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Decision Making Under Risk Across Different Contexts

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DECISION MAKING UNDER RISK ACROSS DIFFERENT CONTEXTS

by

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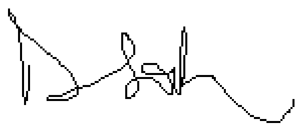

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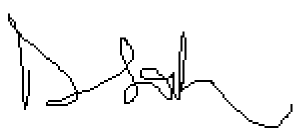

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Abstract

Decision making under risk has been intensively studied; however, little is understood about how decision making under risk changes with increased ecological validity. The current study investigated whether increased ecological validity resulted in greater decision quality and a minimization of the description-experience gap. Whether presenting items as abstract monetary gambles or framed within a meaningful context, decision quality was higher for loss items when presented as a description, and for gain items when experienced. When the rare event was a nonzero gain or loss, decision quality was increased when abstract monetary gambles were presented as a description. When the rare event was a zero gain, higher decision quality resulted if the gamble was experienced. When the rare event was a zero loss, higher decision quality resulted if the gamble was presented as a description. Implications for future research are discussed, with regard to improving understanding of decision making under uncertainty.

Keywords: decision making under risk, ecological validity, description-experience gap

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Introduction

Many situations we face involve decision making under risk. Deciding whether or not to cross a busy intersection when the traffic light is about to change, deciding how to invest retirement savings, or deciding between different cancer treatments – all of these scenarios involve risky decisions (Trepel, Fox, & Poldrack, 2005). Decision making under risk has been intensively studied by economists, psychologists, and neuroscientists, providing explanatory and descriptive accounts of phenomena such as risk seeking and loss aversion (Kahneman & Tversky, 1979). However, little is understood about how decision making under risk changes with increased ecological validity. To help address this gap, the current study compared the factors that influence risky choice behaviour when decision making information is delivered across abstract and ecological contexts. Prior decision making research has focused on factors that influence risky choice when options are presented in an abstract context, i.e. when probabilistic information is presented as monetary gambles. The current study investigated whether increased ecological validity, through use of scenarios depicting everyday situations, maximizes selection of higher expected value choices, in order to better understand factors that will improve decision making quality.

1.1 Decision Making Under Risk

Researchers distinguish between decision making under risk and decision making under uncertainty. Decision making under risk involves options that have well-specified or concrete numerical outcomes (e.g., "Get $4 with probability 0.8;" Trepel et al., 2005). Conversely, decision making under uncertainty involves options that do not (e.g., "Should I move out of my house and into a condo?"). These options are imprecise, as objective probabilities are not available to the decision maker. As a result, the expected outcome cannot be objectively defined, and determining the more beneficial option becomes a more difficult and complex process. Decision making research has focused primarily on decision making under risk because it involves less ambiguity (Platt & Huettel, 2008).

Theories of risky choice can be either normative/prescriptive or descriptive. Normative or prescriptive theories propose a standard for decision making processes. They assume that the decision maker computes his or her decision in a rational manner in order to derive the best possible outcome. An example would be expected value theory or expected utility theory. Descriptive theories explain the actual behaviour people display when making a decision. An example would be prospect theory (Kahneman & Tversky, 1979).

Expected value (EV) theory was based on principles of probability formulated by Blaise Pascal and Pierre Fermat in the 17th century. EV theory states that the decision maker should always select the option that will provide the higher expected value. The expected value of an option with possible outcomes i = 1, …n, is defined as $EV = \Sigma p_i x_i$, where p_i is the probability and x_i the monetary value of outcome i (e.g., in the earlier example, EV = (0.8)($4) = $3.20). However, EV theory has been found to be inaccurate in predicting choice behaviour. For example, there has been contradictory evidence demonstrating that people are often willing to pay only small amounts of money when faced with the possibility of receiving an infinite expected value (Hertwig et al., 2004).

In order to account for this inconsistency, objective monetary outcomes were replaced with subjective utility in expected utility theory (EU). Expected utility is defined as $EU = \Sigma p_i u(x_i)$, with $u(x_i)$ being a positive, decelerating function of the monetary amount. This theory suggests that the "utility of money increases nonlinearly with its amount, rising at a decreasing rate as absolute monetary value increases" (Hertwig et al., 2004, p. 535). For example, the utility gained by receiving $50 would be greater than half of the utility gained by receiving $100 (Trepel et al., 2005). However, research has shown that behaviour does not always conform to this axiom (Kahneman & Tversky, 1979; Hertwig et al., 2004). An example of this would be the fact that when participants were given two options (A: 50% chance to win $1000, 50% chance to win $0; or B: $450 for sure), they were more likely to select option B, a violation of EU theory. This preference demonstrated that outcomes which are obtained with certainty are overweighted when offered alongside uncertain outcomes (Kahneman & Tversky, 1979).

Prospect theory (Kahneman & Tversky, 1979) is a descriptive account of risky choice that accounts for many of the violations of normative choice behaviour. In prospect theory, the value of each outcome is multiplied by a decision weight (Kahneman & Tversky, 1979); thus, the decision maker does not necessarily weigh his or her options rationally in order to select the option with the greatest expected value, nor does s/he have an accurate estimation of a probability's true occurrence. Decision weights are not explicit on the part of the decision maker, but inferred from his or her choices, and provide a measure of how much an outcome influences the decision (Hertwig et al., 2004). People tend to overweight a small probability event and underweight a large probability event as the probability gets closer to 1. For example, when given two options, A and B (Option A: Get $4 with probability 0.8, $0 otherwise; or Option B: Get $3 for sure), most people would choose the sure thing (Option B), overweighting the 0.2

chance of getting $0 (Hertwig et al., 2004). However, according to EV theory, the expected value is higher for Option A, and therefore, *this* would be the "better" choice. It is possible that people underweight the 0.8 chance of getting $4, leading to the same result; however, no studies to date have investigated this way of interpreting such probabilities.

EV is considered an appropriate measurement of decision quality for choices pertaining to monetary gambles because such outcomes are easily qualified by their monetary outcomes. In other realms of decision making, however, EV may not be an appropriate measure of decision quality. For example, decisions that pertain to non-monetary outcomes, such as whether a life should be saved (Tversky & Kahneman, 1981), involve additional factors that cannot be quantified, and therefore cannot be adequately measured by EV.

Prospect theory also involves an S-shaped value function (see Figure 1). The *x*-axis that the function is mapped on ranges from gain outcomes (positive *x*-values) to loss outcomes (negative *x*-values), and the *y*-axis ranges from positive to negative values of the outcome. This value function is concave for gains in the upper-right quadrant and convex for losses in the lower-left quadrant. The concavity for gains leads to risk aversion for gains, while the convexity for losses leads to risk seeking for losses. The value function is steeper for losses than gains, demonstrating an overall trend towards loss aversion. This leads to risk aversion for mixed (gain-loss) gambles (Trepel et al., 2005), e.g., "Get $100 with probability .5 and lose $100 with probability .5." People will typically reject such gambles.

Four risk attitudes have emerged in the literature on risky choice. They are not mutually exclusive, and typically co-exist within the same individual. These risk attitudes demonstrate how people behave when making risky choices and are accounted for by prospect theory (Trepel et al., 2005). The four attitudes include risk seeking for low-probability gains and high-probability losses, and risk aversion for high-probability gains and low-probability losses. Risk seeking for low-probability gains involves overweighting a low-probability positive outcome (e.g., Get $100 with probability .05). Risk seeking for high-probability losses, on the other hand, involves underweighting a high-probability negative outcome (e.g., Lose $100 with probability .95), focusing instead on the .05 chance that s/he will lose nothing. Risk aversion for high-probability gains leads the decision maker to underweight the high-probability positive outcome (e.g., Get $100 with probability .95), focusing on the .05 chance of getting nothing. Risk aversion for low-probability losses leads to overweighting the low-probability negative outcome (e.g., Lose $100 with probability .05). Prospect theory also predicts loss aversion, the idea that a decision maker will place more emphasis on disadvantages or losses as opposed to advantages or gains.

1.2 Description- and Experience-Based Decisions

Recent studies suggest that decisions under risk are strongly influenced by the way in which knowledge about outcome probabilities is obtained. Specifically, people overweight low-probability events (e.g., adverse effects of childhood vaccines) when learning about the probability from description (e.g., reading a website), as would be predicted by prospect theory. By contrast, people underweight rare events if their probabilities are learned through experience (e.g., by a nurse who has administered thousands of vaccinations and seen few negative side effects; Hertwig et al., 2004). Both under- and overweighting can negatively affect decision quality, in the sense of producing choices that diverge from EV theory.

