INTUITIVE RISK AVERSION AND REFLECTIVE RISK TAKING

IN GAIN-FRAMED ECONOMIC GAMES

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Intuitive Risk Aversion and Reflective Risk Taking
in Gain-Framed Economic Games

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ABSTRACT

We typically think of risk taking as impulsive, but evolutionary pressure may actually favor playing it safe as a default strategy. In the context of dual-process theory of reasoning (Evans, 2003), we hypothesized that risk aversion is intuitive for an average decision maker and reflective thinking serves to reduce this intuition. This idea was tested in two studies using economic decision-making tasks. Information processing style was manipulated by forcing fast or slow decisions (Study 1) and by picture priming (Study 2). These manipulations did not affect decisions. We also measured participants' cognitive reflection ability as an individual difference variable in both studies. As expected, greater reflection ability predicted a greater frequency of risky choices (Study 1 and 2). The findings are consistent with the perspective that risk aversion is impulsive while risk taking is reflective, at least under certain conditions.

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INTRODUCTION

We live in a world full of risks where chosen activities may lead to undesirable outcomes, yet we often have to face choices involving risks. One common decision in everyday life is the choice between a risky option and a riskless option (Kahneman & Tversky, 1984). Should we put money in the bank where the gain (i.e., interest) is guaranteed but relatively meager? Or should we invest in the stock market where the profit could be fairly attractive but under the potential risk of total loss? Should we buy flood insurance that covers a huge loss (although the probability of the loss is low) or should we count on our luck? These are important choices faced by virtually everyone and the decisions could have significant consequences.

Prospect Theory and Risk Aversion

To date, Kahneman and Tversky's (1979) prospect theory provides one of the most recognized descriptive models of human decision making under risk. According to the prospect theory, the subjective value of an outcome is a nonlinear function of the objective value of that outcome. This function is concave in the domain of gains and convex in the domain of losses (See Figure 1). The "S" shape of the function leads to one important prediction: decision makers are generally risk averse in the domain of gains and risk seeking in the domain of losses (termed the *reflection effect*). In the current studies, we are interested in decisions that involve risk in the domain of gains. Consider the following two options: A. A sure gain of $500; B. A 50% chance of gaining $1000 and a 50% chance of gaining nothing. Because the subjective (though not objective) value of $1000 is less than two times that of the subjective value of $500, half the chance to gain $1000 is less attractive than a sure gain of $500 (see Figure 1). Numerous studies have confirmed that people are generally risk-averse when it comes to gains (e.g., Kahneman & Tversky, 1979; Stanton et al., 2011).

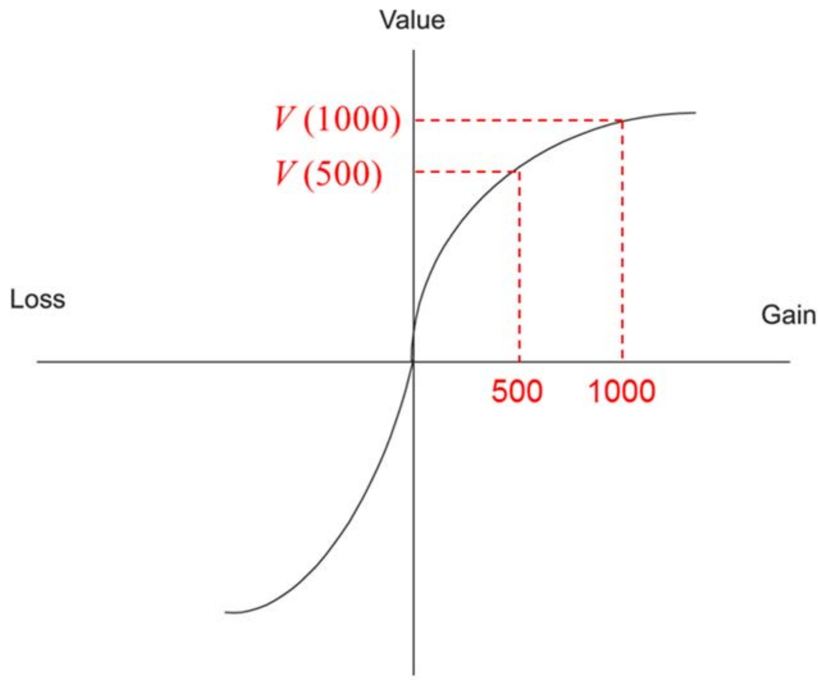

Figure 1. The Value Function of Prospect Theory.

The Cognitive Mechanism Underlying Risk Aversion

The prospect theory describes the way people make choices under risk, and predicts that people are generally risk averse in gain-framed choices (Kahneman & Tversky, 1979). However, it does not explain the mechanism underlying this phenomenon. In two studies presented here, we adopt the dual-process account of reasoning (Evans, 2003; 2008) to explore the cognitive basis of risk aversion. The dual-process theory posits that there are two distinct cognitive systems underlying thinking and reasoning. System 1 is in charge of intuitive thinking and instinct behaviors. It is generally automatic, heuristic, independent of cognitive capacity, and thus operates relatively quickly. System 1 is considered to be old in evolutionary terms, and is prominent in both animals and humans. System 2, on the other hand, is in charge of reflective thinking and reasoned behaviors. It is generally controlled, rule-based, dependent of cognitive capacity, and thus operates relatively slowly. System 2 is considered to have appeared more recently in evolutionary history than System 1, and it appears to be unique to humans (Evans, 2008).

Viewing decision making processes under risk from this dual-process perspective raises the following questions: Are we intuitively risk seekers, who reject our impulses only after reflection? Or are we intuitively risk averse, and are willing to take risks only after reflection? In other words, is risk aversion mainly the product of System 1 or System 2? Data that are relevant to this question appear contradictory.

