.

(We put some black and white balls in the sealed box, and the participants watch this on the main screen.) Hereafter, you will choose a ball from the box. When the staff member comes to your desk, please choose one ball from the sealed box. After confirming the color, you will put the ball back into the box. Please input the color (black or white) you draw on your computer screen.

After the ball selection, the computer will calculate your final points. When X is the insurance price, the points are decided as follows.

You purchase the insurance and choose a white ball: $(1000 - X)$ points

You purchase the insurance and choose a black ball: $(1000 - X)$ points

You do not purchase the insurance and choose a white ball: 1000 points

You do not purchase the insurance and choose a black ball: 0 points

Table 1: Earnings

		No-loss treatment (Windfall)			Loss treatment (No windfall)		
		Final earning	Total points	Change	Final earning	Total points	Change
	Color drawn	(Show-up fee+Y)	(Y)	($Y - 1,000$(Real effort task))	(Show-up fee+Y)	(Y)	($Y - 1,000$(Real effort task))
WTP$\geq I$	Black or White	$3,000 - I$	$2,000 - I$	$1,000 - I(> 0)$	$2,000 - I$	$1,000 - I$	$-I$
WTP$< I$	Black	2,000	1,000	0	1,000	0	−1,000
	White	3,000	2,000	1,000	2,000	1,000	0

Note that Y represents the total point and I is the price of the insurance.

Table 2: Big Five Questionnaire

Please choose one applicable number next to each statement to indicate the extent to which you agree or disagree with that statement. You should rate the extent to which the pair of traits applies to you, even if one characteristic applies more strongly than the other.

Table 2:

	I see myself as;	Disagree Strongly	Disagree Moderately	Disagree A Little	Neither Agree Nor Disagree	Agree A Little	Agree Moderately	Agree Strongly
A	Extraverted, enthusiastic.	1	2	3	4	5	6	7
B	Critical, quarrelsome.	1	2	3	4	5	6	7
C	Dependable, self-disciplined.	1	2	3	4	5	6	7
D	Anxious, easily upset.	1	2	3	4	5	6	7
E	Open to new experiences, complex.	1	2	3	4	5	6	7
F	Reserved, quiet.	1	2	3	4	5	6	7
G	Sympathetic, warm.	1	2	3	4	5	6	7
H	Disorganized, careless.	1	2	3	4	5	6	7
I	Calm, emotionally stable.	1	2	3	4	5	6	7
J	Conventional, uncreative.	1	2	3	4	5	6	7

Table 3: The number of black ball

Probability	NA	LA	HA
0.02	20	10, 15, 20, 25, 30	0, 10, 20, 30, 40
0.03	30	20, 25, 30, 35, 40	0, 15, 30, 45, 60
0.05	50	40, 45, 50, 55, 60	0, 25, 50, 75, 100
0.075	75	65, 70, 75, 80, 85	0, 37, 75, 112, 150
0.1	100	90, 95, 100, 105, 110	0, 50, 100, 150, 200
0.15	150	140, 145, 150, 155, 160	0, 75, 150, 225, 300
0.2	200	190, 195, 200, 205, 210	0, 100, 200, 300, 400

Table 4: Mean WTP

A: No-loss treatment

(a) Mean WTP by probability				(b) Difference of mean WTP		
Probability	NA	LA	HA	NA vs. LA	NA vs. HA	LA vs. HA
2%	97.692	106.944	129.792	9.252	32.099	22.847
3%	123.462	142.500	136.458	19.039	12.997	-6.042
5%	116.923	159.722	165.625	42.799	48.702	5.903
7.5%	145.000	194.167	202.500	49.167	57.500	8.333
10%	181.154	183.611	200.417	2.457	19.263	16.806
15%	201.923	216.111	250.625	14.188	48.702	34.514
20%	237.885	279.444	294.167	41.560	56.282	14.722

B: Loss treatment

(a) Mean WTP by probability				(b) Difference of mean WTP		
Probability	NA	LA	HA	NA vs. LA	NA vs. HA	LA vs. HA
2%	116.200	114.167	159.773	-2.033	43.573	45.606
3%	129.000	112.500	184.773	-16.500	55.773	72.273*
5%	175.600	146.250	217.955	-29.350	42.355	71.705*
7.5%	219.400	165.417	247.046	-53.983	27.646	81.629*
10%	252.600	195.417	289.773	-57.183	37.173	94.356**
15%	262.600	223.125	332.955	-39.475	70.355	109.830**
20%	300.200	270.833	369.773	-29.367	69.573	98.939*

C: Difference of mean WTP (no-loss vs. loss)

Probability	NA	LA	HA
2%	18.50769	7.2223	29.981
3%	5.5385	-30	48.3144
5%	58.6769	-13.4722	52.3295
7.5%	74.4*	-28.75	44.5455
10%	71.4462	11.8056	89.356*
15%	60.6769	7.0139	82.3295*
20%	62.3154	-8.6111	75.606

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$: The p-value is the probability of obtaining t-test for Student's t-distribution results.

