Attention, Frame Condition and Decision Making Under Risk:

An Empirical Test of the Contingent Focus Model using an Eye Gaze Recorder

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Abstract

Identical problems may give rise to different decisions, due to subjective decision framing in which the decision-making process depends on how the situation is described. This is called the *framing effect*. We applied the contingent focus model (Takemura, 1994a) to explain the framing effect. The model hypothesizes that risk attitude depends on the extent to which a subject focuses on possible outcomes and probabilities (the *focusing hypothesis)*, and that focusing on possible outcomes and probabilities is, in turn, contingent on contextual factors including positive/negative frame condition (the *contingent focus hypothesis)*. These hypotheses were tested by the eye movement data obtained from 33 participants using an eye gaze recorder. The data indicated that participants whose ratio of total time gazing at words representing possible outcomes to the total time gazing at words representing possible outcomes and probabilities was higher preferred a risk-taking option. This ratio was higher under negative frame conditions than under positive frame conditions.

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Introduction

Identical problems may lead to different decisions because of subjective decision framing, in which the decision-making process depends on how the situation is described. This is called the *framing effect* (Tversky & Kahneman, 1981). For instance, when a decision needs to be made concerning whether or not one agrees to undergo a surgical operation, the decision may be different when a doctor tells one that there is a 95% probability of living following the surgery, as compared to when one is told that there is a 5% probability of dying. This effect violates the principle of description invariance, which states that different representations of the same choice problem should yield the same preference (Tversky & Kahneman, 1986).

Tversky and Kahneman (1981) posed a question under the following two framing conditions; this typical and well-known example, known as the Asian disease problem, allows subjects to make a choice under each condition and results in the framing effect.

[Problem 1]

Positive frame condition:

“Imagine that the U.S. is preparing for the outbreak of an unusual Asian disease, which is expected to kill 600 people. Two alternative programs to combat the disease have been proposed. Assume that the exact scientific estimates of the consequences of programs are as follows. Which of the two programs would you favor?

If program A is adopted, 200 people will be saved.

If program B is adopted, there is 1/3 probability that 600 people will be saved, and 2/3 probability that no people will be saved. (p.193.)”

Negative frame condition:

The question is the same except for the description of programs, which were changed as follows:

“If program C is adopted, 400 people will die.

If program D is adopted, there is 1/3 probability that nobody will die, and 2/3 probability that 600 people will die. (p.193)”

Here, although the program descriptions are different, it is clear that programs A and C, and programs B and D, respectively, have equivalent meanings. “Be saved” equals “not die,” and “not be saved” equals “die.” Tversky and Kahneman (1981) reported that when a profitable position was emphasized in the description of a positive frame condition, most subjects chose risk aversive programs, i.e., program A. But, if a losing position was emphasized in the description of a negative frame condition, most subjects chose the risk taking program, i.e., program D.

Tversky and Kahneman (1981, 1986) reported that the framing effect is a robust phenomenon and suggested that, similar to visual illusion, the framing effect leads to a paradoxical result, even though the paradox may only be recognized afterwards. Framing effects have been reported to occur in relation to medical judgments made by doctors (McNeil, Pauker, Sox, & Tversky, 1982), in managerial decision making (Qualls & Puto, 1989), and in many other decision making situations (Wang, 1996; Kühberger, 1998; Shafir & LeBoeuf, 2002; LeBoeuf & Shafir, 2003).

Prospect Theory and Reference Point

Tversky and Kahneman (1979) proposed *prospect theory* as a way of explaining framing effects. They highlighted a difference in subjective values between gains and losses associated with choice behavior. The value function in prospect theory is concave in the gain area and convex in the loss area, which implies that a decision maker is risk averse in the gain area but chooses to take risks in the loss area. Prospect theory also assumes that original points of the value functions, i.e., *reference points*, shift depending on the description of a decision problem. Prospect theory explains framing effects by a shift of the reference point. When a reference point is greater than an outcome, the outcome is interpreted as a gain. However, if the reference point shifts to be less than the outcome, it then comes to be regarded as a loss. Since prospect theory assumes that subjects avoid risks when outcomes are framed as gains (i.e., positive frame), and that subjects take risks when outcomes are framed as losses (i.e., negative frame), the theory predicts that risk attitudes change, depending on the frame condition.