In support of the idea that risk seeking is intuitive and risk aversion is reflective, impulsivity, an important attribute of System 1 (Strack & Deutsch, 2004), has been found to be closely linked to risk taking at a genetic level (Kreek, Nielson, Butelman, & LaForge, 2005). In line with this finding, self-report measures of impulsivity predict a wide range of risk taking behaviors, both in lab tasks (Lejuez et al., 2002) and in daily life (Zuckerman & Kuhlman, 2000). Also, pathological gamblers are found to be more impulsive than the average person (Leeman & Potenza, 2012), and positive feelings towards risky actions are a strong predictor of impulsivity (Whiteside & Lynam, 2001). From another angle, within iterated trials in an experimental learning paradigm, decision-makers tend to be largely risk-neutral early in the task, but quickly lean towards less risky options as trials progress when possible outcomes are positive; such results suggest that risk aversion can be learned (March, 1996). It is reasonable to speculate that decision-makers in such paradigms start with more intuitive decisions (risk neutral in this case), and later adjust their choices towards more cautious, rational decisions (i.e., risk aversion), in part on the basis of learning history with the paradigm.

Although the evidence in favor of the first hypothesis seems strong, we argue that the opposite hypothesis (i.e., risk aversion is intuitive and risk taking is reflective) is still tenable for many reasons. It is well known that the need for safety plays a big role in early attachment (Bretherton, 1992; Harlow, 1958), and that attachment emerged as a result of the evolutionary pressure (Cassidy, 1999). Therefore, inherent risk aversion might be crucial to motivate infants to stay close to their caregivers and this tendency is likely to be evolutionarily adaptive. Consistent with this reasoning, mathematical simulations of evolutionary processes suggest that risk aversion appears to be “an evolutionary-developed heuristic aimed to maximize the probability of having descendants forever” (Levy, 2012). Given the importance of risk aversion in passing on genes, it is likely to be evolutionarily inveterate and preprogramed in our minds, which is consistent with the description of System 1. Indeed, risk aversion is found in other animals. Non-human primates demonstrate risk aversion when outcomes are presented as gains in a manner similar to humans (Lakshminarayanan, Chen, & Santos, 2011). As an example from even more primitive species, white-crowned sparrows usually prefer a constant food reward to a variable food reward with an equal average expected value (Caraco, 1982). These findings provide evidence for the idea that risk aversion may be evolutionarily old and shared with other animals, thus suggesting a likelihood of governance by System 1.

From another perspective, the outcome of the risky alternative is generally not as straightforward as the safe alternative and thus requires a greater amount of controlled cognitive processing to solve/understand in terms of its eventual outcome (Whitney, Rinehart, & Hinson, 2008). It is possible that a risky alternative is often avoided because decision-makers only seek to find an acceptable (as opposed to optimal) choice with minimum cognitive effort in most situations, an efficient heuristic hard-coded by evolutionary processes (Shah & Oppenheimer, 2008). Following this line of thinking, a greater depth of processing should generally favor risk taking relative to a lesser depth of processing.

In summary, there seems to be ample evidence for both hypotheses. Because evolutionary recency is the most fundamental distinction between the two reasoning systems (Evans, 2008), we view the second hypothesis as more plausible. Thus, in two studies, we tested the hypothesis that risk aversion is intuitive (System 1) and that reflective thinking (System 2) is needed to overcome/suppress such intuitions.

In two pilot studies previously conducted in our lab, we focused on the fast/slow dimension of the System 1 versus 2 distinction, and found that more time spent on processing alternatives predicted lower levels of risk aversion – that is, more time thinking about a problem systematically predicted more risky choices. In more particular terms, participants in our first pilot study were given Kahneman and Tversky's (1984) original problem, which involves choosing between a sure gain of $240 and a 25% chance to gain $1000. The time taken to reach a decision was registered along with the actual decision. We found that participants who spent more time before making the choice were more likely to choose the risky option than participants who spent less time. In our second pilot study, participants made similar choices between a sure gain and a probabilistic gain for 96 trials. We found that for an average participant, his/her slower choices were more likely to be risky than his/her faster choices.

In two studies presented here, we aimed to strengthen the above correlational findings, and also extend them by examining the potential *causal* relationship between reflective thinking and decision-making under risk. In Study 1, participants were asked to make a choice between a sure gain and a probabilistic gain for multiple trials. Half of the participants were forced to respond quickly within 2 seconds, while the other half were given 5 seconds to deliberate. If reflective thinking reduces risk aversion, the manipulation of the time available to make a decision should have an impact on the choice made, such that under time pressure people should be more risk averse, while given enough time people should be less so. In addition, we measured participants' reflective thinking ability using short questions and hypothesized that higher reflective thinking ability would predict lower risk aversion, independent of the experimental manipulation.

Although fast versus slow is an important indicator of the operation of System 1 and System 2, respectively, more time spent in reaching a decision does not guarantee deeper processing. It is possible that slower responses instead reflect diminished cognitive ability or distraction from the task. Therefore, Study 2 aimed to directly manipulate reflective thinking style. Before making a choice on each trial, participants were briefly exposed to either a picture that primes reflective thinking style or to a control picture that does not. It was hypothesized that the reflective thinking priming would lead to reduced risk aversion compared to the control priming condition. In addition, we included two different measures of reflective thinking ability and hypothesized that higher reflective thinking ability would predict lower risk aversion.

Study 1 aimed to test the hypothesis that when forced to make a quick choice between a safe option and a risky option, people would be more likely to choose the safe option (i.e., they would be more risk averse) than when given enough time to evaluate the options. Additionally, we predicted that higher reflective thinking ability, as measured by 3 short problems (Frederick, 2005), would be associated with lower risk aversion.

Method

Participants

Eighty-two participants (39 female) were recruited from North Dakota State University via the web-based SONA research platform. Participants came into the lab in groups of 6 or less and were each assigned to a private cubicle space. All tasks were completed on desktop computers.

