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Report

You can't always get what you want: The motivational effect of need on risk-sensitive decision-making

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ABSTRACT

Risky behavior in humans is typically considered irrational, reckless, and maladaptive. Risk-sensitivity theory, however, suggests that risky behavior may be adaptive in some circumstances: decision-makers should prefer high-risk options in situations of high need, when lower risk options are unlikely to meet those needs. This pattern of decision-making has been well established in the non-human animal literature, but little research has been conducted on humans. We demonstrate in a two-part experimental study that young men and women ($n = 115$) behave as predicted by risk-sensitivity theory, shifting from risk-aversion to risk-proneness in situations of high need. This shift occurred whether decisions were made from description or from experience, and was observed controlling for sex and individual differences in general risk-taking propensity. This study is the first ecologically-relevant demonstration of risk-sensitive decision-making in humans.

1. Introduction

Risk-sensitive decision-making is an important topic of research in the behavioral sciences, including psychology, economics, and behavioral ecology. These fields have generally converged on an operational definition of risk involving outcome variance, where the riskier of two options with the same mean expected value is that with a higher outcome variance (Daly & Wilson, 2001). Animals, including humans, are generally risk-averse in that they prefer low variance options; reviewed in Kacelnik and Bateson (1996, 1997) and Weber, Shafir, and Blais (2004).

In psychology, risky behavior is typically considered irrational, pathological, and against an individual's best interests because of the potential for negative health or social outcomes (e.g., accidents, sexually transmitted diseases, social stigma). Under certain conditions, however, it may be advantageous to engage in risky behavior. Risk-sensitivity theory predicts that animals shift from risk-aversion to risk-proneness in situations of high need, where need refers to a disparity between an individual's present state and a goal (or desired) state. This pattern of behavior is known as the energy-budget rule, named after decision patterns observed in animals in response to foraging circumstances (Stephens, 1981; Stephens & Krebs, 1986).

Consider a foraging bird that must consume 1000 calories before dusk to survive the night. This bird seeks food from one of two different food patches. Both offer the same mean payoff (120 calories), but differ in payoff variance: patch one ranges from 110 to 130 calories (low variance), and patch two ranges from 40 to 200 calories (high variance). Foraging in patch two is riskier due to its higher outcome variance. The patch chosen by the bird should depend on its budgetary needs. If the bird acquired 900 calories through the day and requires 100 more to meet its caloric need for the night, its survival is guaranteed if it forages from the low-risk patch. If the bird has acquired 800 calories through the day, however, and requires 200 more to survive, it effectively guarantees its death if it forages from the low-risk patch. As a consequence, the high-risk patch should be favored in this situation because it at least allows for a *chance* of survival.

The energy-budget rule was originally conceived to explain foraging patterns in non-human animals, but can be generalized to most decision-making situations involving need. According to this rule, organisms do not seek to maximize desirable outcomes, but rather, seek to avoid outcomes failing to meet one's needs (Rode, Cosmides, Hell, & Tooby, 1999). This pattern of decision-making is known as satisficing, whereby decision-makers encounter and evaluate options until they happen upon an option that meets their need (Simon, 1956; Todd & Gigerenzer, 2000). Satisficing is contrasted with maximization, where decision-makers seek out an optimal outcome.

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If someone is far from an acceptable threshold (e.g., low income, poor social status) he may do well to engage in risky behavior to improve his situation (Wilson & Daly, 1997). People in situations of high economic need, for example, are more likely to engage in pathological gambling, a behavior that exposes one's resources to highly variable outcomes (Stinchfield, 2004). Similarly, poor social status may represent a condition of need whereby the minimum threshold required for attracting a quality mate or securing alliances may not be met; this situation may influence such risk-accepting behavior as interpersonal violence (e.g., Wilson & Daly, 1985).