A reference point is necessary for prospect theory to explain decision making under risk because risk attitude, which determines a decision, depends on the relation between a reference point and an outcome. This implies that one must be able to predict the position of a reference point and its shift due to contextual factors, including positive/negative frame conditions, in order to predict decision making under risk in an actual environment, in which numerous contextual factors are embedded.

Does prospect theory, then, provide a theoretical and quantitative explanation for the shift of a reference point *per se*? With respect to this question, Tversky and Kahneman (1981) stated briefly:

> "The frame that a decision maker adopts is controlled partly by the formulation of the problem and partly by the norms, habits, and personal characteristics of the decision maker" (p. 453)

In line with this conjecture, Fischhoff (1983) reported an experiment that investigated reference point positions while postulating the validity of prospect theory. However, he found that it was difficult, or even impossible, to identify a reference point position from external observations, i.e., actual choices. In addition, he found an inconsistency between a reference point that is derived from actual choice based on prospect theory, and a self-reported reference point. To date, a methodology that identifies the reference point position does not seem to have been proposed.

While prospect theory postulates one reference point, a decision maker may actually use multiple reference points. For instance, Takemura (2001) proposed the mental ruler theory that postulates two reference points to explain numerical judgments. He confirmed that the theory provides a better fit to judgmental data than other theories. In addition, Maule (1989) collected verbal protocol data in decisions involving the Asian disease problem and found that 5 subjects out of 12 made their decisions while adopting two different reference points.

Contingent Focus Model

The reference point concept is useful with respect to explaining the framing effect. However, it is difficult to define a reference point and to predict its position and shift; furthermore, prospect theory cannot explain decision making when a decision maker has multiple reference points. For these reasons, one of the authors of the present study proposed the *contingent focus model*, which does not employ the concept of reference point to explain the framing effect (Takemura, 1994a; Fujii & Takemura, 2000, 2001, 2003).

The basic assumption of the contingent focus model is that framing effects emerge, not when a reference point shifts, but when a decision maker changes focus on possible outcomes and probabilities, depending on the frame conditions of decision problems. As shown in Figure 1, under positive frame conditions, a decision maker is assumed to pay more attention to probabilities than to possible outcomes, which results in the decision maker being risk averse. On the other hand, under negative frame conditions, a decision maker is assumed to pay more attention to possible outcomes than to probabilities, which results in the decision maker being risk inclined. In other words, a decision maker is assumed to attend to negative outcomes (i.e., loss) more intensely than to positive outcomes (i.e., gain).

This hypothesis is in line with the *loss sensitivity principle* (Gärling, et al., 1997; Romanus & Gärling, 1999), which presumes that a decision maker is more sensitive to a negatively framed outcome (i.e., loss) than to a positively framed outcome (i.e., gain). Prospect theory hypothesizes that the value function of outcomes is steeper for losses than for gains, which is also congruent with the hypothesis, since the curvature of the value function implies the decision maker's sensitivity to outcome. Furthermore, Kahaneman & Tversky (1984) have argued that "losses loom larger than gains (p. 348)." We can then infer that a decision maker pays more attention to outcomes under negative frame conditions than under positive frame conditions, as is assumed in the contingent focus model.