Choice Problems

The structure of the choice problems was similar to those originally developed by Kahneman and Tversky (1984). Participants were asked to choose between a safe option that pays them a certain amount of money and a risky option that might pay them more money than the safe option, but also might pay them nothing. Previous studies of this choice type typically used plain text to display the options (e.g., Kahneman & Tversky, 1984; Whitney et al., 2008). However, people vary in their reading speed (Jackson & McClelland, 1979). Because Study 1 involves a manipulation of decision time, differences in reading speed would add unwanted noise variance to the data. In order to minimize the demand for reading, we created graphic illustrations to display the options (Stanton et al., 2011). Safe options were presented as solid circles, while risky options were presented as pie charts, with the proportion of green sectors indicating the probability of winning the money. Relevant numbers were printed at the appropriate locations inside the circles (see Figure 2 for an example).

Figure 2. Sample Stimuli from Study 1.

Three numeric parameters were manipulated and varied across trials. The first variable was the amount of sure gain in the safe option. There were 6 possible values: $100, $200, $300, $400, $500, and $600. The second variable was the chance of winning in the risky option. There were 3 possible values: 25%, 50%, and 75%. Accordingly, the values of the chance of not winning were 75%, 50%, and 25%, respectively. Finally, the third variable was the amount of gain in the risky option if the person happened to win that trial. This value was not directly manipulated but rather calculated from ratios of the expected value of the risky option (EV_R) to the value of the safe option (V_S), in the following manner:

$$\because \text{Ratio} = \frac{EV_R}{V_S} = \frac{RiskyGain \times Chance}{SureGain}$$

$$\therefore \text{RiskyGain} = \frac{Ratio \times SureGain}{Chance}$$

The included EV_R/V_S ratios were 1.0, 1.5, and 2.0. Note that as this ratio increased, the risky option should become increasingly appealing compared to the safe option. Accordingly, the percentage of risky choices should increase as the ratio increases. For such reasons, ratio was treated as a factor of interest in data analysis. Three different ratios along with 6 different sure gains and 3 different chances of winning yielded 54 unique choice problems.

Reflective Thinking Ability Measure

Reflective thinking ability was measured using the Cognitive Reflection Test (CRT) by Frederick (2005), which contains three problems (Table 1).

Table 1

The Cognitive Reflection Test (Frederick, 2005)

CRT Questions	**Intuitive answer**	**Reflective answer**
A bat and a ball cost $1.10 in total. The bat costs $1.00 more than the ball. How much does the ball cost? _____ cents	10	5
If it takes 5 machines 5 minutes to make 5 widgets, how long would it take 100 machines to make 100 widgets? _____ minutes	100	5
In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half of the lake? _____ days	24	47

These three problems have been designed such that a quick answer is typically generated rather automatically upon reading. However, such intuitive reactions are inaccurate and reflective thinking is needed to suppress them. For example, the first problem reads: A bat and a ball cost $1.10 in total. The bat costs $1.00 more than the ball. How much does the ball cost? An intuitive answer that comes to mind quickly is “10 cents”. However, anyone who reflects upon it for a few seconds would realize that if the ball costs 10 cents, the bat costs $1, and thus the bat costs 90 cents more than the ball, not $1 more. Hence the intuitive answer is wrong. Once people overcome this intuitively inaccurate answer, figuring out the right answer (which is 5 cents in this example) is relatively easy. Actually, in the present study, nearly everyone who did not respond “10 cents” gave the correct response, which was consistent with findings from previous research (Frederick, 2005). Response to each problem was coded as 0 = incorrect and 1 = correct and then summed. A higher total score thus indicates higher reflective thinking ability. Previous research has shown that this task indeed predicted judgments and behaviors related to reflective thinking (e.g., Gervais & Norenzayan, 2012).

The three CRT questions appeared to be rather difficult for our participants. With an average score of only 0.41, 58 of the 82 participants scored 0. Or, in other words, only 24 participants got at least one correct answer out of the 3 questions (of these 24 participants, 14 scored 1, 8 scored 2, and only 2 scored 3). Considering the apparently skewed distribution and inadequate variation for the CRT score, it would not be very useful to treat it as a continuous predictor. Accordingly, in our analyses the CRT score was recoded in a dichotomous manner such that 0 was given if the person made no correct answers (n = 58) and 1 was given if the person made at least one correct answer (n = 24).

Procedures

Upon entering the lab, participants were told that this study was about “Writing and Judgment” (there was an 8-minute guided writing section conducted before this study, which was conducted for another purpose not relevant to the current study). After signing an informed consent form, participants were instructed to enter one of six private cubicles with a computer. The choice problem was the second program of the 1-hour session (after the guided writing).

Once the E-Prime program started, participants were first introduced to the pie chart illustration method of the safe and risky options. They read: “In this part of the study, you are going to play some economic games. First let’s get familiar with some of the symbols used in this game. Please press SPACE bar to continue...” Eight examples were shown serially with their corresponding meanings shown in text below them. Participants were given as much time as they needed to examine each example, and were asked to press the SPACE bar to continue to the next example once they fully understood the meaning of the pie chart. On average, participants viewed each example for 4.4 seconds. After the presentation of 8 examples, 3 test questions were given in which participants were asked to indicate what each chart meant by choosing one of 4 alternative answers below it. No error feedback was given for these test questions. None of the examples used in the training or test trials were used in the following actual experiment. On average, these 3 test questions only took about 25 seconds to finish. After the training and the test, instructions of the formal experiment appeared and read as follows:

> Imagine that you face the following pairs of concurrent decisions. First examine both options, and then indicate the option YOU PREFER. If you prefer the left option, press “Q” on the keyboard. If you prefer the right option, press “P” on the keyboard. You will have some time to think, and then you will hear a beep. PLEASE RESPOND IMMEDIATELY AFTER YOU HEAR THE BEEP AND DO NOT RESPOND BEFORE YOU HEAR THE BEEP. Make sure you are wearing the black headphone. Press “Q” or “P” to continue … In the next part, you will have 2 (5) seconds to examine the options before you hear the beep. Remember: 1) Make a choice by press “Q” or “P” immediately after you hear the beep; 2) Do not respond before you hear the beep; 3) Put your left index finger on “Q” and right index finger on “P”. Press “Q” or “P” to start…

Participants then finished 9 practice trials followed by 54 experimental trials, one trial for each combination of varied trial parameters. At the beginning of a trial, one safe option and one risky option were displayed on a black background, one on the left and one on the right. On half of the trials, the risky option was displayed on the left side and on the other half the risky option was on the right. Participants then examined both options. After a certain amount of time (depending on condition; see below), participants heard a beep from the headphones, which served as a response prompt. Participants were required to make their decisions by pressing “Q” if left option was preferred, or by pressing “P” if right option was preferred, immediately after hearing the beep. If no response was detected within 1.5 second after the beep, a feedback slide displaying “TOO SLOW!” was shown for 1 second. On the other hand, if any response was detected before the onset of the beep, a feedback slide displaying “TOO FAST! PLEASE WAIT FOR THE BEEP!” was shown for 1 second, in which case the response on that trial was dropped. The trial display was terminated after a response or after feedback was given. A one-second blank interval was displayed before the onset of the next trial.