Such divergences are illustrated as follows. In the earlier example of two options (Option A: Get $4 with probability 0.8, $0 otherwise; or Option B: Get $3 for sure), the higher expected value choice was Option A. When presented in a description format, the decision maker would be expected to overweight the 0.2 chance of getting $0 in Option A, and as a result, select Option B, the less advantageous choice. In another example of two options (Option A: Get $4 with probability 0.2, $0 otherwise; or Option B: Get $3 with probability 0.25, $0 otherwise), the higher expected value choice is Option A (since Option A's *EV* = $0.80 and Option B's *EV* = $0.75). When presented in an experiential format, the decision maker would underweight the 0.2 chance of getting $4 and select Option B, the less advantageous choice.

Decisions from description involve *a priori probabilities*, containing a "standard of accuracy" that is lacking in decisions from experience (Knight, 1921). They provide the decision maker with possible decision outcomes and their probabilities, but do not allow the decision maker to repeatedly sample his or her options before making the final choice. Decisions from experience, on the other hand, involve *statistical probabilities*, and are dependent on tabulating prior results. They do not provide descriptions of choice outcomes or their probabilities, but instead allow the decision maker to sample the options before making the final choice. The decision maker is faced with two options from which s/he can sample repeatedly to learn the options' underlying payoff distributions. After sufficient sampling, determined by either the decision maker or the experimenter, the decision maker selects the option s/he prefers, and receives the corresponding payout.

A decision-experience gap emerges in risky decision making. The decision-experience gap is defined as oversensitivity to rare events, according to their objective probabilities, when they are learned through description, but insensitivity to the same rare events when they are learned through experience (Hertwig & Erev, 2009). Compared to options offered in a description format, presenting options in an experience format leads to greater risk seeking for gains, greater loss aversion for losses, and the underweighting of small probabilities (Barron & Erev, 2003). In contrast, prospect theory predicts risk aversion for gains, risk seeking for losses, and the overweighting of small probabilities.

Neither description nor experience format is inherently superior in producing more advantageous decision making. Item type (whether the rare event is a nonzero or zero gain or loss) also influences decision behaviour. When the rare event is a nonzero gain or loss, it involves a positive outcome when receiving a gain, but a negative outcome when receiving a loss (e.g., gaining or losing $4 with probability .2). A higher proportion of higher EV choices will be made in decisions from description, due to the overweighting of small probabilities and preference for the sure thing (e.g., when faced with Option A: Get $4 with probability .2, $0 otherwise; Option B: Get $3 with probability .25, $0 otherwise). When the rare event is a zero gain or loss, this results in a negative outcome when receiving a gain, but a positive outcome when receiving a loss (e.g., gaining or losing $0 with probability .2). This is a negative outcome when receiving a gain because the decision maker gained $0 instead of a positive sum of money. A higher proportion of higher EV choices will be made in decisions from experience, due to the underweighting of small probabilities and choosing the riskier option (e.g., when faced with Option A: Get $4 with probability .8, $0 otherwise; Option B: Get $3 with certainty).

Several explanations have been posited for the description-experience gap. Hertwig and colleagues (2004) proposed that limited information search, i.e., small sampling, is one reason. Smaller samples from the payoff distribution increase the likelihood that participants will remain ignorant of the rare event, as they will fail to come across it in their sampling. For example, when sampling from an option offering $32 with a probability of .1 (and $0 otherwise), Hertwig and colleagues (2004) found that the majority of respondents (18 out of 25) never encountered the rare event (the $32). In addition to the objective probability being quite small, limited sampling increases the likelihood that the rare event won't be encountered, and leads to an underestimation of the distribution's actual variability (Kareev, Arnon, & Horwitz-Zelinger, 2002).

Why don't people invest in large samples? Hertwig and Pleskac (2010) theorized that people choose to rely on small samples because small samples emphasize the difference between each option's expected outcome. This makes the options more distinct and the final decision easier. However, as mentioned earlier, smaller samples have negative implications. With smaller samples, it becomes more likely that each option's actual payoff distribution will not be learned. The resulting choice will therefore not be as well-informed, as the decision maker will have an inaccurate perception of each distribution.

When sample size is defined as the number of draws from both options combined, previous studies have found the median number of draws per problem to be 15 (Hertwig et al., 2004) and 17 (Weber et al., 2004). Hau and colleagues' (2010) review paper found that it ranged between 11 and 19 across studies. Some studies determined sample size in advance, so that participants did not decide when they terminated their information search. For example, one study set the sample size at 80 (Ungemach, Chater, & Stewart, 2009), and another set it at 100 samples (Hau et al., 2008). Regardless of this increase information search, researchers still found a marked description-experience gap. Only in one study (Rakow et al., 2008), in which participants in the description condition were yoked to experience condition, was the gap eliminated. Participants in the yoked description condition saw the same outcomes that those in the free-sampling experience condition saw. When comparing the two groups, choice concordance was very high. The concordance was even greater than that between the free-sampling experience condition and the yoked experience condition (i.e., each participant clicked on the same options and was given the same information as the participant to whom s/he was yoked in the free-sampling condition).

But even in a full-feedback paradigm, when participants received immediate feedback for both their choice option and the alternate option, the gap persisted. As a result, Hertwig and Erev (2009) stated that small samples alone cannot be responsible for this gap.

Recency effects are another proposed explanation for the underweighting phenomenon in decisions from experience. Rare events have been found to have less impact than their objective probabilities, due to participants not having sampled them recently (Hertwig et al., 2004; Barron & Yechiam, 2009). Similarly, common events are overweighted because they are more likely to have occurred recently. Even when people are able provide accurate estimates of an option's probabilities, recently sampled outcomes tend to receive greater weight than earlier sampled outcomes. This is the case even in large, representative samples, as the rarity of the rare event makes it less likely than more common events to have occurred recently. Hertwig and colleagues (2004) found, when dividing participants' sequence of draws for each option into two halves, the second half of samples had greater predictive power for participants' choices; the same authors later retracted this finding due to later studies finding little or no effect of recency on decisions (Hertwig & Erev, 2009). In another study, earlier samples predicted decisions just as well as later samples (Ungemach, Chater, & Stewart, 2009), further disproving the recency effects.

It is possible that choice inertia, i.e., a primacy effect, occurs in an experiential paradigm, leading to the description-experience gap persisting even with larger sampling. Hau and colleagues (2010), however, found that the description-experience gap was not explained by choice inertia. They used the natural-mean heuristic as a baseline, with the assumption that people would choose the risky option if their sample had a better average outcome than the sure thing. The observed overlap between subsequent choices (i.e., between the first and second choice, second and third, etc.) was only slightly larger than what would be expected by the natural mean heuristic, demonstrating that participants did not tend to stick with the option they initially preferred.

Another possible explanation for the description-experience gap is estimation error (Herwig & Erev, 2009), the systematic underestimation of the frequencies of the rare event experienced. However, it has been shown that participants often overestimate the frequency of the rare event when sampling (Hau et al., 2008), or estimate the frequency accurately (Ungemach, Chater, & Stewart, 2009). Other possible explanations include contingent sampling (decision makers base their decisions on recent or past experiences from similar situations) and information format and cognitive algorithms (different formats, i.e., described single-event probabilities versus sequential experience of events, give rise to different cognitive algorithms).

Of particular interest, one study demonstrated the ability to reverse the description-experience trend. Jessup and colleagues (2008) incorporated experience into decisions from description. After receiving feedback for their choices, participants began to underweight small probabilities, following the trend of decisions from experience. These findings suggest that incorporating feedback into decisions from description would improve decision making quality, and could also lessen the gap between decisions from description and experience.

1.3 The Role of Context and Emotion in Decision Making

Previous studies on decision making have presented probabilistic information in an emotionally neutral manner--as numerical values. Castel (2005) found that performance on cognitive tasks improves when tasks are meaningful and have relevance to everyday life. Tversky and Kahneman (1981) similarly found that context influences decision making, with choice preferences shifting when the same problem was framed in different ways. Changes in framing resulted in greater risk aversion for choices involving gains, and greater risk seeking for choices involving losses. Thus, increased task meaningfulness could have implications for risk attitude. Individuals might behave in a more risk seeking or risk averse manner, depending on the meaning that is attached to the possible outcomes. For example, in the current study, an individual who is moderately risk seeking in an abstract decision making task might display greater risk seeking behaviour when in the context of not wanting to give up one's possessions while checking baggage at the airport (see Procedure).

The issue of gains and losses highlights the fact that risky choice often involves emotion (Peters & Västfjäll, 2005). Decision makers must choose between options with potential positive outcomes (e.g., stock market earnings; successful treatment of a disease) or negative outcomes (e.g., stock market losses; adverse consequences of a medical treatment). Affect has the ability to influence prospect theory's weighting function (Rottenstreich & Hsee, 2001). The inverse-S-shaped weighting function is concave near a probability of zero and convex and much steeper near a probability of one. This steepness leads to the difference between a .99 and a certain chance of a gaining a positive outcome appearing larger to the decision maker than the difference between a .10 and .11 chance of the same positive outcome (Trepel et al., 2005). Rottenstreich and Hsee (2001) found that affect makes the weighting function more S-shaped for gambles involving affect-rich outcomes; more specifically, the weighting function becomes more sensitive to departures from impossibility and certainty. It can also improve the quality of decisions (Peters & Västfjäll, 2005). Applied to risky choice, affect may lead decision makers to assign more weight to potential gains, leading to increased risk seeking, or losses, leading to increased risk aversion.