There has been little investigation of the energy-budget rule in humans, although it has been broadly supported in non-human studies (reviewed in Kacelnik & Bateson, 1996, 1997). It is difficult to directly manipulate energy needs in human participants, but other currencies, including money, offer analogues through which risk-sensitive decision-making can be investigated in a laboratory setting. Some studies of humans have demonstrated shifts from risk-aversion to risk-proneness using monetary rewards. These studies used arbitrary requirements for creating situations of low need and high need, such as point totals that had to be met before any money was earned (Deditius-Island, Szalda-Petree, & Kucera, 2007; Ermer, Cosmides, & Tooby, 2008; Pietras & Hackenberg, 2001; Pietras, Locey, & Hackenberg, 2003; Rode et al., 1999). Other studies have manipulated need in other domains, such as social status (Ermer et al., 2008), or survival decisions (Wang, 2002) with similar results. For example, Wang (2002) found that participants' purported "minimum requirement" thresholds predicted risky decisions in the well-known "Asian disease problem" (Tversky & Kahneman, 1981). These studies provide some support for risk-sensitive decision-making in humans, but do not adequately account for three important aspects of decision-making under risk: sex differences, other individual differences associated with risk-taking propensity, and ecological relevance.

Sex differences in risky behavior are well documented. Men take significantly more risks than women in most domains (Byrnes, Miller, & Schafer, 1999). In most situations of need, however, there is little reason to expect that men and women should behave differently. Sex differences would be expected, however, in situations where men and women differentially value a resource. For example, men are more status-seeking than women, and exhibit greater sensitivity to status competition (Wilson & Daly, 1985). Thus, men should be more risk-seeking in situations where one is below an acceptable status threshold, and some evidence supports this notion (Ermer et al., 2008). In situations of need where there are no differential benefits for either sex, however, males and females should be similarly affected by need.

Studies of risk-sensitive decision-making under conditions of need have not measured nor controlled for individual differences that may be relevant to risk decisions, although more general personality traits have been incorporated in one study of risk-sensitive decision-making (the "big five" personality traits, Deditius-Island et al., 2007). Several stable personality traits have been associated with real-world risky behavior, including sensation-seeking, impulsivity, and self-control (e.g., Zuckerman, 2007; Zuckerman & Kuhlman, 2001), but it is unclear whether these traits moderate the effect of need on risk-sensitive decision-making.

Most importantly, previous studies of risk-sensitive decision-making have largely used explicit instructions to describe decision scenarios (known as *decision from description*; Hertwig, Barron, Weber, & Erev, 2005), and none have used ecologically relevant decision scenarios. Although these studies demonstrate that people are able to make risk-sensitive decisions based on descriptive information (e.g., probabilities, explicitly described mean and variance of options), this type of information is rarely available in natural environments. Outside of the laboratory, people usually make risk-sensitive decisions based on experience with different behavioral options and acquire a sense of the likelihood and magnitude of various outcomes associated with different behavioral options (known as *decision from experience*; Hertwig et al., 2005). A more ecologically-relevant demonstration of risk-sensitive decision-making in humans thus requires learning the outcomes of various complex options through experience.

In this study, we sought to (1) replicate previous experiments demonstrating that people make risk-sensitive decisions as a function of need when making decisions from description, and (2) extend these studies by using an ecologically relevant decision-making task based on decision-making from experience. For both (1) and (2), we sought to examine, and control for, any impact of sex and other individual differences on risk-sensitive decision-making.

2. Method

2.1. Participants

This study had two phases. In phase I, 240 participants (120 men), age 18–25 ($M = 20.3$, $SD = 1.9$) were recruited from undergraduate psychology classes and completed measures of personality associated with risky behavior (sensation-seeking, impulsivity, and self-control). We conducted a principal components analysis without rotation on these measures. A single principal component, *risky personality*, explained 66.4% of the variance. All measures on this factor loaded highly (>.70) and positively. This factor was used to select participants for the second phase of the experiment.

Phase II participants were 58 men and 57 women (age: $M = 20.0$, $SD = 2.0$). Those phase I participants scoring highest (20 men, 19 women), lowest (19 men, 23 women), and in the middle (19 men, 15 women) of the sex-specific distribution of risky personality participated in phase II of the experiment. Uneven group numbers are due to some phase I participants being unavailable to participate in phase II. Other questionnaires and behavioral tasks were administered to participants, but were not relevant to the present study.