Figure 1

As in prospect theory (Kahneman & Tversky, 1979) and subjective expected utility theory (Von Neumann and Morgenstern, 1944; Savage, 1954), the contingent focus model also describes decision making under risk. Within the contingent focus model, it is hypothesized that a decision maker chooses an alternative whose subjective decisional value is maximum from among possible alternatives. The value is formulated as follows.

$$U(X, P) = F(X)^{a} G(P)^{(1-a)} \qquad (1)$$

where X denotes possible outcome, P denotes the probability that a decision maker gets X, $U(X, P)$ denotes a subjective decisional value of an alternative of X and P, $F(X)$ denotes the subjective value of a possible outcome X ($F(X) > 0$), $G(P)$ denotes the subjective value of P ($G(P) > 0$), and a denotes a parameter ($0 \leq a \leq 1$) indicating the degree of focus on outcome X. We label this parameter the *focal parameter*. As the focal parameter a approaches 1 from 0, a decision maker makes riskier decisions. When a equals 1, only outcomes influence the decision making, and a decision maker is making extremely risky choices. On the other hand, as a approaches 0 from 1, a decision maker becomes risk averse. When a equals 0, only probabilities influence the decision making, and a decision maker is extremely risk averse. This hypothesis, which explains how focusing on possible outcomes and probabilities determines risk attitudes, is called the *focusing hypothesis*.

The hypothesis that focal parameter a changes depending on contextual factors, including frame condition, is the *contingent focus hypothesis*. Thus, in the contingent focus model, framing effects are ascribed to changes of the focal parameter a and not to reference point shifts. This contingency of the focal parameter is formulated as follows:

$$a = \Psi(\theta) \qquad (2)$$

where θ denotes a vector of contextual factors and $\Psi(\ )$ denotes a function indicating the contingency of the focal parameter a on θ. Contextual factors (θ) include positive/negative frame conditions. The basic contention within the contingent focus model, that a decision maker attends to negative outcomes more intensely than to positive outcomes, indicates that the focal parameter a will be larger under negative frame conditions than under positive frame conditions.

Figure 2 summarizes the contingent focus model hypothesis that contextual factors, including frame conditions, affect attention on possible outcomes and probabilities, and that attention, in turn, determines risk attitudes.

Empirical Hypotheses

The hypotheses of the contingent focus model, i.e., the focusing hypothesis and the contingent focus hypothesis, are supported by data from previous studies. Two experiments manipulated the size of letters describing outcomes and probabilities in decision problems under risk (Fujii & Takemura, 2000). Results were compatible with predictions; that is, the subjects more frequently selected risky options when outcomes were emphasized. The data from an experiment using an information board technique, which manipulated time to display possible outcomes and probabilities, also supported the hypothesis. Results indicated that participants accepted more risk as possible outcomes were displayed longer (Takemura, Hu & Fujii, 2001). We also applied the model to a psychometric meta-analysis of subjects' responses in 4 experiments of the Asian disease problem reported in Tversky & Kahaneman (1981), Takemura (1994b) and Fujii & Takemura (2000). The results reported in Fujii & Takemura (2001) were also compatible with predictions derived from the hypotheses; a ratio developed by calculating the weighting parameter of possible outcomes to probabilities under negative frame conditions was significantly greater than that under positive frame conditions.

While the two hypotheses of the contingent focus model are supported by experimental data, attention to possible outcomes and probabilities was not explicitly observed in previous studies.

In the present study, we used an eye gaze recorder to record the time that the participants gazed at words representing possible outcomes and probabilities in a decision problem involving risk. Based on the contingent focus hypothesis, it was predicted that the ratio of time to gaze at words representing possible outcomes to time to gaze at words representing probabilities would be greater under negative frame conditions than under positive frame conditions (Hypothesis 1). Based on the focusing hypothesis, we predicted that the ratio of time to gaze at possible outcome words to the time to gaze at probability words would be greater for risk-taking participants than for risk-averse participants (Hypothesis 2).

Method

Participants

Thirty-three undergraduate university students (25 men and 8 women) at the Tokyo Institute of Technology participated in the experiment in return for the equivalent of $xx. The mean age of the participants was 22.18 years (Sd = 1.97), within a range of 19 to 24 years. Subjects were randomly assigned to two conditions: the negative frame condition (n = 18) and the positive frame condition (n = 15)[1].