1.4 Rationale for the Current Study

In summary, current decision making research suggests that changes in context may affect decision making behaviour. At current, it remains unknown whether improving ecological validity improves the quality of decisions from description and experience. It is also unknown whether improved ecological validity interacts with the valence of the outcomes to produce higher EV choices. This study will explore the ways in which different contexts affect decision making under risk with regards to gains and losses, and item type (whether the rare event is associated with a nonzero gain or loss, or a zero gain or loss). Findings will inform current probabilistic decision making models, and will elucidate methods of improving the communication of probabilistic information.

In this study, risky choice behaviour was compared in two groups matched on demographic and health variables that could affect cognitive performance. One between-subjects variable and three within-subjects variables were manipulated: the format in which outcome probabilities are conveyed (description vs. experience), the decision context (abstract vs. ecological), the valence of the risky options (gains vs. losses), and the item type (rare event associated with a nonzero gain/loss vs. rare event associated with a zero gain/loss). The dependent variable was decision quality, defined as the proportion of higher EV choices selected by participants. Multiple within-subject manipulations were used, with each participant being presented with 16 items (i.e., pairs of options) in both description and experience formats. This differed from previous research designs, in which participants are typically presented with a single item (e.g., Barron & Erev, 2003). The rationale for the current design was to evaluate whether previous patterns of decision making behaviour would be replicated (e.g., Hertwig et al., 2004), and if these patterns would generalize across all 16 items.

The hypotheses of interest were as follows: (1) A significant two-way interaction was predicted between Format X Item Type for both contexts. This would be consistent with literature on the description-experience gap. The description group would outperform the experience group when the rare event is associated with a nonzero gain or loss, due to overweighting the rare event. The experience group would outperform the description group when the rare event is associated with a zero gain or loss (Hertwig et al., 2004). (2) A significant Format X Valence interaction was predicted for both abstract and ecological contexts. Participants in the description group were expected to select a higher proportion of higher EV loss options due to risk aversion for gains and risk seeking for losses (Kahneman & Tversky, 1979). Participants in the experience group were expected to select a greater proportion of higher EV gain options due to risk seeking for gains and risk aversion for losses (Barron & Erev, 2003). (3) Improved decision quality was predicted in the ecological conditions, compared to the abstract conditions, due to the increased meaningfulness of the task (e.g., Castel, 2005). (4) And finally, correlations were predicted between decision quality (i.e., higher proportion of higher EV choices) and four personality variables, included for exploratory purposes: need for cognition, numeracy, risk propensity, and self-control.

Method

2.1 Participants

72 undergraduate students (55 females) participated in this study for course credit. Mean age of participants was 20.7 (range 17-33 years). Participants completed a screening questionnaire pertaining to demographic (e.g., education, handedness, language, gambling habits) and health variables (e.g., history of psychiatric or neurological illness, use of medication, uncorrected vision, hearing deficits) that could affect cognitive performance. The study was conducted in the Memory and Decision Processes Laboratory at Ryerson University.

2.2 Materials

For the study, stimuli were shown on a computer screen and participants were asked to provide their responses using one of two designated keys on the keyboard. The stimuli consisted of pairs of choice options similar to those used by Hertwig and colleagues (2004). Four of Hertwig and colleagues' stimuli (see Table 1) were used, along with three additional sets of four stimuli. The new stimulus sets were designed to match the original set by Hertwig and colleagues in all respects except the dollar amounts associated with Options A and B. The 16 loss stimuli were identical to the 16 gain stimuli except for the sign of the dollar values (negative rather than positive).

After completing the study, participants were given several questionnaires pertaining to personality variables to complete.

2.2.1 Need for Cognition Scale (NCS). The NCS (Cacioppo, Petty, & Kao, 1984) is an 18-item scale assessing individual differences in the preference for engaging in challenging cognitive tasks. Participants indicated "true" or "false" for each item, corresponding with whether or not each statement pertained to them. The scale possesses high internal consistency ($r = .95$, $p < .001$) and reliability (Cronbach's alpha = .90).

2.2.2 Numeracy Scale. The Numeracy Scale (Reyna & Brainerd, 2008) consists of mathematical questions pertaining to fractions, percentages, and proportions. The 11-item scale allowed for an assessment of participants' mathematical proficiency and understanding of probabilities. In a previous study, the mean number of correct items was 8.4 (Peters et al., 2006).

2.2.3 Risk Propensity Scale (RPS). The RPS (Meertens & Lion, 2008) is an 18-item scale, measuring an individual's tendency to take risks. It allowed participants' risk-seeking or risk-averse behaviour to be measured. Respondents indicated the extent to which they agreed or disagreed with each statement on a 9-point scale (1 = totally disagree to 9 = totally agree). The RPS demonstrates good internal reliability (Cronbach's alpha = .77) and adequate test-retest reliability ($r = .75$, $p = .001$).

2.2.4 Self-Control Scale. The Self-Control Scale (Tangney, Baumeister, & Boone, 2004) consists of 26 items measuring self-regulatory behaviour. Participants indicated the how much each statement was reflective of their typical behaviour (1 = not at all to 5 = very much). The Self-Control Scale possesses good internal consistency (r = .89) and test-retest reliability (Cronbach's alpha = .89).

2.3 Procedure

Participants were told that the study pertained to decision making and that the Principal Investigator was interested in how people make decisions when presented with two options. A practice test, involving tasks analogous to the actual study, was administered to ensure that participants had an adequate understanding of the tasks to be performed during the actual study. Participants in the description group learned which key related to each option, and those in the experience group completed eight practice trials of the actual study. For each pair of options, participants were told to select the option that they would realistically prefer.

Forty-two participants were tested in the description-format condition. The description group was shown two options conveying probabilities and monetary outcomes on the computer screen and selected which of the options was preferable to them. In this condition, choice options were presented as summary descriptions (e.g., “Option A: Get $4 with probability 0.8, $0 otherwise; Option B: Get $3 with certainty”). Participants made their selection based on the information provided to them. They did not receive feedback for their choices.

Thirty participants were tested in the experiential-format condition. A standard sampling paradigm was used (see Hertwig & Erev, 2009). Participants were shown two buttons on a computer screen, corresponding to Options A and B, and were told to sample as many times as they liked and in whatever order until they were confident in their choice (see Barron & Erev, 2003). Pressing each key randomly sampled an outcome (with replacement) from the option’s underlying probability distribution. Each pair of options involved identical probabilities and monetary outcomes to the description group. However, for the experience group, the outcomes and probabilities remained unknown to the participant (see Hertwig et al., 2004). Participants thus learned about outcomes and probabilities through repeated choice with feedback.

Each participant encountered eight abstract-context stimuli and eight ecological-context stimuli. Within each of the two contexts, four stimuli offered gains and a different set of four stimuli involved losses. Within the four gain stimuli, one item was associated with a zero gain, and three items were associated with a nonzero gain. Within the four loss stimuli, one item was associated with a zero loss, and three items were associated with a nonzero loss. Therefore, in total, each participant encountered each of the 16 stimuli once. The 16 items were divided into four blocks of four, and the blocks were counterbalanced across conditions (i.e., abstract gain, abstract loss, ecological gain, and ecological loss). Each participant therefore received one of four presentation orders. Gain and loss stimuli within each block were presented in a random, intermixed order.

The abstract-format condition presented the options as abstract monetary gambles, as is commonly done in the literature (e.g., Hertwig et al., 2004). In contrast, the ecological-format condition couched the options in brief summaries providing a meaningful context. The gain scenario revolved around the decision maker possibly gaining a free gift while at the airport with a friend (Appendix A). The loss scenario revolved around the decision maker having to decide which of two items would be taken out of his/her airport luggage and potentially left behind (Appendix B).

Results

A 2 X 2 X 2 X 2 mixed design was used, with one between-subjects factor and three within-subjects factors. The between-subjects factor was the format in which outcome probabilities were conveyed (description vs. experience). The within-subjects factors were the decision context (abstract vs. ecological), the valence of the risky options (gain vs. loss), and the item type (a nonzero gain or loss vs. a zero gain or loss). Each participant thus contributed choice data in eight conditions (2 contexts X 2 valences X 2 item types). The dependent variable was decision quality, operationalized as the proportion of decisions favouring the "better" option (e.g., the option providing the higher EV). The higher EV option was always the option that featured the rare event (i.e., Option A) for gains, and was always the option that did not feature the rare event (i.e., Option B) for losses.