2.2. Measures

2.2.1. Individual differences

We administered several measures of individual differences, including personality questionnaires associated with risk (sensation-seeking, impulsivity, self-control), and laboratory-based behavioral measures of risk-acceptance (choice task, variance preference, and the balloon analogue risk task).

2.2.2. Zuckerman's sensation-seeking scale (SSS-V)

The SSS, Version 5 (Zuckerman, 1994), consists of 40 choices between pairs of antithetical statements about preferences for varied, stimulating experiences and disinhibited behavior (e.g., "A sensible person avoids activities that are dangerous" versus "I sometimes like to do things that are a little frightening"). A total sensation-seeking score was obtained by summing the number of high sensation-seeking choices.

2.2.3. Eysenck's impulsivity scale (EIS)

The EIS (Eysenck, Pearson, Easting, & Allsopp, 1985) consists of 19 yes/no statements about impulsive behaviors (e.g., "Do you often buy things on impulse?"). A total impulsivity score was obtained by summing the number of "yes" answers.

2.2.4. Retrospective behavioral self-control scale (RBS)

The RBS (Marcus, 2003) measures behaviors across the lifespan that are associated with low self-control. It consists of 67 items, measuring the frequency of behaviors associated with low self-control in childhood, adolescence, and adulthood. Behaviors were rated on a scale from 1 (never) to 7 (always). A total self-control score was obtained by summing ratings of frequency of engagement in risky behaviors (e.g., "I was responsible for a road accident"); a higher score indicated lower self-control.

2.2.5. Choice task (CT)

Participants made six decisions, each between two monetary options (adapted from Fessler, Pillsworth, & Flamson, 2004). Both options had equal mean expected values, but differed in payoff variance (e.g., "Would you rather choose (A) $3 guaranteed, or (B) a 30% chance of earning $10?"). At the end of the task, participants rolled a die and received the value of one of the six choices they made corresponding with the number on the die. A total score of number of risky choices was computed.

2.2.6. Variance preference task (VPT)

Participants chose one of two options (Rode et al., 1999): (1) "Choose one of two cups, one with 100 black beads (Cup A), and one with 100 white beads (Cup B). You are allowed to pick either Cup A or Cup B (without knowing which contains the black or white beads), and draw 10 beads from that single chosen cup; or (2) "A single cup that contains a random combination of white and black beads totaling 100. You are allowed to draw 10 beads from this cup, replacing each bead after drawing it." Participants earned $1 for each black bead drawn. Option 1 is a riskier option (all-or-nothing) than Option 2. A dichotomous score of risky/not-risky was computed.

2.2.7. Balloon analogue risk task (BART)

Participants saw a computer screen with a deflated balloon and a "PUMP" button (adapted from Lejuez et al., 2002). For each pump of the balloon, participants earned one cent and increased the balloon in size. The balloon was set to pop randomly, with an average of 65 pumps required before popping. If the balloon popped, participants lost all money gained for that trial. Participants could end the trial at any time by clicking on a "COLLECT" button. Thirty trials were presented; the first five were excluded from analysis as training. The average number of pumps for all trials where the balloon did not pop was computed.

2.2.8. Decision-making under need

The dependent measures in this study were two decision-making under need tasks, one from description and the other from experience. Decision-making from description refers to participants being provided with explicit option information in the form of probabilities. Decision-making from experience refers to participants having to learn the characteristics of different options through interactive experience.

2.2.9. Decision-making from description: variance preference under need (VPN)

Participants made twenty decisions between a certain option, consisting of one of four fixed ratios of black to white beads totaling 100 (30:70, 50:50, 60:40, 70:30), and a risky option, consisting of a randomly determined combination of black and white beads totaling 100 (Rode et al., 1999). For each decision, participants drew ten beads with replacement. In order to earn any money, participants had to draw a specific number of black beads (i.e., meet a need requirement). Five need requirements were constructed. This need requirement was either one or two beads above, one or two beads below, or equal to the expected value of the certain option (abbreviated +1EV, +2EV, −1EV, −2EV, and 0EV, respectively).