Materials

[1] There were 3 participants (out of 18 participants who were assigned to positive frame condition) whose eye movement data we fail to obtain by eye gaze recorder. Therefore, we eliminate these 3 participant for the analysis, and we report results from 15 participants for positive frame condition.

We adopted the Asian disease problem and reflection-effect problem used in Tversky and Kahneman’s (1981) original framing study. Eye gaze recorder equipment (NAC EMR-8) was used to test the present hypotheses. This equipment used the pupil-center/corneal reflection method, which has the same function as the eye-tracking equipment used in previous decision research (Lohse & Johnson, 1996; Boe, Selart, & Takemura, 2000; Selart, Boe, & Takemura, 2000).

Procedure

Each participant was individually invited to an experimental room and sat in a chair placed 2 meters in front of a screen on the wall. The screen was approximately 1.5 meters high and approximately 2 meters wide. After s/he sat in a chair, s/he put on a cap equipped with a small camera to detect movement of the right eye. An experimenter then calibrated the eye gaze recorder to detect the participant’s eye movement, a process that averaged two minutes. The eye movement was recorded in the video picture of the angular range of view that was simultaneously captured by another camera. After the calibration, the participant was instructed to say “yes” immediately after s/he understood the instructions displayed on the screen, and was also instructed to verbally answer the questions displayed on the screen immediately after making a decision.

“Which do you choose if you have to choose from 2 alternatives?” was then displayed on the screen. If s/he said “yes,” the experimenter changed the display.

The following two options were displayed for the participants assigned to the positive frame condition:

[A]
certainly gain 20,000 yen

[B]
a lottery with a 50 % chance to gain 40,000 yen and
a 50 % chance for no gain.

For the participants assigned to the negative frame condition, the following two options were displayed:

[A]
certainly lose 20,000 yen

[B]
a lottery with a 50 % chance to lose 40,000 yen and
a 50 % chance for no loss.

We labeled this the "reflection-effect problem", as it is a version of a decision problem that exhibits the reflection effect (Kahnemen & Tversky, 1979).

After s/he reported hers/his choice, the experimenter again changed the display so that instructions for the Asian disease problem (Tversky and Kahneman, 1981) were displayed. After the participant finished reading, s/he said "yes," and the experimenter changed the display to the following for the participants assigned to the positive frame condition:

[program A]
200 people will be saved.

[program B]
there is 1/3 probability that 600 people will be saved,
and 2/3 probability that no people will be saved.

For the participants assigned to the negative frame condition, the following was displayed:

[program A]
400 people will die.

[program B]
there is 1/3 probability that nobody will die,
and 2/3 probability that 600 people will die.

After s/he said "A" or "B," the experiment was concluded.

Results

Choice Data

As can be seen in Table 1, participants preferred a risk-taking option to a risk-averse option in the negative frame condition and preferred a risk-averse option to a risk-taking option in the positive frame condition for both the reflection-effect problem and the Asian disease problem. The results from the reflection-effect problem supported the reflection effect, and the results from the Asian disease problem supported the framing effect. A χ^2 test was significant for the reflection effect data (χ^2 [df = 1] = 3.91, $p < .05$), but did not reach significance for the framing effect data (χ^2 [df = 1] = 13, $p = .25$).

Table 1

Recoding of the eye fixation data

We created the ROF variable, Rate of Outcome Focusing, for each choice problem using data from the eye gaze recorder.

$$\text{ROF} = \text{T(outcome)} / [\text{T(outcome)} + \text{T(probability)}]$$

where T(outcome) is the total time to gaze at possible outcome words after the participant read sentences on the screen and T(probability) is the total time to gaze at probability words after the participant read sentences on the screen. The possible outcome words in the reflection-effect problem for both frame conditions were ”20,000 yen,” ”40,000 yen,” and “no.” The probability words in the problem for both frame conditions were “certainly” and “50%.” The possible outcome words in the Asian disease problem for the positive frame condition were “200 people,” “600 people,” and “no people;” those for the negative frame condition were “400 people,” “600 people,” and “nobody.” The probability words in the Asian disease problem for both frame conditions were “1/3” and “2/3.” Since the time required to acquire information using eye fixations varies between 200 ms to 400 ms (Russo, 1978; Card, Moran, &, Newell, 1983), we defined “gazing at a word” as gazing at the word for more than 200 ms. We defined the total time to gaze at a word as the sum of time to gaze at the word longer than 200 ms.