3.1 Sampling Frequencies

For participants in the experience format group, sampling frequencies within each condition were investigated. Previous studies have shown that the total number of draws per item tends to be small. For example, Hertwig et al. (2004) found a median of 15 draws per item (see Discussion), suggesting that participants' choices suffered from a limited information search. Participants in the current study sampled much more frequently, with only ten participants sampling on average fewer than 15 times on per item (see Figure 2). The median number of samples across participants was 18.5. It would be expected then that participants in the current study would have a more thorough representation of each item's underlying probability distribution, and would be able to more accurately select the more advantageous choice, compared with participants in previous studies.

3.2 Item-level Analyses

The item-level analyses of variance (ANOVAs) included one between-item factor (item type) and two within-item factors (format and valence). For the first item type, the rare event was associated with a nonzero gain or loss. This would result in a positive outcome when receiving a gain, but a negative outcome when receiving a loss (e.g., gaining or losing $4 with probability .2; see Set II Stimulus Number 2 in Tables 1 and 2). For the second item type, the rare event was associated with a zero gain or loss. This would result in a negative outcome when receiving a gain, but a positive outcome when receiving a loss (e.g., gaining or losing $0 with probability .2; see Set II Stimulus Number 1 in Tables 1 and 2). Data for each level of the context variable (abstract vs. ecological) were analyzed separately, due to the exploratory nature of this variable.

The proportions of higher EV choices for each condition are displayed in Tables 1 to 4. Table 5 compares the relevant proportions to those found previously (i.e., Hertwig et al., 2004). Similar results were found across all items, with regard to overall group performance.

For the abstract context, there was a significant Format X Valence X Item Type interaction, $F(1, 14) = 5.387$, $p = .036$, $\eta_p^2 = .278$ (see Table 6).

To probe the three-way interaction, post-hoc paired-samples t-tests were used to assess the effect of format on valence separately for each item type. When the rare event was associated with a nonzero gain or loss, there was only a negative main effect of format $F(1, 11) = 16.22$, $p = .002$, with higher decision quality in the description condition than in the experience condition. When the rare event was associated with a zero gain or loss, there was a significant Format X Valence interaction, $F(1, 3) = 82.57$, $p = .003$. Higher EV options were less often selected when presented as gains in the description format ($M = .21$, $SD = .04$), as compared to when they were presented as gains in the experience format ($M = .58$, $SD = .12$), $t(3) = -3.27$, $p = .047$.

There was a significant Format X Valence interaction, $F(1, 14) = 8.215$, $p = .012$, $\eta_p^2 = .370$. A greater proportion of higher EV choices were selected for loss items in the description format, and for gains in the experience format. There was also a significant Format X Item Type interaction, $F(1, 14) = 13.065$, $p = .003$, $\eta_p^2 = .483$, showed that participants in the description format selected a greater proportion of higher EV choices when the rare event was a nonzero gain or loss, and in the experience format when the rare event was a zero gain or loss.

Participants in the description format selected a greater proportion of higher EV choices for loss items than for gain items, for both item types (Figures 3 and 4). In the experience format, there was a greater proportion of higher EV choices for loss items when the rare event was a nonzero gain or loss, and for gain items when the rare event was a zero gain or loss.

This pattern mirrors what has been reported in the literature (e.g., Hertwig et al., 2004), with differences between description and experience formats. Rare events have been found to be underweighted in decisions from experience, and overweighted in decisions from description. Thus, when the rare event was associated with a nonzero outcome, it was expected that gain items would evoke more risk-seeking behaviour in the description format than the experience format, due to overweighting the small probability of a positive outcome. This would result in greater higher EV choices being selected in the description group. For losses, participants in the description group were expected to be more risk-averse, overweighting the small probability of a negative outcome and selecting the sure thing. This would also result in greater higher EV choices being made. When the rare event was associated with a zero outcome, participants experiencing gains in the description condition were expected to overweight the small probability of gaining nothing and show risk-averse behaviour, thereby selecting the lower EV choice more often. For losses, they were likely to overweight the small chance of losing nothing and select the riskier choice, which would ultimately be the lower EV choice.

This trend was found in the current study. When the rare event pertained to a nonzero outcome, participants in the description group more often chose the higher EV choice for both gains and losses. When the rare event pertained to a zero outcome, participants in the experience group selected a greater proportion of higher EV gain items, but slightly fewer loss items, than those in the description group.

For the ecological context, there were two significant two-way interactions (see Table 6). A Format X Valence interaction, $F(1, 14) = 16.426$, $p = .001$, $\eta_p^2 = .540$, reflected more advantageous choices when loss items were presented in the description format, and when gain items were presented in the experience format (Figure 5). Post-hoc independent samples t-tests demonstrated a significant effect of format for gains, $t(15) = -2.44$, $p = .028$, with a greater proportion of higher EV choices being made in the experience format ($M = .39$, $SD = .31$) than description format ($M = .22$, $SD = .15$), and a marginal effect of format for losses, $t(15) = 1.84$, $p = .086$, with more higher EV choices made in the description format (M = .53, SD = .19) than the experience format (M = .37, SD = .25).

A Format X Item Type interaction, $F(1, 14) = 7.216$, p =.018, $\eta_p^2 = .340$, demonstrated that participants selected more higher EV choices in the description format when the rare event was a nonzero gain or loss, and more higher EV choices in the experience format when the rare event was a zero gain or loss (Figure 6). Post-hoc independent samples t-tests showed that when the rare event was associated with a zero gain or loss, there was a marginally significant effect of format, $F(1, 3) = 5.97$, $p = .092$, $\eta_p^2 = .666$.

3.3 Individual Differences Analyses

The overall proportion of higher EV choices per subject was calculated for the description (Figure 7) and experience groups (Figure 8). Independent samples t-tests demonstrated that the description and experience groups' were comparable across responses on the four questionnaire scales: need for cognition, $t(69) = -.45$, $p = .66$, numeracy, $t(69) = -.39$, $p = .70$, risk propensity, $t(69) = .29$, $p = .78$, and self-control, $t(69) = -.44$, $p = .66$. This ruled out the possibility that potentially confounding personality variables influenced differences in decision behaviour between the two groups.

A hierarchical regression analysis was performed to determine whether format and questionnaire responses predicted overall proportion of higher EV choices. The first predictor, format, was entered into the model in Step 1, followed by four additional predictors, the four sets of questionnaire responses, in Step 2. The criterion variable was the overall proportion of higher EV choices. The analysis revealed that the overall model was not significant, $F(5, 65) = .969$, $p = .443$, accounting for 6.9% of the total variance in overall proportion of higher EV scores. The description format was associated with a marginally significant increase in the overall proportion of higher EV choices, $p = .069$ (see Table 7). The model indicated by Step 1 approached significance, $F(1, 69) = 3.411$, $p = .069$. When questionnaire responses were entered at Step 2, format remained marginally associated with overall proportion of higher EV choices, $b = -.055$, $SE = .032$, $p = .092$, $\beta = -.206$. When controlling for format, need for cognition, $p = .919$, numeracy, $p = .837$, risk propensity, $p = .358$, and self-control, $p = .316$, were not significantly associated with overall proportion of higher EV scores. Format, on its own, accounted for 4.7% of the total variance in overall proportion of higher EV choices. Questionnaire responses, on their own, contributed a non-significant additional 2.2%, $F(4, 65) = .389$, $p = .816$.

A second hierarchical regression analysis was conducted to investigate the sampling behaviour of participants in the experience format. The first predictor, median number of total samples, was entered in Step 1, and four additional predictors, the questionnaire responses, were entered in Step 2. The criterion measure was the overall proportion of higher EV choices. The overall model was not significant, $F(5, 24) = .668$, $MSE = .013$, $p = .651$, with median number of total samples and questionnaire responses accounting for 12.2% of the variance in overall proportion of higher EV choices (see Table 8). A one-point decrease in the median number of total samples was associated with a non-significant increase in overall proportion of higher EV choices, $p = .382$. The model indicated by Step 1 was not significant, $F(1, 28) = .790$, $p = .382$. When questionnaire responses were entered into the model, the median number of total samples remained non-significantly associated with overall proportion of higher EV choices, *b* = -.001, *SE* = .001, *p* = .390, β = -.181. Need for cognition, *p* = .342, numeracy, *p* = .730, risk propensity, *p* = .628, and self-control, *p* = .790, were not significantly associated with overall proportion of higher EV choices. The median number of total samples alone accounted for a non-significant 2.7% of the variance in overall proportion of higher EV choices, *F*(1, 28) = .790, *p* = .382. The questionnaire responses alone accounted for a non-significant 9.5% of the variance in the outcome variable, *F*(4, 24) = .648, *p* = .634.

A final regression analysis investigated whether questionnaire responses predicted the median number of total samples. The four predictor variables were the four sets of questionnaire responses. The criterion variable was the median number of total samples. The overall models was not significant, *F*(4, 25) = 1.054, *p* = .400, accounting for 14.4% of the overall variance (see Table 9). A one-point decrease for each of the predictors was associated with non-significant increase in median number of total samples: need for cognition, *p* = .782, numeracy, *p* = .939, risk propensity, *p* = .514, and self-control, *p* = .118.