Each level of need was presented for each of the different certain option ratios, leading to twenty decisions (4 certain option ratios $\times$ 5 need requirements). For example, "You are required to draw *seven* black beads out of ten. Would you rather draw from a cup containing (A) 50 black beads and 50 white beads, or (B) a randomly determined combination of black and white beads totaling 100". In this example, option (A) is the certain option, (B) is the risky option, and the level of need is seven (which is equal to two above the expected value of the certain option).

At the end of the task, participants drew one of 20 numbered ping-pong balls and played out their decision in the scenario corresponding to the number drawn. Participants earned $20 if they met their need. The dependent measure was the proportion of risky choices made under each of the five need conditions.

2.2.10. Decision-making from experience: the ecological decision task (ECO)

The ECO was specifically developed for this study to approximate a real-world, ecologically relevant risk-sensitive decision in a foraging context. The ECO consisted of two parts. Part A was the training session. Participants saw 50 cartoon trees of four different colors, randomly presented one at a time on a computer screen. Clicking on each tree revealed some non-zero number of apples shown in the foliage of the tree. Each tree color produced a specific mean and variance of return, approximating a real-world foraging situation of learning the yield characteristics of patches by experience. The four tree colors and four yield characteristics were paired randomly between participants. Two trees had different mean outcomes, but the same variance in outcome (Tree 1: $M_{\text{yield/day}} = 7.3$; $SD_{\text{yield/day}} = 2.5$; Tree 2: $M_{\text{yield/day}} = 4.7$, $SD_{\text{yield/day}} = 2.5$). The other two trees had the same mean outcome, but different variance in outcome (Tree 3: $M_{\text{yield/day}} = 8.0$, $SD_{\text{yield/day}} = 6.0$; Tree 4: $M_{\text{yield/day}} = 8.0$, $SD_{\text{yield/day}} = 0.9$).

Part B was the decision-making phase. There were seven trials per block (described to participants as seven days). Ten blocks were presented to each participant. The participants' goal was to survive the week by obtaining 50 apples (earning $2). For each trial, participants were told to "Click to see what trees [were] available within a day's walking distance." The first five trials in each block presented a single tree, such that participants were fixed to be in one of two conditions by the sixth trial: low need (Tree 1 presented for trials 1–5, resulting in an apple total close to the survival threshold, $M = 36.5$), or high need (Tree 2 presented for trials 1–5, resulting in an apple total far from the survival threshold, $M = 23.5$). The only parameter that varied between the two conditions was the mean yield of the tree presented; trees 1 and 2 both had the same variance in yield (see above). On trials six and seven, participants decided between two trees with the same mean yield, but different variance, one risky (high variance; Tree 3) and the other non-risky (low variance; Tree 4).

Trial six introduced participants to the decision-making task but was not used as a dependent measure. Trial seven represented a risk-sensitive decision based on an immediate situation of low or high need. The dependent measure was the proportion of risky choices on trial seven. Blocks where participants were able to meet their need with certainty by trial seven (by obtaining 49 or more apples) were eliminated from analysis (56 blocks).

The probability of meeting one's need was calculated for each decision in the VPN using the formula, *probability of meeting need by choosing the low-risk option minus probability of meeting need*

Table 1
Descriptive statistics and sex differences for individual differences measures.

Measure	Male		Female		Sex difference	
	Mean	Std. dev.	Mean	Std. dev.	*t*	*p*
SSS-V	23.25	6.68	18.69	5.33	4.04	<.001
EIS	8.19	4.14	6.58	3.78	2.17	.032
RBS	161.02	55.56	130.35	40.57	2.96	.004
CT	2.05	1.67	2.18	1.48	−.421	.675
VPT	1.59	0.50	1.33	0.48	2.79	.006
BART	35.87	15.90	30.06	13.64	2.25	.026

Notes: SSS-V = Sensation-seeking, EIS = Impulsivity, RBS = Self-control (higher score = less self-control); CT = Choice task; VPT = Variance preference task; BART = Balloon analogue risk task.

by choosing the high-risk option.[1] The probability of meeting one's need in the ECO was similarly calculated for each of the 34 possible need scenarios for the seventh day decision trial (ranging from requiring 2 to 35 apples to meet one's need). Participants' actual decision tendencies for both tasks were calculated using the formula, *proportion of low-risk choices minus 0.5* (where 0.5 indicated indifference between the low and high-risk options) for each need scenario.