Participants were randomly assigned to one of two conditions based on the time available to make a response, which was manipulated through the onset time of the beep. In the 2-second condition, the beep was played 2 seconds after the onset of the trial display. In the 5-second condition, the beep was played 5 seconds after the onset of the display. Since participants were required to respond immediately after hearing the beep in both conditions, participants in the 2 seconds condition only had 2 seconds to think about the problem, while participants in the 5 seconds condition had 5 seconds. We chose 2s and 5s because in our previous study where participants responded with no time pressure, the average decision time was about 3.5 seconds.

Thus, 2 seconds is insufficient for an average decision maker to fully process the options, while 5 seconds is more than sufficient. Participants' choice on each trial was registered.

After the decision-making task, participants finished the Cognitive Reflection Test by typing in an answer for each problem. Upon finishing all tasks, participants were fully debriefed and thanked.

Results

Prior to analyzing the data, we examined participants' response accuracy for the 3 questions that tested their understandings of the pie chart display. Because our pilot tests indicated that the logic of the pie charts was easy to understand and because our design requires participants to correctly decode the pie charts quickly, participants who gave incorrect answers on any of the 3 questions were excluded from analyses. Data from 4 participants were excluded based on this criterion.

Next, participants' response rates were examined. Recall that if participants failed to respond within 1.5 seconds after the beep or if they responded before the beep, no response was registered for that trial. On a priori basis, we decided to delete participants who had 10 or more missing trials, which actually ended up excluding nobody. Thus, 78 participants (39 female; M_{age} = 19.9; 82% Caucasian) were included in the following analyses.

Although the expected value of the risky option was identical to (Raito = 1) or larger than (Raito = 1.5 or 2) the value of the safe option, participants were in general risk averse (percentage of risky choices: M = 43.2%, one sample t-test against 50%: t (77) = -2.86, $p < .01$).

We hypothesized that decisions under time pressure would be more risk averse than decisions under no pressure. Considering that Ratio was also likely to have an impact on the choice, a 2 (Time Condition: 2s vs. 5s) × 3 (Ratio: 1.0, 1.5, 2) mixed-model ANOVA was conducted on the percentage of risky choices, with Time Condition as a between-subjects variable and Ratio as a within-subject variable. There was no main effect for Time Condition, F (1, 76) = 0.07, p = .80, unfortunately, nor was there an interaction between Time Condition and Ratio, F (2, 152) = 0.03, p = .97. Despite the care with which the manipulation was constructed, it simply failed to influence participants' decisions. Thus, our main hypothesis was not supported.

The main effect for Ratio was highly significant, F (2, 152) = 167.74, p < .001. Participants chose risky options more often as the expected payoffs of those options increased in comparison to the safe options. When the Ratio was 1, the expected value of the risky option was identical to the value of the safe option. Even so, participants were largely risk averse under this ratio (percentage of risky choices: M = 22.0%, one sample t-test against 50%: t (77) = -11.97, p < .001), replicating classical findings inspired by prospect theory (Kahneman & Tversky, 1979). When the Ratio was 1.5, the expected value of the risky option was 1.5 times the value of the safe option. Under such conditions, neither risk aversion nor risk seeking was evident (M = 48.9%, t (77) = -0.42, p = .67). When the Ratio was 2, the expected value of the risky option was twice the value of the safe option. Participants generally preferred the risky option to the safe option under this ratio (M = 56.6%, t (77) = 2.52, p = .014).

Next, we examined whether reflective thinking ability, as measured by CRT, would predict a preference for risky options. If so, this would represent support for the primary hypothesis from an individual differences perspective.

Recall that CRT was scored dichotomously given the skewed distribution of the number of correct answers. Replacing Time Condition, which was supposed to be a manipulation of reflective thinking, with this CRT grouping variable, we ran a CRT group × Ratio mixed-model

ANOVA. The main effect for Ratio was still highly significant, F (2, 152) = 147.63, $p < .001$. Of greater importance, the main effect for CRT group was significant, F (1, 76) = 5.42, $p = .02$, such that participants who were higher in reflective ability chose risky options more often than those who were lower in reflective ability (see Figure 3). The interaction between CRT group and Ratio was not significant, F (2, 152) = 1.47, $p = .23$, although there was a trend that the effect of CRT group became more pronounced as Ratio increased (see Figure 3 for this small trend).

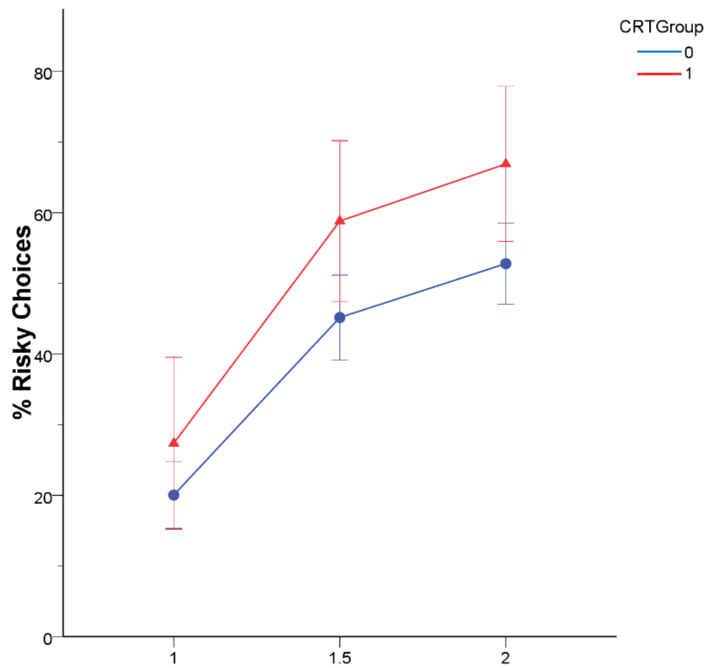

Figure 3. Risky Choices as a Function of CRT Group and Ratio, Study 1.