Discussion

In sum, the results of the current study reflect typical risky choice patterns. Decision quality was increased when abstract monetary gambles were presented as a description when the decision maker was faced with gaining or losing a sum of money greater than zero. When faced with potentially gaining a sum that was zero, higher decision quality resulted if the gamble was sampled. When faced with losing a sum that was zero, higher decision quality resulted if the gamble was presented as a description.

Whether presenting items as abstract monetary gambles or framed within a meaningful context, decision quality was higher for loss items when presented as a description, and for gain items when learned through a sampling paradigm.

Participants in the current study sampled, on average, 18.5 times per item. This is close to the upper boundary of what has been found previously in the literature (Hau et al., 2010). This would suggest that participants' information search was more informed than those in prior studies. As a result, they would be more informed about the payoff distributions, and more likely to select the higher EV choice. Compared with Hertwig and colleagues' (2004) study, upon which the items were based, participants in the current study selected a greater proportion of higher EV choices in one of the six original description items, and three of the six original experience items (see Table 5).

The expected decision behaviour patterns (e.g., Hertwig et al., 2004) generalized across all 16 items. Several significant interactions speak to this. An unexpected significant Format X Valence X Item Type interaction was found in the abstract context. Similar to Hertwig and colleagues' (2004) findings, participants in the description group selected a greater proportion of higher EV choices, compared with participants in the experience group, for nonzero gains and losses. Participants in the experience group followed the predicted trend by selecting a greater proportion of higher EV choices for zero gains, but this was not the case for losses. It would appear that in the experience group, the rare event was not underweighted to the extent that would have been predicted by previous studies documenting a description-experience gap. It is possible that participants' affective responses varied across the different items, leading them to underweight some rare events as would be expected, and failing to underweight others.

For both abstract and ecological contexts, as hypothesized, greater decision quality was found with loss items in the description format, and gain items in the experience format. This is consistent with what would be expected from previous research. According to prospect theory, small probabilities in decisions from description are overweighted, thus leading to risk averse behaviour and higher EV choices in losses (Kahneman & Tversky, 1979). Conversely, small probabilities in decisions from experience are underweighted (Barron & Erev, 2003), leading to risk seeking behaviour and higher EV choices in gains. For both contexts, as hypothesized, the description group outperformed the experience group when the rare event was associated with a nonzero gain or loss, and the reverse was found when the rare event was associated with a zero gain or loss. Thus, the description-experience gap was evident in the current study.

All regression analyses were non-significant, with the exception of the predictor, format, in the first hierarchical regression analysis approaching significance. This showed that presenting items in a description format predicted overall proportion of higher EV choices. This could be due to the experience format being more variable across participants, possibly due to differences in sampling, and thus, less predictive of final choices. Questionnaire responses and median number of total samples did not predict the overall proportion of higher EV choices. Questionnaire responses also failed to predict the median number of total samples. This might have been due to inaccuracies in the questionnaire data resulting from self-report bias. Participants may have been inclined to answer in a socially desirable manner. For example, it was foreseeable that items from the Need for Cognition Scale (e.g., "I would prefer a task that is intellectual, difficult, and important to one that is somewhat important but does not require much thought") and Self-Control Scale (e.g., "I am lazy") would encourage socially desirable responses (i.e., to answer "true" in the first instance and select a low score in the second). And finally, the fact that the median number of total samples failed to predict the overall proportion of higher EV choices might offer evidence for the idea that a more thorough information search, i.e., larger samples, fails to override the description-experience gap.

Participants were numerate, with a mean score of 8.986 out of 11 questionnaire items. Thus, participants were able to solve basic mathematical problems relating to probability, and could understand the information pertaining to probabilities that was provided in the current study. Higher decision quality than what would be expected in the general population was therefore expected. Inability to understand probabilities was ruled out as an explanation for the results of the current study.

4.1 Limitations

The current study had several limitations. Due to the context variable being exploratory in nature, the ecological context scenarios were unique to this study. The degree to which emotional salience and ecological validity were evoked by these scenarios requires further investigation. It was apparent that participants encountered difficulty in comprehending the ecological stimuli, as several asked the experimenter for clarifications pertaining to the scenarios during the study. Difficulty interpreting the stimuli might have compromised their ecological validity, and would have led to their failing to produce a sufficient affective response. Confusion may have also prevented participants from understanding what they were to accomplish by doing the task. For example, for the loss scenario, several participants failed to comprehend the rationale behind taking an object out of one's suitcase and putting it into a carry-on bag instead.

It would have been useful to include several different scenarios, each depicting a different situation, in order to appeal to a wider range of what participants might deem realistic or personally meaningful. Any realistic situation could potentially be used, so long as it involves possibly gaining or losing an object of monetary value, and is personally relevant and meaningful to the decision maker. Participants were asked, during the early stages of the current study, to evaluate the scenarios with regard to personal relevance and effectiveness in evoking affect and interest. Scenarios with greater ecological validity could be developed through more intensive screening with participants.

It would be of interest to explore potential modulations in decision behaviour with substantially larger dollar values as the monetary outcomes, as this too could increase personal meaningfulness for participants.

Results in the current study might have been confounded by attentional demands differing between the two formats in which the probabilistic information was presented. The experiential format placed greater attentional demands on the participants, as information pertaining to each option was presented sequentially. The descriptive format was less demanding, as information pertaining to each option was presented simultaneously. One study (Hau et al., 2010) resolved this issue by using an experiential paradigm that only required the participant to sample for one of the options while the other was held constant, thereby lessening the cognitive demands of the task.

It would have also been beneficial to counterbalance the rare event across options, so that Option B was not always the option that featured the sure thing.

4.2 Future Directions and Implications

The current study reinforced evidence that the method in which probabilistic information is conveyed plays an important role in how that information is interpreted, and the level of decision quality that results. Further research investigating ways of increasing ecological validity in decisions involving risk would help to elucidate its mediating role in the decision-experience gap. Studies combining the two formats, e.g., entering experience into decisions from description (Jessup et al., 2008), would be beneficial in offering new methods of enhancing decision quality.

This is the first time that all 16 items in this study were used collectively as stimuli, compared with 6 of them that were used previously (Hertwig et al., 2004). Risky decision making patterns generalized across the 16 items, demonstrating the items' effectiveness in evoking appropriate affective responses from participants. Hertwig and colleagues' (2004) study used four unique items as gain stimuli, and repeated two of these items as loss stimuli. The items in the current study incorporated the same four unique items from the original study (see Set II in Table 1). This set was copied three times to offer three new versions of the original stimuli. Each new set maintained identical ratios between the four items, but the first item of each set offered a different monetary value ($3, $4, $5, or $6). In a counterbalanced fashion, eight of the sixteen items were shown to participants as gains, and the remaining eight were shown as losses. The patterns' robustness despite this variability offers evidence for the pervasiveness of decision making trends, such as prospect theory and the decision-experience gap, when people are offered two options.

This study explored the factors involved in the interpretation of risky options. This will inform methods of improving the communication of probabilistic information, and will thereby increase decision quality in areas such as medical and financial decision making. Better understanding processes involved in decision making under risk will allow for improvements in understanding decision making under uncertainty. Decisions under uncertainty remain less investigated, yet have more relevance in everyday life. Research investigating decisions under risk would be beneficial, as findings pertaining to decisions that involve probabilities could likely be extended to elucidating decisions that do not involve such probabilities. This would also have implications for potential interventions for clinical syndromes, such as decision making disorders (e.g., compulsive gambling, eating disorders, and drug abuse).

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Table 1

Proportion of Higher EV Choices for Abstract Gain Condition

Set	Stimulus Number	Options A	Options B	Expected value A	Expected value B	Proportion choosing higher EV: Description group	Proportion choosing higher EV: Experience group	Item type	Rare event	Prediction for higher EV choices[a]	Difference between groups[b]
I	1	3, .8	2.20, 1.0	2.40	2.20	0.18	0.33	Zero	0, .2	Higher	+0.15
	2	3, .2	2.20, .25	0.60	0.55	0.55	0.33	Nonzero	3, .2	Lower	-0.22
	3	24, .1	2.20, 1.0	2.40	2.20	0.45	0.17	Nonzero	24, .1	Lower	-0.28
	4	24, .025	2.20, .25	0.60	0.55	0.45	0.17	Nonzero	24, .025	Lower	-0.28
II	1[c]	4, .8	3, 1.0	3.20	3.00	0.18	0.83	Zero	0, .2	Higher	+0.65
	2[c]	4, .2	3, .25	0.80	0.75	0.45	0.50	Nonzero	4, .2	Lower	+0.05
	3[c]	32, .1	3, 1.0	3.20	3.00	0.36	0	Nonzero	32, .1	Lower	-0.36
	4[c]	32, .025	3, .25	0.80	0.75	0.45	0.33	Nonzero	32, .025	Lower	-0.12
III	1	5, .8	3.80, 1.0	4.00	3.80	0.22	0.67	Zero	0, .2	Higher	+0.45
	2	5, .2	3.80, .25	1.00	0.95	0.56	0.33	Nonzero	5, .2	Lower	-0.23
	3	40, .1	3.80, 1.0	4.00	3.80	0.22	0.17	Nonzero	40, .1	Lower	-0.05
	4	40, .025	3.80, .25	1.00	0.95	0.44	0	Nonzero	40, .025	Lower	-0.44
IV	1	6, .8	4.60, 1.0	4.80	4.60	0.27	0.45	Zero	0, .2	Higher	+0.18
	2	6, .2	4.60, .25	1.20	1.15	0.64	0.55	Nonzero	6, .2	Lower	-0.09
	3	48, .1	4.60, 1.0	4.80	4.60	0.27	0.09	Nonzero	48, .1	Lower	-0.18
	4	48, .025	4.60, .25	1.20	1.15	0.27	0.27	Nonzero	48, .025	Lower	0

[a]The entries in this column indicate whether the proportion of respondents choosing the higher EV option was expected to be higher or lower in the experience group than in the description group, assuming underweighting of the rare event in the experience group.