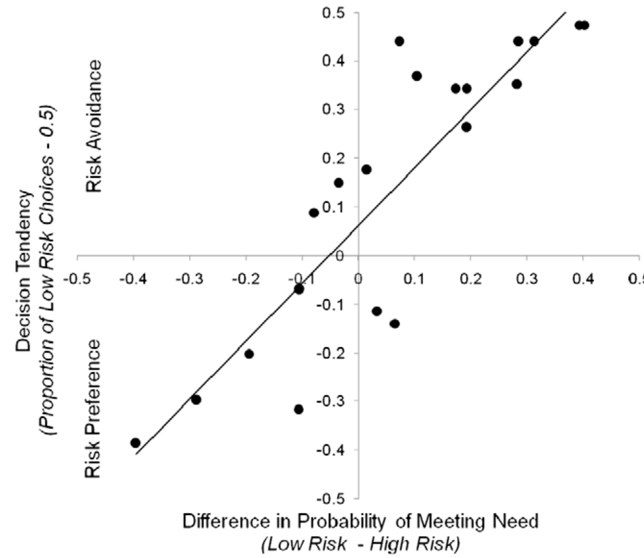

Fig. 1. Correlation between the probability of meeting one's need and the decision tendencies of participants in the VPN. Each point represents the mean decision outcome of all participants, for each of the 20 decisions constructed from the four different bead ratios and five levels of need.

2.3. Procedure

Phase I participants filled out paper versions of the three personality scales (SSS-V, EIS, RBS) in small groups. Phase II participants were tested at individual computer stations, and completed the behavioral measures of risk (CT, BART, VPT, VPN, ECO). In Phase II, after each task, participants called the experimenter to make any relevant draws and collect earnings, denoted with poker chips (in order to make earnings more tangible). Earnings were exchanged at the end of the session for a cheque. All questionnaires and tasks in each phase were presented in fully randomized order. Average earnings were \$44.38 (*SD*: \$22.54, *Range*: \$10.75–\$106.50).

3. Results

All data except for the BART, RBS, and EIS were normally distributed. All data were normalized using a logarithmic transformation. Missing values ($n = 1$ for EIS, RBS; $n = 2$ for SSS) were imputed with the full sample mean. No outliers were detected. All but one measure of risky personality traits and behavioral measures of risk-acceptance showed significantly higher scores in men than women (Table 1). Descriptive statistics are shown in Table 1; all means presented are unadjusted. All analyses were conducted using SPSS version 17.0.0.

3.1. Decision-making from description (VPN)

The proportion of risky choices made in the VPN was highly correlated with the probability of meeting need with higher risk options, $r = .88$, $p < .001$ (Fig. 1).

A sex (male/female) × need (5 levels) × risky personality group (low/middle/high) mixed analysis of covariance (ANCOVA) was conducted on proportion of risky decisions made in the VPN.[2] Covariates were the three laboratory measures of behavioral risk-acceptance (CT, VPT, BART), controlling for general tendencies to select high-risk options in computer-presented tasks. Multicollinearity among these measures was not problematic, with all VIFs <2.12. Including covariates that correlate with independent variables in an ANCOVA may lead to increased Type I errors (Yzerbyt, Muller, & Judd, 2004). To correct for this problem, we included two interaction terms as additional covariates (BART × sex, and VPT × sex); BART and VPT were the only covariates significantly correlated with any of the independent variables.