Discussion

We hypothesized that when facing choices between a sure gain and a risky gain, people would make more risky choices if given more time to think. To test this hypothesis, the time available for decision making was manipulated in Study 1. Although this original hypothesis was not supported, the analysis including individual differences in reflective thinking ability, as measured by the 3-item cognitive reflection test, yielded findings in line with the original hypothesis: Participants high in reflective thinking ability were on average more willing to gamble (i.e., they were less risk averse) in economic games than those low in reflective thinking ability. This result is consistent with our hypothesis that risk aversion is intuitive, such that it may only be overcome to the extent that reflective thinking occurs (here, as a function of abilities to do so).

STUDY 2

Study 1 aimed to show that reflective thinking reduces risk aversion through the manipulation of decision time, with the underlying assumption that the more time one spends on making a decision, the more thought one gives to the problem. Study 2 was designed to directly test the causal relationship between reflective thinking and reduced risk aversion. In Study 2, we used visual cues to elicit reflective thinking and hypothesized that these cues would lead to enhanced reflective thinking and thus reduced risk aversion in choice problems similar to those administered in Study 1. As the individual difference approach was proven promising in Study 1, we retained and extended the measures of reflective thinking ability in Study 2. In addition to CRT, which is an objective test, we also included a self-report measure: the Rational Ability (RA) scale of the revised Rational-Experiential Inventory (REI-40; Pacini & Epstein, 1999).

Method

Participants and General Procedures

A new sample of 142 participants (59 female) was recruited in the same fashion as Study 1. The general procedures were similar to Study 1. Participants first finished a multi-trial choice task (described in detail below), and then completed two cognitive reflection measures, namely the REI-40 and the CRT. Upon finishing all tasks, participants were fully debriefed.

Choice Task

We created a new paradigm for the purpose of this study. As in Study 1, participants were asked to choose between a sure gain and a gamble through multiple trials. All parameters were identical to those in Study 1. Unlike Study 1, the problems were presented in a card game with explicit feedback of outcomes provided to the participants. At the beginning of this task, participants read the following instructions:

Next you will play a card game. You will see two cards placed face-down on the screen, with a money reward associated with each card written below it. Examine the offers provided by both cards very carefully, and then choose the one you prefer. If you prefer the card on the left, press “Q” on the keyboard. If you prefer the card on the right, press “P” on the keyboard. Your goal is to gain more money on each trial so that you will gain more money in total. Please place you left index finger on “Q” and right index finger on “P”. Press “Q” or “P” to start…

As shown in Figure 4, each trial started with two cards displayed face down on the screen (i.e., the participant saw the back of the cards). Each card represented an option.

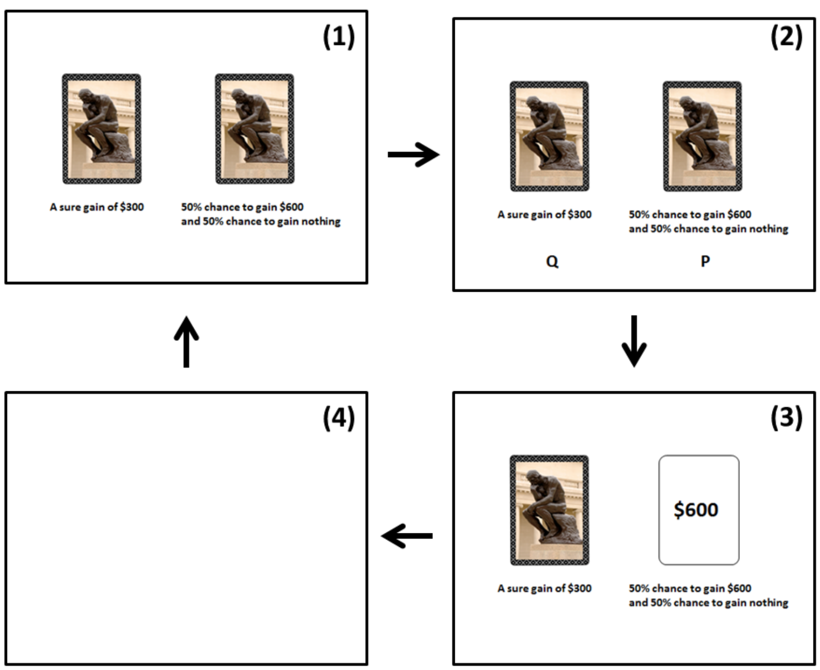

Figure 4. Trial Procedures in Study 2.

For example, in Figure 4, the card on the left represented the safe option (in this case, a sure gain of $300), which we name the *safe card.* The card on the right represented the risky option (in this case, a 50% chance to gain $600 and a 50% chance of gaining nothing), which we name the *risky card*. The relative locations of the safe card and the risky card were randomized across trials. Participants were asked to examine the offers of the two cards and choose the one they preferred by pressing the relevant key (“Q” for the left card, “P” for the right card). Once a key press was detected, the chosen card would be turned over (i.e., it would be flipped face-up), revealing the actual outcome. The outcome of the risky card was programmed in exact accordance with the stated probabilities. For example, if a participant chose the risky card as shown in Figure 4, there was a 50% chance that it would read $600 and a 50% chance that it would read $0. The feedback stayed on the screen for 1 second, followed by a blank interval of 1 second before the onset of the next trial.