Hypothesis 1

Table 2 presents ROFs for each condition and each decision problem. Data from instances where eye movement data indicated that participants did not read sentences of each option to the end were eliminated from the following analyses. The ROF was larger under the negative frame condition than under the positive frame condition for both the reflection-effect problem and the Asian disease problem. The difference in ROF for the reflection-effect problem was significant (t [26] = 2.19 $p < .019$), and the difference for the Asian disease problem was marginally significant (t [22] =1.56 p =.067). These results support Hypothesis 1 that predicted, based on the contingent focus hypothesis, that decision makers attend more to possible outcomes under negative frame conditions than under positive frame conditions.

Table 2

Hypothesis 2

In order to test Hypothesis 2, which was derived from the focusing hypothesis, we compared ROF means from those who chose a risk-taking option with those who chose a risk-averse option. According to Hypothesis 2, the ROF for those who chose the risk-taking option would be greater than the ROF for those who chose the risk-averse option. Table 3 presents data that support this prediction. The mean ROF for risk-taking participants was greater than 50 % for both decision problems, but the mean ROF for risk-averse participants was less than 50 %. The difference in ROF between risk-taking participants and risk-averse participants was significant for the reflection-effect problem (t [26] = 3.02, $p <.005$), and was marginally significant for the Asian disease problem (t [22] = 1.57, p =.065).

Table 3

Mediational Analysis

We performed a set of binary logit analyses of the choice data. The results of the logit analyses for the reflection-effect problem are presented in Table 4, and those for the Asian disease problem are presented in Table 5. Frame condition had a significant effect on choice for the reflection-effect problem, if ROF was not included in the model (Table 4). The effect of a negative-frame dummy was significantly positive for the case without ROF, which implies that the probability that participants will select the risk-taking option is larger under negative frame conditions than under positive frame conditions, supporting the reflection effect. However, Table 4 also shows that the effect of frame condition disappeared if ROF was included as an explanatory variable, while the effect of ROF was significantly positive, which indicates that the probability of choosing the risk-taking option increases as ROF increases. Since we found that frame condition was related to ROF in the reflection-effect problem (Table 2), the logit analyses tell us that the effect of frame condition on choice in the reflection-effect problem (the reflection effect) was *indirectly* mediated by ROF.

Similar results were obtained for the Asian disease problem. Table 5 shows that the negative-frame dummy had a negative effect on the responses, suggesting that participants are more likely to select a risk-taking option under negative frame conditions than under positive frame conditions. Although this framing effect did not reach significance, the standardized coefficient for the framing effect and its t-statistics decrease when ROF was included as an explanatory variable. ROF had a marginally significant positive effect, compatible with our Hypothesis 2 derived from the focusing hypothesis. Since frame condition was related to ROF in the Asian disease problem (Table 3), the logit analyses imply that the effect of frame condition on choices in the Asian disease problem (the framing effect) was *indirect*ly mediated by ROF.

Discussion

The contingent focus model incorporates two basic hypotheses: the focusing hypothesis and the contingent focus hypothesis. The focusing hypothesis states that risk attitudes depend on the extent to which a subject focuses on possible outcomes and probabilities. The contingent focus hypothesis states that focusing on possible outcomes and probabilities, or attending to possible outcomes and probabilities, is contingent on decisional contexts. These hypotheses have been supported by experimental data and psychometric tests (Fujii & Takemura, 2000. 2001, 2003; Takemura, Hu, & Fujii, 2001). In the past, however, attention to possible outcomes and probabilities was not explicitly observed, so in the current study we used an eye gaze recorder to observe eye movement during decision making, which may be related to attention to possible outcomes and probabilities.