[b]The proportion of higher EV choices in the experience group minus the proportion of higher EV choices in the description group.

[c]Original choice options used in Hertwig et al. (2004).

Table 2

Proportion of Higher EV Choices for Abstract Loss Condition

Set	Stimulus Number	Options		Expected value		Proportion choosing higher EV					
		A	B	A	B	Description group	Experience group	Item type	Rare event	Prediction for higher EV choices[a]	Difference between groups[b]
I	1	-3, .8	-2.20, 1.0	-2.40	-2.20	0.36	0.27	Zero	0, .2	Higher	-0.09
	2	-3, .2	-2.20, .25	-0.60	-0.55	0.36	0.73	Nonzero	-3, .2	Lower	+0.37
	3	-24, .1	-2.20, 1.0	-2.40	-2.20	0.18	0	Nonzero	-24, .1	Lower	-0.18
	4	-24, .025	-2.20, .25	-0.60	-0.55	0.64	0.27	Nonzero	-24, .025	Lower	-0.37
II	1[c]	-4, .8	-3, 1.0	-3.20	-3.00	0.45	0.67	Zero	0, .2	Higher	+0.22
	2	-4, .2	-3, .25	-0.80	-0.75	0.91	0.50	Nonzero	-4, .2	Lower	-0.41
	3[c]	-32, .1	-3, 1.0	-3.20	-3.00	0.55	0	Nonzero	-32, .1	Lower	-0.55
	4	-32, .025	-3, .25	-0.80	-0.75	0.36	0	Nonzero	-32, .025	Lower	-0.36
III	1	-5, .8	-3.80, 1.0	-4.00	-3.80	0.27	0.33	Zero	0, .2	Higher	+0.06
	2	-5, .2	-3.80, .25	-1.00	-0.95	0.73	0.67	Nonzero	-5, .2	Lower	-0.06
	3	-40, .1	-3.80, 1.0	-4.00	-3.80	0.55	0.33	Nonzero	-40, .1	Lower	-0.22

	4	-40, .025	-3.80, .25	-1.00	-0.95	0.45	0	Nonzero	-40, .025	Lower	-0.45
IV	1	-6, .8	-4.60, 1.0	-4.80	-4.60	0.56	0.33	Zero	0, .2	Higher	-0.23
	2	-6, .2	-4.60, .25	-1.20	-1.15	0.33	0.67	Nonzero	-6, .2	Lower	+0.34
	3	-48, .1	-4.60, 1.0	-4.80	-4.60	0.56	0.17	Nonzero	-48, .1	Lower	-0.39
	4	-48, .025	-4.60, .25	-1.20	-1.15	0.33	0	Nonzero	-48, .025	Lower	-0.33

[a]The entries in this column indicate whether the proportion of respondents choosing the higher EV option was expected to be higher or lower in the experience group than in the description group, assuming underweighting of the rare event in the experience group.

[b]The proportion of higher EV choices in the experience group minus the proportion of higher EV choices in the description group.

[c]Original choice options used in Hertwig et al. (2004).

Table 3

Proportion of Higher EV Choices for Ecological Gain Condition

Set	Stimulus Number	Options A	Options B	Expected value A	Expected value B	Proportion choosing higher EV: Description group	Proportion choosing higher EV: Experience group	Item type	Rare event	Prediction for higher EV choices[a]	Difference between groups[b]
I	1	3, .8	2.20, 1.0	2.40	2.20	0.11	0.67	Zero	0, .2	Higher	+0.56
	2	3, .2	2.20, .25	0.60	0.55	0.11	0.83	Nonzero	3, .2	Lower	+0.72
	3	24, .1	2.20, 1.0	2.40	2.20	0	0	Nonzero	24, .1	Lower	0
	4	24, .025	2.20, .25	0.60	0.55	0	0	Nonzero	24, .025	Lower	0
II	1[c]	4, .8	3, 1.0	3.20	3.00	0.27	0.55	Zero	0, .2	Higher	+0.28
	2[c]	4, .2	3, .25	0.80	0.75	0.45	0.55	Nonzero	4, .2	Lower	+0.10
	3[c]	32, .1	3, 1.0	3.20	3.00	0.09	0.45	Nonzero	32, .1	Lower	+0.36
	4[c]	32, .025	3, .25	0.80	0.75	0.36	0.27	Nonzero	32, .025	Lower	-0.09
III	1	5, .8	3.80, 1.0	4.00	3.80	0.27	0.50	Zero	0, .2	Higher	+0.23
	2	5, .2	3.80, .25	1.00	0.95	0.55	0.83	Nonzero	5, .2	Lower	+0.28
	3	40, .1	3.80, 1.0	4.00	3.80	0.18	0.17	Nonzero	40, .1	Lower	-0.01
	4	40, .025	3.80, .25	1.00	0.95	0.09	0.17	Nonzero	40, .025	Lower	+0.08
IV	1	6, .8	4.60, 1.0	4.80	4.60	0.27	0.83	Zero	0, .2	Higher	+0.56
	2	6, .2	4.60, .25	1.20	1.15	0.27	0.33	Nonzero	6, .2	Lower	+0.06
	3	48, .1	4.60, 1.0	4.80	4.60	0.18	0	Nonzero	48, .1	Lower	-0.18
	4	48,	4.60, .25	1.20	1.15	0.27	0	Nonzero	48,	Lower	-0.27

.025	.025

[a]The entries in this column indicate whether the proportion of respondents choosing the higher EV option was expected to be higher or lower in the experience group than in the description group, assuming underweighting of the rare event in the experience group.

[b]The proportion of higher EV choices in the experience group minus the proportion of higher EV choices in the description group.

[c]Original choice options used in Hertwig et al. (2004).

Table 4

Proportion of Higher EV Choices for Ecological Loss Condition

Set	Stimulus Number	Options		Expected value		Proportion choosing higher EV					
		A	B	A	B	Description group	Experience group	Item type	Rare event	Prediction for higher EV choices[a]	Difference between groups[b]
I	1	-3, .8	-2.20, 1.0	-2.40	-2.20	0.36	0.67	Zero	0, .2	Higher	+0.31
	2	-3, .2	-2.20, .25	-0.60	-0.55	0.64	0.50	Nonzero	-3, .2	Lower	-0.14
	3	-24, .1	-2.20, 1.0	-2.40	-2.20	0.64	0.50	Nonzero	-24, .1	Lower	-0.14
	4	-24, .025	-2.20, .25	-0.60	-0.55	0.82	0.17	Nonzero	-24, .025	Lower	-0.65
II	1[c]	-4, .8	-3, 1.0	-3.20	-3.00	0.22	0.33	Zero	0, .2	Higher	+0.11
	2	-4, .2	-3, .25	-0.80	-0.75	0.56	0.17	Nonzero	-4, .2	Lower	-0.39
	3[c]	-32, .1	-3, 1.0	-3.20	-3.00	0.22	0.33	Nonzero	-32, .1	Lower	+0.11
	4	-32, .025	-3, .25	-0.80	-0.75	0.78	0	Nonzero	-32, .025	Lower	-0.78
III	1	-5, .8	-3.80, 1.0	-4.00	-3.80	0.36	0.18	Zero	0, .2	Higher	-0.18
	2	-5, .2	-3.80, .25	-1.00	-0.95	0.64	0.73	Nonzero	-5, .2	Lower	+0.09
	3	-40, .1	-3.80, 1.0	-4.00	-3.80	0.36	0	Nonzero	-40, .1	Lower	-0.36

	4	-40, .025	-3.80, .25	-1.00	-0.95	0.55	0.45	Nonzero	-40, .025	Lower	-0.10
IV	1	-6, .8	-4.60, 1.0	-4.80	-4.60	0.36	0.83	Zero	0, .2	Higher	+0.47
	2	-6, .2	-4.60, .25	-1.20	-1.15	0.55	0.50	Nonzero	-6, .2	Lower	-0.05
	3	-48, .1	-4.60, 1.0	-4.80	-4.60	0.55	0.17	Nonzero	-48, .1	Lower	-0.38
	4	-48, .025	-4.60, .25	-1.20	-1.15	0.82	0.33	Nonzero	-48, .025	Lower	-0.49

[a]The entries in this column indicate whether the proportion of respondents choosing the higher EV option was expected to be higher or lower in the experience group than in the description group, assuming underweighting of the rare event in the experience group.