The critical manipulation of this study was the back design of the cards, present at the beginning of the trial, which randomly varied across trials. On half of the trials, the back design was a photo of Rodin’s *The Thinker*. On the other half, it was a photo of *Discobolus* (Figure 5). Previous research found that this pair of priming stimuli significantly influenced performance on a syllogistic reasoning task that measures analytic tendencies; in more specific terms, exposure to the *The Thinker* image led to better performance than exposure to the *Discobolus* image (Gervais & Norenzayan, 2012).

Figure 5. Back Designs of Cards in Study 2.

Each of the 54 choice problems (see Method section of Study 1) was presented twice, once with *The Thinker* back design and once with *Discobolus* back design, constituting 108 experimental trials in total. Participants' choices were registered along with their decision times (i.e., the amount of time between the onset of the trial display and a key press).

Reflective Thinking Ability Measures

As mentioned above, we included two measures of reflective thinking ability – the Rational Ability scale of REI-40 and the CRT measure of Study 1.

REI-40 is a revised version of the original 59-item Rational-Experiential Inventory (REI), which was designed to measure rational and experiential thinking styles (Epstein, Pacini, Denes-Raj, & Heier, 1996). The REI-40 was considered an improvement over the original REI in that the scales are balanced in the number of items per scale (10 items) and in the number of positively and negatively worded items, with correspondingly higher reliabilities (Pacini & Epstein, 1999). The instrument has proven to be a useful, valid tool for measuring individual differences in processing styles (e.g., Bjorklund & Backstrom, 2008; Gunnell & Ceci 2010). In the current study, we assessed reflective thinking ability using the Rational Ability (RA) scale of the REI-40. It asks people to rate the extent to which each of 10 descriptions (e.g., "I have a logical mind.") fit them on a 5-point scale (1 = *definitely not true of myself*; 5 = *definitely true of myself*). The measure was reliable in the present study (M = 3.62; alpha = .83).

The CRT was conducted in the same manner as in Study 1. Again, because more than half of the participants scored 0 and the distribution was skewed (M = 0.62 and 58% participants scored 0), we treated the CRT as a dichotomous variable (0 = no correct answer; 1 = at least one correct answer), as in Study 1.

Results

Prior to analyzing the data, we examined participants' response latencies on the choice task. Unduly fast responses on too many trials are an indicator of not taking the task seriously. We set a criterion beforehand that participants with response latencies of less than 1 second (which is faster than these sorts of choices are typically made) on more than half of all trials would be deleted. Data from 6 participants were excluded according to this criterion. Thus, 136 participants (56 female; $M_{\text{age}} = 19.4$; 86% Caucasian) were included in the following analyses.

We expected that decisions following the reflective priming (i.e., *The Thinker*) would be less risk averse than decisions following the control picture (i.e., *Discobolus*). To test this hypothesis, a 2 (Prime Type: *The Thinker* vs. *Discobolus*) × 3 (Ratio: 1.0, 1.5, 2) repeated measures ANOVA was conducted on the percentage of risky choices. There was no main effect for Prime Type, F (1, 135) = 2.15, $p = .15$, unfortunately. There was also no interaction between Prime Type and Ratio, F (2, 270) = 0.38, $p = .68$. The priming stimuli did not seem to produce any effects on risky choices. Thus, our main hypothesis was not supported.

The main effect for Ratio was highly significant, F (2, 270) = 209.52, $p < .001$. Participants chose risky options more often as their expected payoffs increased comparing to the safe options. When the Ratio was 1, participants were risk averse (percentage of risky choices: M = 35.6%, one sample t-test against 50%: t (135) = -8.21, $p < .001$). When the Ratio was 1.5 or 2, participants generally preferred the risky option to the safe option (at Ratio = 1.5: M = 55.5%, t (135) = 2.83, $p < .01$; at Ratio = 2: M = 61.5%, t (135) = 5.85, $p < .001$).

We then examined the effects of individual differences in reflective thinking ability on risky choices. It was hypothesized that people with higher reflective thinking ability would be less risk averse (i.e., they would choose the risky option more frequently), especially at higher ratios. We first tested this hypothesis using the CRT grouping variable in the same manner as Study 1. A CRT group × Ratio mixed-model ANOVA revealed a main effect for Ratio, F (2, 268) = 218.81, $p < .001$, whose nature is similar to that described above. The main effect for CRT group was not significant, F (1, 134) = 2.01, $p = .16$. However, the interaction between the two variables was significant, F (2, 268) = 4.31, $p = .014$. As shown in Figure 6, participants who gave at least one correct answer on the CRT ($n = 57$) tended to choose the risky option more frequently than participants who gave no correct answer ($n = 79$), but only when the risky option had a higher expected payoff than the safe option (i.e., Ratio = 1.5 or 2). Follow-up analyses confirmed this interpretation of the pattern of findings. The percentage of risky choices for the two groups did not differ when the Ratio = 1, t (134) = 0.13, $p = .90$. However, the group differences approached significance when the Ratio = 1.5, t (134) = 1.73, $p = .085$, and when the Ratio = 2, t (134) = 1.93, $p = .056$.

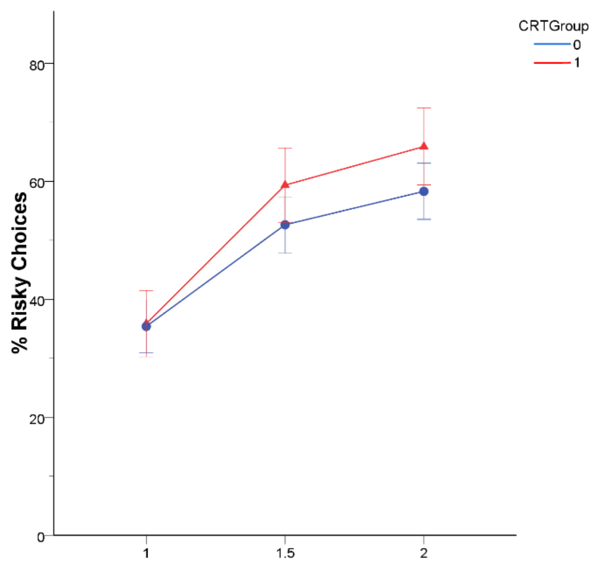

Figure 6. Risky Choices as a Function of CRT Group and Ratio, Study 2.