The choice data from the reflection-effect problem supported the reflection effect; that is, participants preferred a risk-taking option more strongly under negative frame conditions than under positive frame conditions. The choice data from the Asian disease problem indicated that more participants preferred a risk-taking option under negative frame conditions than under positive frame conditions, although the difference between frame conditions was not significant. The effect of frame condition on choice in the reflection-effect problem disappeared, and the effect of frame condition on choice in the Asian disease problem decreased when eye movement data were included as a covariate. These results imply that the effects of frame condition on choice, i.e., the framing effect and the reflection effect, may be mediated by attention.

In the current study, ROF (the ratio of total time to gaze at possible outcome words compared to the total time to gaze at possible outcome words and probability words) was used to analyze the eye movement data. For both the reflection-effect problem and the Asian disease problem, ROFs were larger under negative frame conditions than under positive frame conditions, and participants with higher ROFs were more likely to choose a risk-taking option than those with lower ROFs. The former result supports the contingent focus hypothesis and the latter supports the focusing hypothesis.

Results overall support the contingent focus model’s explanation of the reflection and framing effects; the decision maker attends to possible outcomes more strongly under negative frame conditions than under positive frame conditions, and those who attend strongly to possible outcomes are likely to prefer a risk-taking option. Decision makers thus prefer risk-taking options more strongly under negative frame conditions than under positive frame conditions.

It should be noted that although predicted effects for the reflection-effect problem achieved significance, predicted effects for the Asian disease problem did not. Lack of significance for the framing effect in the Asian disease problem is inconsistent with the original experiment by Tversky and Kahneman (1981); in this respect, the “elaboration effect” (Fujii & Takemura, 2003; Takemura, 1992, 1993, 1994b) may provide an explanation. The elaboration effect refers to the inhibition of the framing effect when decision makers are asked to elaborate their decision making process. Participants in the current experiment might have elaborated their decision making process in the Asian disease problem more than did participants in the original experiment by Tversky and Kahneman (1981) because those in the current study were requested to respond while alone in a experimental room. Although the framing effect was not significant for the Asian disease problem, both the effect of frame condition on eye movement and the effect of eye movement on decisions were marginally significant in the direction compatible with the predictions of the contingent focus model.

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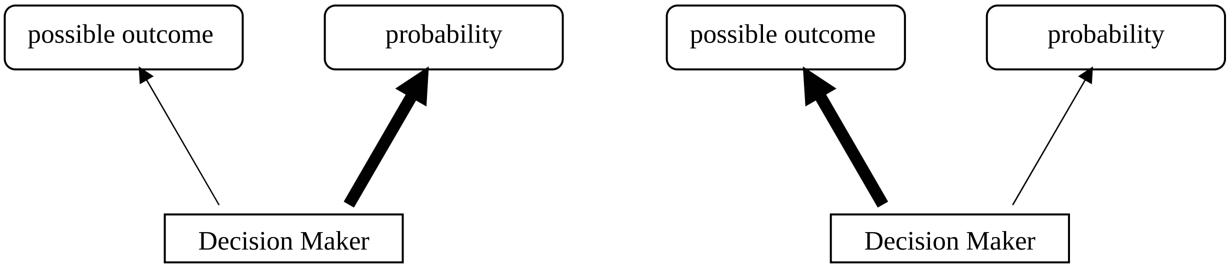

(under positive frame condition) (under negative frame condition)

Figure 1. Contingent focus model (Takemura, 1994a)

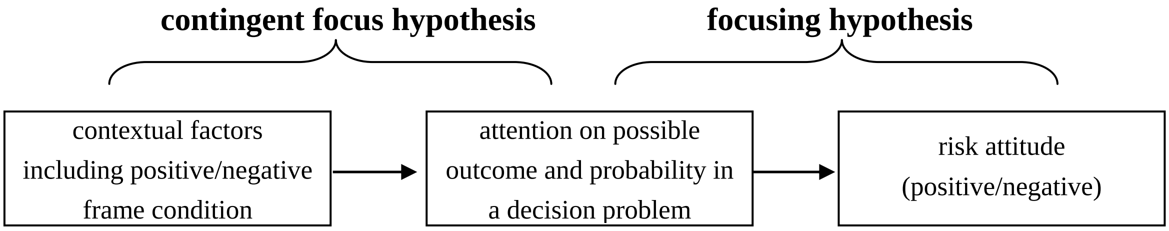

Figure 2. Two hypotheses within the contingent focus model: the contingent focus hypothesis and the focusing hypothesis.