[b]The proportion of higher EV choices in the experience group minus the proportion of higher EV choices in the description group.

[c]Original choice options used in Hertwig et al. (2004).

Table 5

Summary of the Decision Problems and Results in Comparison with Hertwig et al. (2004)

	Options		Expected value		Proportion choosing higher EV							
Decision problem	A	B	A	B	Description group		Experience group		Rare event	Prediction for higher EV choices[a]	Difference between groups[b]	
1 (Set II 1[c])	4, .8	3, 1.0	3.2	3	0.36[d]	0.18[e]	0.88[d]	0.83[e]	0, .2	Higher	+0.52[d]	+0.65[e]
2 (Set II 2[c])	4, .2	3, .25	0.8	0.75	0.64[d]	0.45[e]	0.44[d]	0.5[e]	4, .2	Lower	-0.20[d]	+0.05[e]
3 (Set II 3[c])	-32, .1	-3, 1.0	-3	-3.2	0.64[d]	0.55[e]	0.28[d]	0[e]	-32, .1	Lower	-0.36[d]	-0.55[e]
4 (Set II 1[c])	-4, .8	-3, 1.0	-3	-3.2	0.28[d]	0.45[e]	0.56[d]	0.67[e]	0, .2	Higher	+0.28[d]	+0.22[e]
5 (Set II 3[c])	32, .1	3, 1.0	3.2	3	0.48[d]	0.36[e]	0.20[d]	0[e]	32, .1	Lower	-0.28[d]	-0.36[e]
6 (Set II 4[c])	32, .025	3, .25	0.8	0.75	0.64[d]	0.45[e]	0.12[d]	0.33[e]	32, .025	Lower	-0.52[d]	-0.12[e]

[a]The entries in this column indicate whether the proportion of respondents choosing the higher EV option was expected to be higher or lower in the experience group than in the description group, assuming underweighting of the rare event in the experience group.

[b]The proportion of higher EV choices in the experience group minus the proportion of higher EV choices in the description group.

[c]Numbering of items used in the current study.

[d]The proportion of higher EV choices in Hertwig et al. (2004).

[e]The proportion of higher EV choices in the current study.

Table 6

Analysis of Variance for Abstract and Ecological Contexts

Context	*df*	*F*	*p*	η_p^2
Abstract				
Format	1	.072	.792	.005
Valence	1	.328	.576	.023
Format X Valence	1	8.215	.012*	.370
Format X Item Type	1	13.065	.003*	.483
Format X Valence X Item Type	1	5.387	.036*	.278
Ecological				
Format	1	2.023	.177	.126
Valence	1	2.260	.155	.139
Format X Valence	1	16.426	.001*	.540
Format X Item Type	1	7.216	.018*	.340

Note: * $p < .05$.

Table 7

Summary of Hierarchical Regression for Format and Questionnaire Responses Predicting Overall Proportion of Higher EV Choices

Variable	ΔR^2	*B*	*SE B*	β
Step 1	.047*			
Format		-.059	.032	-.217
Step 2	.022			
Need for Cognition		0	.004	.013
Numeracy		-.002	.008	-.026
Risk Propensity		.002	.002	.116
Self-Control		-.001	.001	-.126
Total R^2	.069			

*Marginally significant, p = .069.

Table 8

Summary of Hierarchical Regression for Median Number of Total Samples and Questionnaire Responses Predicting Overall Proportion of Higher EV Choices

Variable	ΔR^2	*B*	*SE B*	β
Step 1	.027			
Median Number of Total Samples		-.001	.001	-.166
Step 2	.095			
Need for Cognition		-.007	.007	-.211
Numeracy		-.003	.008	-.071
Risk Propensity		.001	.003	.108
Self-Control		0	.001	-.058
Total R^2	.122			

Table 9

Summary of Regression for Questionnaire Responses Predicting Median Number of Total Samples

Variable	Δ R^2	*B*	*SE B*	β
Need for Cognition		-.255	.911	-.059
Numeracy		-.083	1.077	-.015
Risk Propensity		-.256	.386	-.140
Self-Control		-.130	.080	-.320
Total R^2	.144			

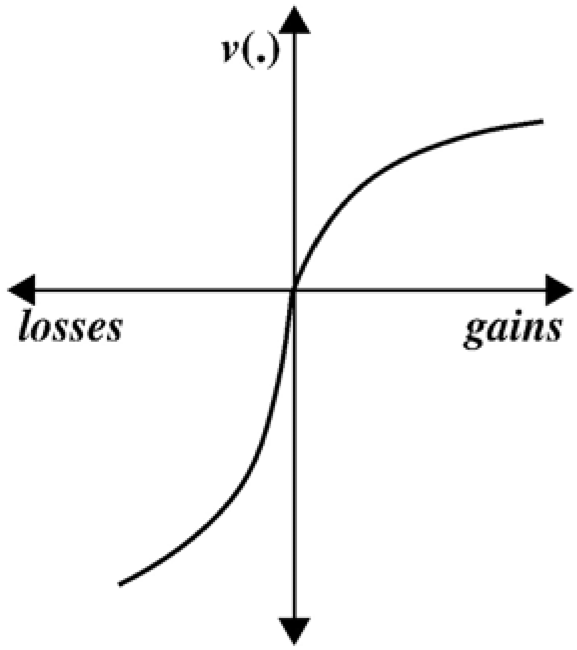

Figure 1. Prospect theory's value function.

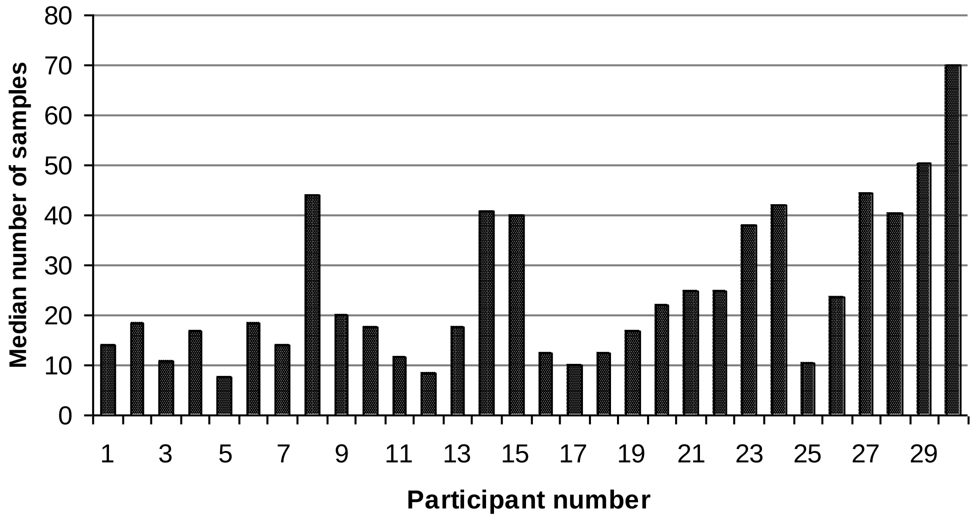

Figure 2. Median number of samples per item per participant in the experience group.

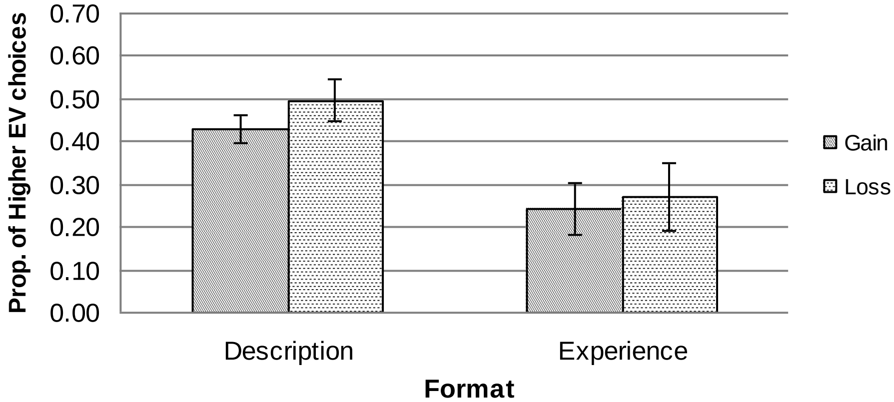

Figure 3. Decision making performance in the abstract context when the rare event was a nonzero gain or loss.