Table 5: Regression results in no-loss treatment

No-loss treatment						
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	Two part model		OLS	Two part model	
		Probit	OLS (WTP>0)		Probit	OLS (WTP>0)
Probability=3%	21.704	0.051	24.754	21.704	0.066	22.859
	(21.815)	(0.171)	(25.938)	(21.181)	(0.178)	(24.395)
Probability=5%	33.481	0.104	35.931	33.481	0.121	33.730
	(21.394)	(0.173)	(25.038)	(20.754)	(0.180)	(23.626)
Probability=7.5%	67.111**	0.189	72.031**	67.111**	0.213	71.394**
	(22.573)	(0.176)	(25.852)	(21.889)	(0.183)	(24.188)
Probability=10%	76.963***	0.219	82.572**	76.963***	0.247	79.340**
	(23.052)	(0.177)	(26.270)	(22.207)	(0.184)	(24.545)
Probability=15%	110.741***	0.219	122.490***	110.741***	0.243	119.698***
	(23.530)	(0.177)	(26.330)	(22.950)	(0.184)	(24.990)
Probability=20%	156.741***	0.382*	163.482***	156.741***	0.415*	159.395***
	(24.259)	(0.183)	(26.486)	(23.694)	(0.192)	(25.339)
NA	-24.279	0.167	-40.931*	-25.944	0.113	-29.441
	(17.069)	(0.120)	(19.466)	(16.772)	(0.127)	(18.980)
HA	13.869	0.124	8.328	19.563	0.108	29.257
	(18.176)	(0.121)	(20.541)	(18.312)	(0.128)	(20.440)
Male				5.389	-0.629***	42.302**
				(13.927)	(0.106)	(15.370)
Calculation				-17.886	0.410***	-44.661***
				(12.283)	(0.104)	(12.978)
Big five (Extroversion)				19.364***	-0.060	27.925***
				(4.915)	(0.035)	(5.031)
Big five (Agreeableness)				-20.953***	0.037	-27.850***
				(5.139)	(0.043)	(5.509)
Big five (Conscientiousness)				2.413	0.071	-1.909
				(4.828)	(0.039)	(5.166)
Big five (Neuroticism)				25.269***	0.145***	21.468***
				(5.562)	(0.038)	(5.855)
Big five (Openness of experience)				9.529*	-0.024	10.387*
				(4.595)	(0.036)	(4.821)
Constant	116.537***	0.659***	156.960***	-55.612	0.281	-16.917
	(19.221)	(0.142)	(22.938)	(43.537)	(0.340)	(45.866)
Results from OLS						
Observations	945			945		
Adjusted R-squared	0.061			0.117		
F statistics	8.226			10.464		
Results from Two-part model						
Observations		945			945	
Observation (second part)		777			777	
Wald chi (first part)		7.778			91.272	
Adjusted R-squared (second part)		0.072			0.161	
F statistics (second part)		8.283			11.767	
Log likelihood		-5632.600			-5558.812	
Log likelihood(probit)		-438.325			-407.328	
Log likelihood(OLS)		-5194.276			-5151.485	

Dependent variables are the levels of WTP, and robust standard errors in parentheses.

Note that *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, and that dummies for 2% probability and LA are reference groups.

Table 6: Regression results in loss treatment

Loss treatment						
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	Two part model		OLS	Two part model	
		Probit	OLS (WTP>0)		Probit	OLS (WTP>0)
Probability=3%	11.857	0.050	12.384	11.857	0.084	11.443
	(16.780)	(0.172)	(18.431)	(15.639)	(0.188)	(17.716)
Probability=5%	50.143**	0.260	46.244*	50.143**	0.349	46.128*
	(18.312)	(0.180)	(19.727)	(17.289)	(0.193)	(19.185)
Probability=7.5%	81.357***	0.326	78.357***	81.357***	0.417*	79.433***
	(19.626)	(0.183)	(20.863)	(18.711)	(0.200)	(20.356)
Probability=10%	116.357***	0.676**	101.353***	116.357***	0.805***	104.686***
	(19.538)	(0.207)	(20.421)	(18.678)	(0.234)	(19.772)
Probability=15%	142.429***	0.799***	125.132***	142.429***	0.943***	128.822***
	(19.685)	(0.219)	(20.476)	(18.977)	(0.249)	(19.932)
Probability=20%	183.643***	0.793***	169.111***	183.643***	0.934***	173.075***
	(20.865)	(0.219)	(21.475)	(20.416)	(0.250)	(21.072)
NA	30.520*	-0.203	42.825**	35.629**	-0.113	43.076**
	(13.232)	(0.125)	(14.107)	(12.867)	(0.143)	(13.830)
HA	80.013***	0.250	79.258***	94.054***	0.526**	88.704***
	(13.015)	(0.148)	(13.161)	(12.414)	(0.163)	(12.907)
Male				-81.334***	-1.292***	-49.863***
				(11.026)	(0.159)	(11.333)
Calculation				-6.184	0.361**	-19.045
				(10.297)	(0.122)	(10.929)
Big five (Extroversion)				-10.086**	-0.189***	-5.183
				(3.819)	(0.041)	(4.097)
Big five (Agreeableness)				4.567	0.129*	3.302
				(4.653)	(0.055)	(4.992)
Big five (Conscientiousness)				14.706**	0.064	15.411**
				(5.014)	(0.054)	(5.401)
Big five (Neuroticism)				1.948	-0.064	4.123
				(4.317)	(0.051)	(4.773)
Big five (Openness of experience)				6.811	0.011	8.287*
				(3.837)	(0.043)	(4.155)
Constant	93.739***	0.856***	120.925***	76.216	1.914***	55.120
	(14.253)	(0.143)	(15.628)	(44.792)	(0.551)	(48.919)
Results from OLS						
Observations	980			980		
Adjusted R-squared	0.139			0.195		
F statistics	22.579			20.899		
Results from Two-part model						
Observations		980			980	
Observation (second part)		867			867	
Wald chi (first part)		35.041			112.772	
Adjusted R-squared (second part)		0.122			0.152	
F statistics (second part)		18.229			13.703	
Log likelihood		-5997.082			-5923.109	
Log likelihood(probit)		-327.993			-272.845	
Log likelihood(OLS)		-5669.089			-5650.263	

Dependent variables are the levels of WTP, and robust standard errors in parentheses.

Note that *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, and that dummies for 2% probability and LA are reference groups.

Figure 1: The flowchart in our experiments