In addition to the CRT, reflective thinking ability was also assessed with the self-report Rational Ability (RA) scale. To test the individual difference hypothesis with this measure, we conducted a GLM with RA as continuous, z-scored between-subjects variable and Ratio as a within-subject variable. There was a main effect for Ratio, F (2, 268) = 216.16, $p < .001$. The main effect for RA was not significant, F (1, 134) = 1.27, $p = .26$. However, the interaction between the two variables was significant, F (2, 268) = 7.42, $p < .01$. As can be seen from the estimated means shown in Figure 7, the pattern of this result highly resembles that found in relation to the CRT.

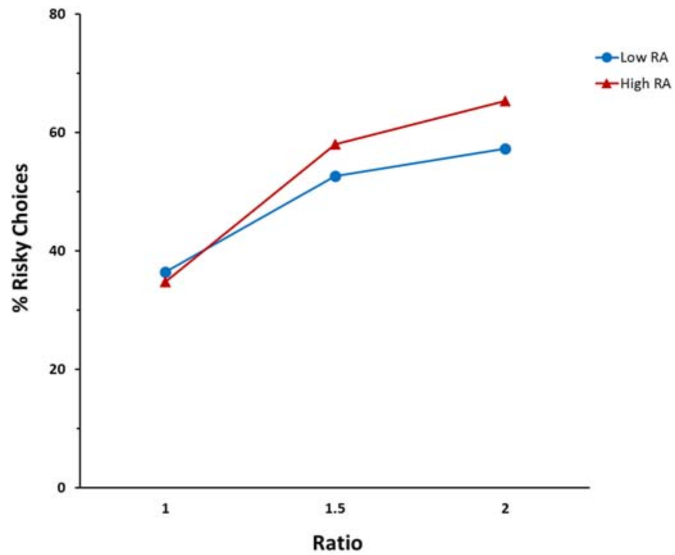

Figure 7. Risky Choices as a Function of RA and Ratio, Study 2.

As we mentioned in the Method section, participants' decision time on each trial was registered. Because intuitive responses can be generated relatively fast, while reflective responses require additional time for deliberation (Rand, Greene, & Nowak, 2012), individual differences in average decision time could be used as another index for measuring information processing style (i.e., fast = intuitive; slow = reflective) alongside CRT and RA. Prior to this analysis, the decision time data was handled using the procedures recommended by Robinson (2007), which involve log-transforming decision time distributions and then replacing outliers </> 2.5 *SD*s from the mean (2.1% of all trials) with the cutoff scores. After such transformations, we averaged decision time across trials as an individual difference. Next, we conducted a GLM similar to those above, with Decision Time as a z-scored continuous predictor and Ratio as a within-subject predictor. We again found a main effect for Ratio, F (2, 268) = 279.02, $p < .001$. There was also a Ratio by Decision Time interaction, F (2, 268) = 45.78, $p < .001$. In addition, a main effect for Decision Time reached significance, F (1, 134) = 5.58, $p = .02$, such that slower average decision time predicted more risky choices overall. The interaction was such that this influence of decision time was more pronounced as ratio increased (see Figure 8), interactive results conceptually similar to those occurring with CRT and RA.

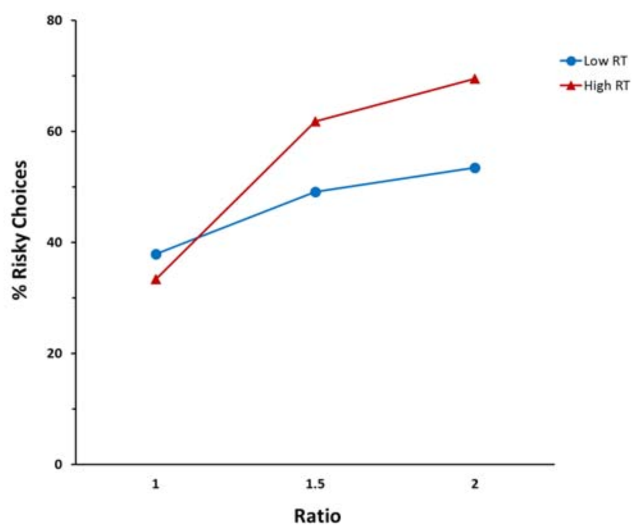

Figure 8. Risky Choices as a Function of Average Decision Time and Ratio, Study 2.

Discussion

Our attempt to manipulate intuitive vs. reflective thinking style once again failed. However, individual difference measures again provided useful information. Individual differences in reflective thinking ability as measured by the CRT and RA scales, or information processing style as measured by average decision time on the choice task, all converged on the following conclusion: Compared to participants with relatively intuitive thinking styles, those with relatively reflective thinking styles were more willing to take risks in the choice task, mainly when doing so is probabilistically favored (i.e., Ratio = 1.5 or 2).

One might argue that longer decision time could indicate impaired cognitive ability instead of reflection, as is true for many reaction time tasks (Deary, Der, & Ford, 2001). Should this be the case, more risky choices for the slower participants might reflect lower intelligence. However, this cannot be the case because these results were in parallel to those involving the CRT and RA scales, for which higher scores necessarily capture higher levels of reflective thinking or insight. Moreover, participants' average decision time positively correlated with their CRT and RA scores (See Table 2), indicating that decision time in the present task was indeed a measure of cognitive reflection rather than mental agility.

Table 2

Correlations between CRT, RA, and Average Decision Time, Study 2

Measure	1	2	3
1. CRT	—		
2. RA	.24**	—	
3. Decision time	.15†	.26**	—

Note: CRT = Cognitive Reflection Test. RA = Rational Ability scale. Decision time is log-transformed.
** $p < .01$. $^{\dagger}p < .10$.