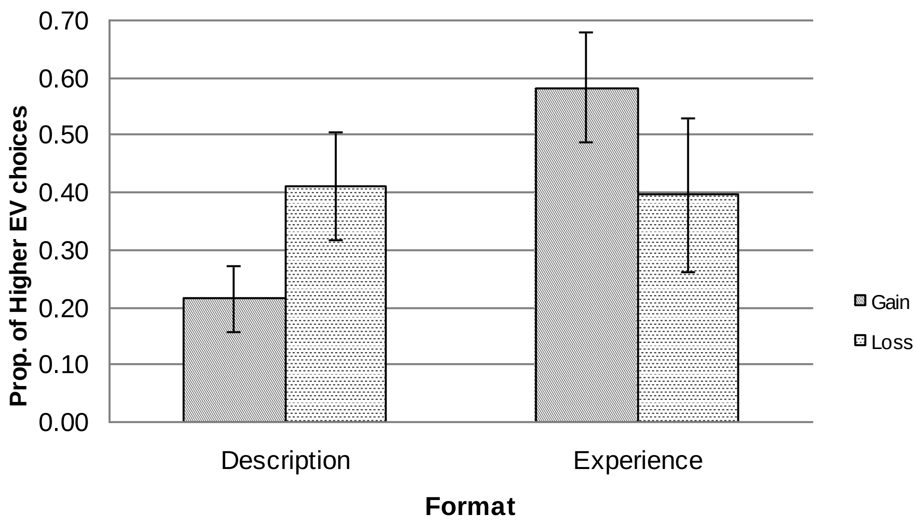

Figure 4. Decision making performance in the abstract context when the rare event was a zero gain or loss.

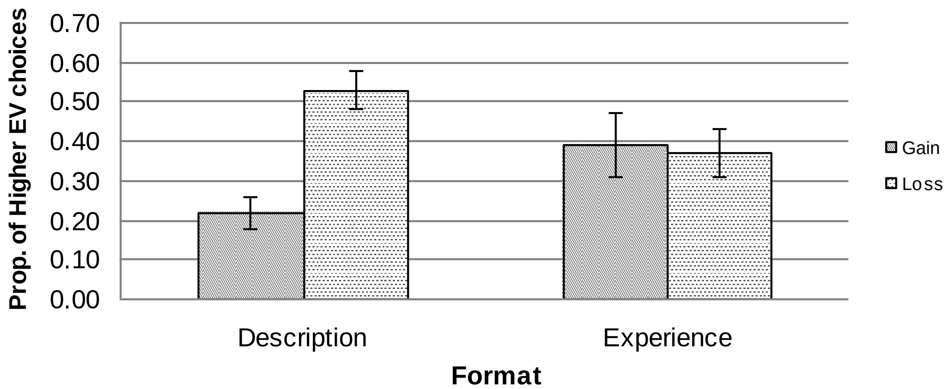

Figure 5. Decision making performance in the ecological context.

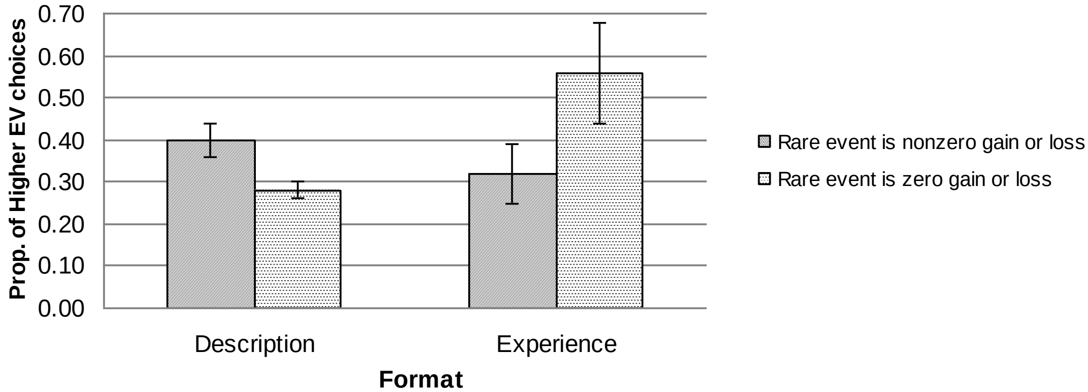

Figure 6. Decision making performance in the ecological context.

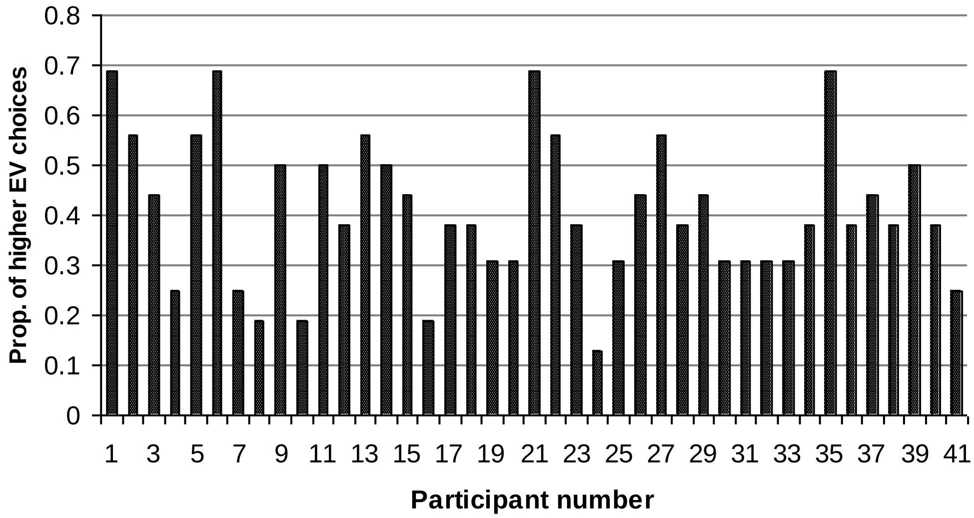

Figure 7. Overall proportion of higher EV choices per participant in the description group.

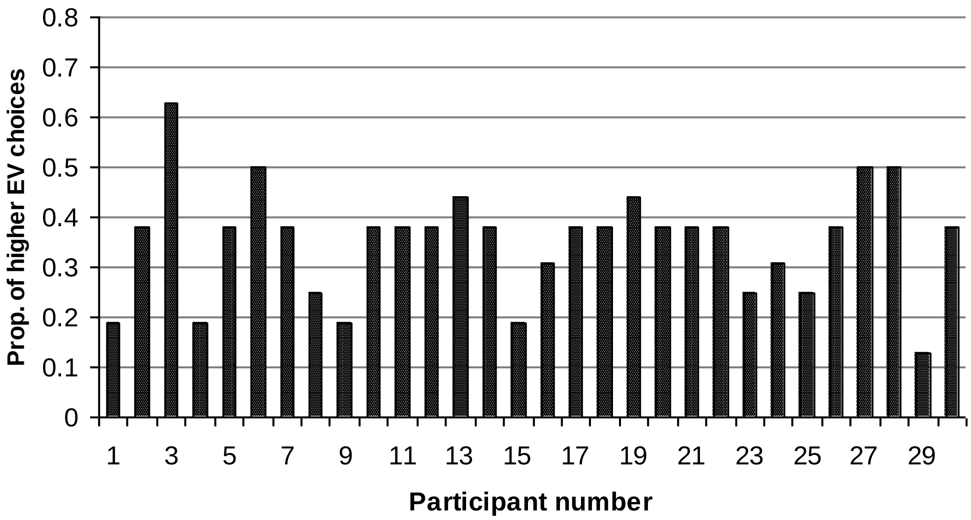

Figure 8. Overall proportion of higher EV choices per participant in the experience group.

Appendix A

Gain Scenario

You have spent the last two weeks traveling and visiting with old friends. Today is your last day and one of your friends takes you to the airport. After you have checked your suitcase, you and your friend stroll into a gift shop. Your friend insists on buying you a souvenir: Item 1 or Item 2. One of these items is more valuable, but also more difficult to fit into your carry-on bag. You have two options:

Option A: Accept Item 1, which is worth $4. The airline will allow you to carry it on board with a probability of .8. Otherwise, you will not be allowed to carry it on board.

Option B: Accept Item 2, which is worth $3. The airline will allow you to carry it on board with certainty.

Appendix B

Loss Scenario

You have spent the last two weeks traveling and visiting with old friends. Today is your last day and one of your friends takes you to the airport. After you have said good-bye, the ticket agent informs you that your suitcase is too heavy. You have to remove something from the suitcase: Item 1 or Item 2. One of these items is more valuable, but it might fit into your carry-on bag. The less valuable item will not. You have two options:

Option A: Remove Item 1, which is worth $4. If you put it in your carry-on bag, the airline will stop you from taking it on board with a probability of .8. Otherwise, you will be allowed to take it on board.

Option B: Remove Item 2, which is worth $3. If you put it in your carry-on bag, the airline will stop you from taking it on board with certainty.