Table 1. Distributions of participants' choices between the risk-taking and risk-averse options under negative and positive frame conditions.

	reflection-effect problem		Asian disease problem	
	negative frame condition (n = 18)	positive frame condition (n = 15)	negative frame condition (n = 18)	positive frame condition (n = 15)
risk-taking	11 (61.1%)	4 (26.7%)	12 (66.7%)	7 (46.7%)
risk-averse	7 (38.9%)	11 (73.3%)	6 (33.3%)	8 (53.3%)

Table 2. ROF (rate of outcome focusing) under negative and positive frame conditions.

	reflection-effect problem		Asian disease problem	
	negative frame condition (n = 15)	positive frame condition (n = 13)	negative frame condition (n = 12)	positive frame condition (n = 12)
M[†1]	65.0%	47.2%	59.0%	44.6%
SEM[†2]	(5.1%)	(6.5%)	(5.6%)	(7.4%)

[†1]mean

[†2]standard error of the mean

Table 3. ROF (rate of outcome focusing) of risk-taking participants and risk-averse participants.

	reflection-effect problem		Asian disease problem	
	risk-taking (n = 13)	risk-averse (n = 15)	risk-taking (n = 14)	risk-averse (n = 10)
M[†1]	69.1%	46.0%	58.0%	43.2%
SEM[†2]	(5.3%)	(5.4%)	(6.5%)	(6.5%)

[†1]mean

[†2]standard error of the mean

Table 4. Estimation of logit regression analysis of choice[†1] of the reflection-effect problem with and without ROF as an explanatory variable.

	without ROF			with ROF		
	β[†2]	t	*p*	β[††]	t	p
constant	-0.45	-0.93	.175	3.47	1.90	.028
negative-frame dummy[†3]	1.46	1.93	.027	-0.64	-0.71	.240
ROF				6.22	2.15	.016
sample size		33			28	
L (C)[†4]		-18.64			-5.15	
L (B)[†5]		-14.09			-3.14	

[†1] The dependent variable of the logit regression analysis = 1 if the risk-taking option was chosen, = 0 if the risk-averse option was chosen. Therefore, if an explanatory variable whose coefficient is positive increases, the probability of choosing the risk-taking option increases.
[†2] standardized coefficient.
[†3] = 1 if negative-frame condition, = 0 otherwise.
[†4] log-likelihood for the model only with constant.
[†5] log-likelihood for the model with constant and the other variables.

Table 5. Estimation of logit regression analysis of choice[†1] of the Asian disease problem with and without ROF as an explanatory variable.

	without ROF			with ROF		
	β[†2]	t	*p*	β	t	p
constant	-0.69	-1.39	.083	1.70	1.17	.120
negative-frame dummy[†3]	0.83	1.15	.125	0.51	0.54	.794
ROF				3.50	1.53	.063
sample size		33			24	
L (C)[†4]		-15.61			-3.90	
L (B)[†5]		-14.19			-3.22	

[†1] The dependent variable of the logit regression analysis = 1 if the risk-taking option was chosen, = 0 if the risk-averse option was chosen. Therefore, if an explanatory variable whose coefficient is positive increases, the probability of choosing the risk-taking option increases.

[†2] standardized coefficient.

[†3] = 1 if negative-frame condition, = 0 otherwise.

[†4] log-likelihood for the model with constant only.

[†5] log-likelihood for the model with constant and the other variables.