A main of effect of need on the proportion of risky decisions made in the VPN was obtained, $F(4, 424) = 3.96$, $p = .004$, $\eta^2 = .036$ ($M_{-2EV} = .29$, $M_{-1EV} = .32$, $M_{0EV} = .35$, $M_{+1EV} = .39$, $M_{+2EV} = .51$), indicating that participants made a significantly higher proportion of risky decisions in conditions of higher need, *linear contrast*, $F(1, 106) = 9.58$, $p = .003$, $\eta^2 = .083$. No significant main effects of sex, $F(1, 106) = .037$, $p = .85$, $\eta^2 < .001$ ($M_{men} = .37$, $M_{women} = .38$), or personality, $F(2, 106) = .640$, $p = .53$, $\eta^2 = .012$ ($M_{low} = .36$, $M_{moderate} = .37$, $M_{high} = .39$), were observed. All two and three-way interactions were tested, with none significant (all Fs < 2.40, ps > .19).

Two of the three behavioral measures of risk-acceptance (VPT, BART) showed significant sex differences (Table 1). Thus, controlling for these behavioral measures of risk may have eliminated any effect of sex in the ANCOVA. We conducted an identical ANOVA as above without controlling for behavioral measures of risk, and found a similar pattern of results; the only change was a substantial increase in the magnitude of the main effect of need on proportion of risky decisions made, $F(4, 436) = 25.94$, $p < .001$, $\eta^2 = .20$. A linear contrast test as above indicated that participants made significantly more risky decisions under conditions of higher need, $F(1, 109) = 64.29$, $p < .001$, $\eta^2 = .37$. The effect of sex remained non-significant, as did all two and three-way interactions.

3.2. Decision-making from experience (ECO)

The proportion of risky choices made in the ECO was also highly correlated with probability of meeting need with higher risk options, $r = .59$, $p < .001$ (Fig. 2).

A sex (male/female) × need (high/low) × risky personality group (low/middle/high) mixed ANCOVA was conducted on

[1] For example, consider the VPN choice where participants had to draw 8 or more black beads to meet their need, and the certain option was a cup containing 60 black and 40 white beads. The probability of meeting one's need drawing from the low risk option was .17, and from the high risk option, .28, with a difference in probability of -.11. For a complete table of probabilities for each of the decisions in the VPN, see Rode et al. (1999, p. 294).

[2] We note that risky personality comprised three groups based on the Phase II selection procedure.

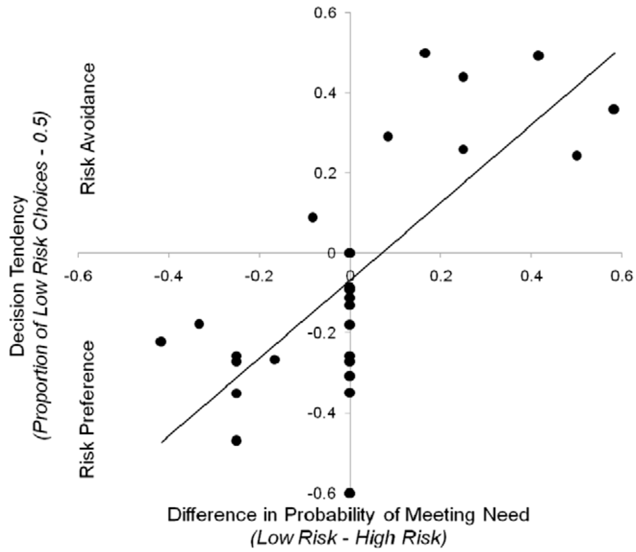

Fig. 2. Correlation between the probability of meeting one's need and the decision tendencies of participants in the ECO. Each point represents the mean decision outcome of all participants, for each of the 34 possible need scenarios for the seventh day decision trial (ranging from requiring 2 to 35 apples to meet one's need).

proportion of risky decisions made in the ECO. Covariates were measures of behavioral risk-acceptance (CT, VPT, BART). As above, multicollinearity was not a problem in this analysis, with all VIFs <2.19. A main effect of need was obtained for proportion of risky decisions made in the ECO, $F(1, 104) = 4.39$, $p = .04$, $\eta^2 = .04$. A significantly higher proportion of risky choices were made in the high need condition compared to the low need condition, $M_{high} = .65$, $M_{low} = .42$. No significant main effects of sex, $F(1, 104) = .265$, $p = .61$, $\eta^2 = .003$ ($M_{men} = .57$, $M_{women} = .50$), or risky personality group, $F(2, 104) = .170$, $p = .84$, $\eta^2 = .002$ ($M_{low} = .53$, $M_{moderate} = .55$, $M_{high} = .54$), were observed. All two and three-way interactions were tested, with none significant (all Fs < 1.55, ps > .22).