GENERAL DISCUSSION

A risk-averse predisposition should be beneficial in allowing animals to survive to pass on their genes. Under ambiguous situations, it is better to stay hungry for a few days than to go out hunting in the context of a known predator presence. Thus, it stands to reason that natural selection has hardwired the brain to respond to any potential risk with a fixed rule – avoid it unless you know it is safe. This would be a useful heuristic because it provides efficient, satisfying decisions under most circumstances without excessive cognitive demand. In two studies presented here, we pursued this logic in the context of decision making under uncertainty. In more specific terms, it was proposed that lesser reflection should generally favor risk aversion in gambling games.

Recap of Results

Processing speed is one important psychological feature that could distinguish intuition from reflection (Rand et al., 2012). If so, a manipulation of the time available for choosing between a sure gain and a gamble should be informative in determining whether risk aversion is intuitive or reflective. Such a manipulation was used in Study 1. Because we think that intuition favors risk aversion, we hypothesized that restricting the time available to make decisions would render people more risk averse. This causal relationship was not supported in Study 1. Instead, individual differences in reflective thinking ability, as assessed by 3 math problems, provided some support consistent with hypotheses in that higher reflection ability predicted a greater frequency of risky choices.

Study 2 attempted to manipulate intuitive and reflective thinking styles with trial-to-trial priming stimuli, with the hypothesis that reflective priming (in the form of seeing a “thoughtful” pictured statue) would encourage people to think more deeply on that trial, in turn producing a greater frequency of risky choices. This manipulation also failed to influence decision making. Nonetheless, by including two measures of reflective thinking ability (i.e., the CRT of Study 1 and a new rational ability self-report scale), the individual difference findings of Study 1 were replicated and extended. Higher reflection ability predicted more risky choices when the expected value of the risky option was superior to the value of the safe option. Additionally, self-paced decision time, conceptualized as a measure of information processing style, also predicted choices in a similar fashion as the two reflection scales.

Taken together, the findings from the two studies are consistent with the perspective that risk aversion is intuitive, while risk taking is reflective, in gain-framed economic games, with a major caveat. The manipulations of processing styles simply proved uninformative in supporting such ideas and therefore causal evidence for them could not be provided.

Limitations, Implications, and Future Directions

As just stated, the manipulations failed to affect participants' choices in both studies. At this point, it might be useful to consider what went wrong. In Study 1, participants were forced to respond within 1.5s after hearing a beep. It is possible that this time window put extra attentional load on participants, as they would need to monitor the beep and then to respond to it, which could affect the decision process. It is also possible that the 5s condition did not trigger cognitive reflection as it was designed to. Participants in this condition could have made a decision in less than 5s and then have just waited for the beep to input this (already decided) response. In Study 2, participants were exposed to priming pictures at the beginning of each trial. It is possible that the amount of time the priming stimuli were displayed was too short to alter any thinking style. It is also possible that thinking styles could not be switched quickly from trial to trial. Indeed, in the previous study where this priming procedure triggered reflective thinking, participants viewed the pictures for 30 seconds in a one-shot between-subjects design (Gervais & Norenzayan, 2012). In one way or another, it appears that better manipulations would be necessary to determine whether risk aversion is the product of intuition or reflection.

The patterns of the correlational findings were somewhat different across the two studies. Study 1 found a significant main effect for reflection ability, but its interaction with Ratio (how favorable the risky option was) did not reach significance. By contrast, in Study 2, 2 predictors (CRT & RA) resulted in interactions in the absence of a main effect, whereas a third predictor (response speed) resulted in both a main effect and an interaction. In other words, the main effect only pattern of Study 1 was not directly replicated in Study 2. Differences in paradigms could have contributed to these discrepancies. Notably, Study 2 included feedback on outcomes of the gambles, whereas Study 1 did not. It is documented that feedback in decision tasks influences people's responses, such that decision makers tend to adjust their choices based on the outcomes of prior trials (March, 1996). It would be easy to over-emphasize dissimilarities between the results of the two studies, however. The reflection × Ratio patterns are very similar across two studies (see Figures 3 & 6-8), such that higher levels of cognitive reflection ability predicted more risky choices, mainly at higher ratios favoring those choices.

On the whole, individual differences in reflection ability affected the percentage of risky choices only when the expected value of the risky option surpassed the value of the safe option (i.e., only when the Ratio > 1). This pattern of findings is worthy of further consideration in that it could be that participants higher in reflection ability are generally more intelligent and this led them to choose risky options when those options had higher expected values. Consistent with this interpretation, reflection ability typically did not matter when the two options had equal expected values (i.e., when the Ratio was 1). However, the latter test is under-powered and a greater range of ratios may be useful in further disentangling rationality from a willingness to tolerate risk.

The idea that reflection can promote risk taking should be examined in domains other than economic decisions. For example, will an average person be more likely to engage in risky behaviors in daily life after pondering the risks? This sounds quite counterintuitive, since risky behaviors in everyday life are often associated with impulsivity (Zuckerman & Kuhlman, 2000). However, in line with this hypothesis, adolescents who engage in risky behaviors such as smoking, drinking, and unprotected sex *cannot* be characterized as thoughtless when engaging in these behaviors. Quite the contrary, they actually put more effort into weighing the costs and benefits of such high-risk behaviors than adults do and they engage in such behaviors when they decide that the benefits outweigh the costs (Reyna & Farley, 2006). On the other hand, more experienced decision makers like adults tend to avoid high-risk behaviors because they rely more on fuzzy reasoning and intuition to evaluate risks, essentially rendering them “no”-saying automatons (Reyna & Farley, 2006). In light of such results, it is not unreasonable to speculate that if adult decision makers are encouraged to reflect on risky behaviors, then they might actually be more likely to engage in those behaviors. This is an interesting empirical question that future research can examine.

Should the risky-reflection link prove robust in future research, the ideas of this project have implications for real-life decision making. For example, lottery ticket sellers might want buyers to take time before making a decision, whereas the insurance business might be better off by rushing their customers into buying insurance that they probably do not need.

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