Once again, sex differences for two of the three behavioral measures of risk-acceptance may have hidden an effect of sex in the ANCOVA. We conducted an identical ANOVA as above, without controlling for behavioral measures of risk, and found that there was a substantial increase in the magnitude of the main effect of need on proportion of risky decision made, $F(1, 109) = 34.00$, $p < .001$, $\eta^2 = .24$. None of the other main effects or two or three-way interactions were significant.

3.2.1. Learning in the ECO

Foragers in a natural environment learn the yield of various patch options through experience (i.e., implicit learning). Because we did not provide any descriptive information in the training session of the ECO, it is likely that participants made decisions based on implicitly learning the mean and variance of the different choice options. We tested whether participants were aware of what they learned from exposure to the trees in the training session of the ECO.

Twenty-two other participants (11 male) were asked whether they recognized any difference between the four different trees. Only 45% recognized the trees varied in some way. Of the nine participants who indicated the trees differed, two noted differences in variability; seven noted differences in mean. Participants were then provided with definitions of mean and variance and asked to rank the four trees in order of highest to lowest for both. Rankings did not significantly differ from chance, for both mean (38% correct; $\chi^2 = 1.00$, $p = .32$) and variance (38% correct; $\chi^2 = .99$, $p = .32$), suggesting that participants were not explicitly aware of the yield characteristics of the four trees. It is therefore probable that decisions made in the ECO were a consequence of participants implicitly learning the yield characteristics of different decision options. We do note that the low power of this test, however, limits any strong conclusions.

3.3. Constraint and individual differences in risk-sensitive decision-making

In situations without clear need constraints, where there is no single "right" option that minimizes the probability of an unfavorable outcome, sex and individual differences may play a larger role in observed decision behavior. One such situation occurred in this study. A "safe" decision scenario, where individual differences may have been more likely to manifest, involved trial blocks in the ECO where participants were guaranteed to meet their need by obtaining 49 or more apples before the last trial. In this situation (56 blocks), the risky personality factor score obtained from phase I was correlated with proportion of risky decisions made, $r = .359$, $p = .007$, suggesting that general risky personality is associated with a tendency to choose high variance options in situations without constraint. Individual measures of risky personality were not, however, significantly correlated with the proportion of risky decisions made (sensation-seeking: $r = .21$, $p = .13$; impulsivity: $r = .13$, $p = .32$; and self-control: $r = .17$, $p = .22$), although all correlations were in the expected direction. Behavioral preference for risk as measured by the BART and the CT were both significantly associated with the proportion of risky decisions made in this situation, $r = .288$, $p = .03$, and $r = .307$, $p = .02$, respectively, although the VPT was not, $r = .07$, $p = .60$. No sex difference in proportion of risky decisions made was observed, $M_{men} = .73$, $M_{women} = .67$, $t(54) = .569$, $p = .57$, $r = .08$.

4. Discussion

This study represents the first demonstration of risk-sensitive decision-making from ecologically relevant experience in humans. People made decisions based on the reward variance of behavioral options, in tasks involving both decision from description and decision from experience. Decisions also conformed to the predictions of the energy-budget rule: Participants exhibited elevated risk-preference when they were placed in a situation of high need (where a low-risk behavioral option was less likely to meet their need). People who experienced conditions of low need generally preferred low-risk options that were sure to meet their needs. These results were obtained even controlling for sex and individual differences that we attempted to maximize by utilizing an extreme-groups approach. People exhibited risk-sensitive decision-making in the ECO even though very few of our manipulation check participants correctly identified any differences between the four trees, suggesting that implicit knowledge of option yields may have driven decision behavior.

We found, like others, that men scored higher than women on personality and behavioral measures of risk (Byrnes et al., 1999), but sex had little influence on risk-sensitive decision-making in this study. As noted earlier, some situations might generate predictable sex differences in decision-making. For example, Ermer et al. (2008) demonstrated that men were more likely to choose risky options in resource loss problems when they thought they were being evaluated by other males of similar status. Women did not show the same pattern of decision behavior when exposed to a similar manipulation. Deditius-Island et al. (2007) demonstrated sex differences in risky decision-making under need conditions that may have been perceived as competitive; participants made decisions based on their relative status to purported others playing the same task. Competition for status may be more important for men than for women, explaining such sex differences in decision-making (Wilson & Daly, 1985). Our behavioral tasks did not involve any competition with others.

Individual differences in personality did not appear to play a significant role in decision-making under high need situations, possibly because most people elevate risk-acceptance regardless of personality traits. In situations where need constraints were lifted, and there was no single "right" decision available, however, individual differences played a larger role. In the ECO, personality traits associated with risk were significantly associated with the proportion of risky decisions made in trials where participants were guaranteed to meet their need. Furthermore, a behavioral preference for risk as measured by the BART and the CT was also significantly associated with the proportion of risky decisions made in conditions where need was no longer a constraint. These results provide some evidence that individual differences may be important predictors of risk-taking in situations where there are no need constraints.

Several problems have been associated with the extreme group approach (EGA) to experimental design, including issues of statistical power, effect size, and reliability (Preacher, Rucker, MacCallum, & Nicewander, 2005). We attempted to alleviate potential problems associated with EGA by using a moderate risky personality group, in addition to groups based on higher and lower extremes. Because extreme scores are less reliable than moderate scores, the moderate risky personality group helped to mitigate potential inflation of effect size and problems with reliability, among other issues (Preacher et al., 2005). Issues of statistical power were of concern given our relatively small sample size, which was constrained by limitations of funding and variability in risky personality. In order to keep behavioral tasks salient, we paid participants a relatively large sum of money to participate (average earnings were $44.38). Among university students, there is little variability in risky personality traits due in part to constrained age range and high education level. Thus, we chose to use EGA, because this approach increases statistical power in situations with constrained variability in measures of interest (Preacher et al., 2005). In future research, it would be worthwhile to investigate risk-sensitive decision-making in groups of individuals who have demonstrated high risk-acceptance (e.g., criminal offenders, extreme-sports competitors).

The external validity of several of the behavioral measures used in this study is currently unknown. The BART has been associated with various risky behaviors outside of the laboratory, including addictive, health, and safety risk behaviors (Lejuez et al., 2002), risky sexual behaviors (Lejuez, Simmons, Aklin, Daughters, & Dvir, 2004), substance use (Aklin, Lejuez, Zvolensky, Kahler, & Gwadz, 2004), and general delinquency and gambling (Lejuez, Aklin, Zvolensky, & Pedulla, 2003). Several of these studies have demonstrated that behavioral measures of risk explain additional variance in risky behavior above and beyond that accounted for by self-report personality traits. Direct associations between other measures used in this study and real-world risk-taking, however, have not been examined. Although the ECO is an analogue of ecologically relevant foraging behavior, it does not capture the urgency under which almost all animal foraging decisions are made, and it is difficult to induce such urgency in a laboratory setting. We are presently collecting data on the risk-preferences of people currently experiencing situations of high need in non-laboratory settings (e.g. among the homeless, unemployed, and impoverished), and will investigate the external validity of the measures presented in this paper.

It is difficult to directly compare decisions made in a laboratory under temporarily imposed need constraints with life-or-death situations faced by animals in a natural environment. One could argue, however, that most risk-sensitive decisions in the real-world are made under some consideration of one's immediate situation of need. Cognitive mechanisms that motivate risk-accepting behavior may be generally sensitive to any situations in which a need is imposed. People who experience low life expectancy, high income inequality, and low status (all situations of high need), for example, appear to be more willing to accept risky, high variance outcomes (e.g., the chance of winning a fight versus the cost of getting seriously hurt) in order to have a chance at attaining tokens of biological fitness such as resources, status, or mates (Wilson & Daly, 1985, 1997). Overall, our results support a notion of ecological rationality, which states that decision-making mechanisms have evolved to allow organisms to make adaptive decisions based on environmental conditions (Todd, 2000).

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